TRANSLANGUAGING IN A MIDDLE SCHOOL SCIENCE CLASSROOM:
CONSTRUCTING SCIENTIFIC ARGUMENTS IN ENGLISH AND SPANISH

A Dissertation in
Curriculum and Instruction

by
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ABSTRACT

This dissertation investigates translanguaging in an English/Spanish dual language middle school science classroom as the teacher and students worked through a curriculum unit focusing on socioscientific issues and implementing a scientific argumentation framework. Translanguaging is the process in which bilingual speakers fluidly and dynamically draw from their full linguistic repertoire to perform a communicative act. Using ethnographically informed data collection in conjunction with discourse analysis, teacher translanguaging was examined for its related functions in the science classroom and how teacher translanguaging afforded opportunities for framing and supporting scientific argumentation. Results suggest that the functions of teacher translanguaging fell into three main themes: maintaining classroom culture, facilitating the academic task, and framing epistemic practices. Of the three categories of translanguaging, framing epistemic practices proved to be of paramount importance in the teacher presenting and supporting the practice of scientific argumentation. Implications from this study are relevant for pre-service science teacher preparation and in-service science teacher professional development for teachers working with emergent bilingual students.
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Forward ever, backwards never. None but ourselves can free our minds.
Chapter One

INTRODUCTION

This study examines the construction of and access to science discourse and practices through translanguaging in a 7th grade science class curriculum unit. The curriculum unit focused on engaging students in socioscientific issues and using evidence to support their points of view. Using discourse analysis and based on sociocultural psychology and sociolinguistics, the research approach considers the ways that students learn to engage with science. The study has implications for curriculum and instruction and teacher education. In this first chapter I describe the influences impacting the science classrooms of the United States of America, elaborate on how these influences intersect to present opportunities for research, and provide background for the development of this research study. This chapter ends with a presentation of the research questions.

Terminology

As with any scholarly work, it is important to provide definitions for the terms used in any study. This dissertation does include a host of specific terminology and at various points I do provide definitions for these terms as they are first introduced. However, there are a few terms that warrant definition before I proceed. This is a study about the use of language and it is also a study about scientific argumentation. As it relates to the study of language, I use the word discourse to refer to the practice of language use, or languaging, be it written or verbal. I use the word language to refer to the different systems of communication, used by the participants, present in the study: English and Spanish. So in fact this study is also about discourse and language. In a later
section, I refer to language as a practice in which individuals engage and not necessarily a bound system which individuals possess. I would like to avoid confusion by clarifying my use of the word language and the fact that throughout this work I need to distinguish between the English and Spanish languages, for a number of reasons.

I use the term linguistic repertoire to refer to the varied linguistic practices, in English and/or Spanish which the teacher and students employ as they engage in communicative acts. Each individual’s linguistic repertoire is different; an individual’s linguistic repertoire may consist of extensive linguistic practices in both English and Spanish, while others’ may consist of linguistic practices that favor the use of English or Spanish. This study is situated in a dual language school setting that is further situated in a multilingual community in which both English and Spanish are extensively spoken. Furthermore, the language practices in the homes vary: some individuals speak only English, only Spanish, or a mix of both English and Spanish in their homes. Therefore, it can be reasonably assumed that the teacher’s and students’ individual linguistic repertoires include both Spanish and English.

As it relates to scientific argumentation, I use the phrases scientific argumentation and constructing scientific explanations, interchangeably throughout this work. I also use the terms scientific argument and scientific explanation interchangeably. I do this for many reasons. First and foremost, argumentation and argument carry particular connotations in everyday vernacular. Argumentation can often be perceived as the process of fighting and argument is often perceived as a heated verbal altercation between two people. Therefore, both argumentation and argument can carry negative connotations. Secondly, in the research setting, there was an explicit rule in the classroom
that forbade arguing. It was decided by both the researcher and classroom teacher to use
the terms “constructing a scientific explanation” for the process and “scientific
explanation” as the product, when presenting this practice to students. McNeill and
Krajcik (2012) have recommended this substitution of terms, but find it most important to
engage students in the activity and less important whether the practice is called
constructing scientific explanations or scientific argumentation. Based on the nature of
the curriculum, students were engaged in argumentation – providing a claim, supporting
the claim with evidence, and connecting the evidence to the claim through reasoning – in
order to respond to an open-ended scientific question or make a decision about an open-
ended socioscientific issue. While some researchers (Osborne & Patterson, 2011) position
scientific argumentation and scientific explanation as different processes, this study will
use them interchangeably.

A specific scientific argumentation framework, the Claim, Evidence, and
Reasoning (CER) framework (McNeill & Krajcik, 2012) was employed throughout the
curriculum. Throughout the dissertation, I will use the terms claim, evidence, and
reasoning in reference to this framework. I use the term claim to represent a student’s or
teacher’s statement or response, in writing or verbally, to the open-ended questions posed
throughout the curriculum. I use the term evidence to refer to data or information that the
teacher or students use to support their claim(s). I use the term reasoning to refer to the
principles that the teacher or students provide that connect the evidence to their claim(s).
As the curriculum materials were provided in both English and Spanish, I use the terms
afirmación, evidencia, and razonamiento as the Spanish equivalents of claim, evidence,
and reasoning, respectively. While the term claim has multiple meanings in English, in
fact the different meanings of claim are represented by different words in Spanish. Based on conversations with the classroom teacher, it was decided to use the term afirmación to represent the word claim, as other words in Spanish connote a different meaning of claim. We also chose to use the Spanish words evidencia and razonamiento as equivalents to the English words evidence and reasoning, respectively.

Influences on K-12 Science Classrooms

Influences on the K-12 school system of the United States of America come from both the shifting demographics of the nation’s school-aged population and educational reform efforts from the science education research community. Intersections of these influences have the potential to create unique and dynamic learning environments in science classrooms. Furthermore, both challenges and opportunities present themselves as science educators and researchers plan and investigate learning environments that take into account these influences. One particular influence that is having a very strong impact on the nation’s educational system and warrants much attention is the increase in culturally and linguistically diverse (CLD) students in our schools. Culturally and linguistically diverse is a blanket phrase that describes students whose culture and language differ from the dominant society’s culture and language. While I use this term, I also acknowledge that culture and language are not static. Nonetheless, it is evident that there are many students in our nation’s school system whose language and culture are different from the dominant language and culture privileged in our schools. As such, the term refers to many students from many different cultural and linguistic backgrounds.

Increase in the Culturally and Linguistically Diverse Student Population
The K-12 school system in the United States of America is continuing to diversify both culturally and linguistically. The culturally and linguistically diverse student population is the fastest growing demographic group in the school-aged population and has increased by a staggering 57.2 percent from 1995/1996 to 2005/2006, as compared to an overall student increase of 3.7 percent (NCELA, 2007). The K-12 school system finds itself shifting from a monolingual setting to one that is bilingual or even multilingual. The largest proportion, 73%, of CLD students are Latinas/os of Spanish-speaking heritage (Batalova and McHugh, 2010) making many schools sites where both English and Spanish are spoken. From fall 2001 through fall 2011, the number of Hispanic students enrolled in our nation’s public schools increased from 8.2 million to 11.8 million, representing an increase of 44%, while the overall increase in total students increased by 3.7% (National Center for Education Statistics, n.d.a).

The increase in Latina/o students is predicted to continue to increase in the future. By 2023, Latina/o students are projected to comprise 30% of the total public K-12 student population (National Center for Education Statistics, n.d.a). I acknowledge that ethnicity and home language is not a one-to-one relationship, but it is not beyond reason to assume that an increase in the Latina/o student population, due to both immigration and domestic births, will result in an increase in the use of Spanish in our schools. Therefore, we can expect that our classrooms will, as a result, become much more

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1 I use the terms Hispanic and Latina/o, Hispanics, and Latinas/os according to how the terms are used in the referenced literature. In my own writing I use Latina/o or Latinas/os.
linguistically diverse. One opportunity that presents itself to educators and researchers is how to plan science learning environments that are able to embrace this linguistic diversity using it as a resource for teaching and learning, as opposed to seeing it as a challenge to be overcome. While the focus of this study is Spanish, the ideas presented in this study can apply to many K-12 classrooms with high student populations whose first or primary language is not English (and not necessarily Spanish).

**Emergent Bilinguals, Dynamic Bilingualism, and Translanguaging**

Historically, students whose first or primary language in the home is not English have been classified as Limited English Proficient (LEP), English Language Learners (ELLs), or English Learners (ELs). These labels are problematic for numerous reasons. One particular reason is that students are positioned or framed based on their fluency in English. This labeling effectively discounts all other proficiencies, be it academic or linguistic, that students may have in favor of classification based on English fluency. In other words, this label is based solely on proficiency or deficiency in English, making all other proficiencies invisible. In recent years, the term emergent bilingual (García, Kleifgen, & Falchi, 2008) has been used to replace former terms privileging English acquisition or fluency. Emergent bilingual recognizes and embraces the realization that these students are in the process of developing fluency in more than one language. Hornberger (1989) referred to the process of acquiring two languages as falling somewhere on the continua of biliteracy. Furthermore, the use of the term emergent bilingual is a shift away from a deficiency-based paradigm towards a paradigm that conceptualizes linguistic diversity as a resource for student learning and not a challenge to be overcome. As the term emergent bilingual refers to individuals in the process of
developing fluency in two languages, I realize that many individuals are developing fluency in two or more languages; therefore the term emergent bilingual can also refer to emergent multilinguals.

In addition to a shift in the conceptualization of language learners, new conceptualizations of bilingualism have emerged. Dynamic bilingualism (Flores & Schissel, 2014) is a theory of bilingualism that stands in contrast to previous theories, such as subtractive bilingualism and additive bilingualism. Dynamic bilingualism theorizes bilingualism as a process by which both languages are developing through use at the same time and each works to develop the other. Similar to my use of the term emergent bilingual, I use the term dynamic bilingualism to indicate the process of developing fluency in two languages but also recognize that this process includes the development of two or more languages. Therefore, dynamic bilingualism also refers to dynamic multilingualism.

Related to dynamic bilingualism and emergent bilinguals is the linguistic practice of translanguaging (García, Kleifgen, & Falchi, 2008), which can be described as individuals drawing on their full linguistic repertoire in order to perform a communicative action. Emergent bilinguals have a linguistic repertoire that includes two, or more, languages that can be drawn upon as needed according to the demands of the particular communicative situation. Emergent bilinguals translanguage as they navigate the complex linguistic landscapes that characterize the bilingual or multilingual communities in which they reside. Spanish may be the dominant language of home, English may be the dominant language of school or business, and emergent bilinguals may draw upon both languages as they interact in their peer groups or with their families.
Therefore, many emergent bilinguals flow in and out of English and Spanish as they move throughout their daily activities. Translanguaging is a resource for emergent bilinguals to draw upon as they carry out their everyday lives, make sense of their worlds, and engage in communicative acts. This authentic languaging practice found in bilingual communities is beginning to make its presence felt in schools, as bilingual education is being re-envisioned to meet the needs of a changing society.

**Dual Language Education**

Disregarding the political debate regarding national language policies, scholars and researchers realize the value of and support bilingual education (Collier and Thomas, 2004; Herrera and Murry, 2011; Ovando and Combs, 2012). One such conceptualization of bilingual education is termed dual language education, or dual or two-way immersion. Dual language education consists of programs that enroll both English-dominant students and minority language-dominant students. Minority language refers to all languages that are not the societally and politically dominant language. The goals of dual language education may vary, but all include the development of bilingual and bicultural students. Furthermore, dual language education positions both languages as equal and conceptualizes linguistic diversity and bilingualism as both normal and as resources to be used in teaching and learning. Therefore, it is reasonable to assume that translanguaging is a practice one would expect to observe in a dual language education environment.

**Science Education Reform**

The increase of emergent bilinguals in our schools continues to occur at a time when science education researchers have advocated for reform in the way that science is
being taught in the K-12 classrooms. One recent document from the science education research community that addresses the entire spectrum of K-12 science education is *A Framework for K-12 Science Education* (NRC, 2012), hereafter referred to as the *Framework*. This document recommends that K-12 science education incorporate three intertwining dimensions: scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The *Framework* represents a shift in science education towards greater uses of discourse to engage students with the subject matter (practices, crosscutting concepts, disciplinary ideas) in new ways that may facilitate learning science. Previous work (Lee & Fradd, 1998; Lemke, 1990; Warren, Ballenger, Ogonowski, Rosebury, & Hudicourt-Barnes, 2001) has demonstrated the importance of providing students opportunities to “talk science” and thus learning the meaning of scientific concepts and ideas and engaging in scientific practices through the use of discourse. Therefore, these implications impact both K-12 science teachers and students.

The *Framework* is an extensive document that addresses various practical and epistemological goals of a K-12 science education. One goal of the *Framework* is to align K-12 science education to more realistically mirror the authentic work of scientists in the field or laboratory. This goal positions science education in terms of what Roberts (2007) refers to as “Vision I scientific literacy,” which frames science as thinking and talking like scientists, as well as redefines what it means to construct scientific knowledge. To frame school science as comparable to the work of scientists, the following eight science and engineering practices have been recommended for inclusion in K-12 science education: asking questions (for science) and defining problems (for engineering), developing and using models, planning and carrying out investigations, analyzing and
interpreting data, using mathematical and computational thinking, constructing explanations (for science) and designing solutions (for engineering), engaging in argument from evidence, and obtaining, evaluating, and communicating information. These practices redefine what it means to engage in scientific inquiry, a term that often carries multiple, if not vague, meanings. The eight scientific and engineering practices require students to actively engage in practices to mediate understanding of how scientific knowledge develops (NRC, 2012) and how to make sense of extant scientific knowledge. Furthermore, the practices show that science is not the use of preformed scientific knowledge as is often thought by students, but

“seeing science as a set of practices shows that theory development, reasoning, and testing are components of a larger ensemble of activities that includes networks of participants and institutions, specialized ways of talking and writing, the development of models to represent systems or phenomena, the making of predictive inferences, construction of appropriate instrumentation, and testing of hypotheses by experiment or observation (NRC, 2012, p. 43).”

While each of the science and engineering practices has been informed by research from the science education community, one practice, engaging in argument from evidence, is supported by a wide body of research within the science education research community.

**Scientific Argumentation**

Scientific argumentation has been a research interest within science education for a number of years (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Patronis, Potari, & Spiliotopoulou, 1999; Sampson & Clark, 2008). The *Framework* (NRC, 2012) justifies the inclusion of engaging in argument from evidence in K-12 science classrooms by the following:
“In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.” (p. 52).

The importance of argumentation is not new, as a number of scholars have, for some time, advocated for the inclusion of argumentation in the K-12 science classroom (Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Tiberghien, 2007). Argumentation can be discussed in terms of its contributions to (Jiménez-Aleixandre & Erduran, 2007) and the goals of (Tiberghien, 2007) science education. The Framework (NRC, 2012) lists seven goals of scientific argumentation that students should meet by grade 12. These seven goals have applicability to the construction of scientific knowledge, as well as to students being able to examine media reports of science or technology in a critical manner. Thus, the inclusion of scientific argumentation in science classrooms has epistemological and practical applications.

In addition, and complementary, to the inclusion of scientific practices (e.g., scientific argumentation), the science education research community has continued to call for curriculum and pedagogy that make science education meaningful and relevant to students’ lives (NRC, 1996; NRC, 2012). One rationale for making science class relevant to students’ lives is that it may promote the use of science in everyday decision-making, or citizenship science (NRC, 2012). For example, the Framework calls for citizenship science as demonstrated by the following excerpts: “…careful consumers of scientific
and technological information related to their everyday lives” (NRC, 2012, p. 1); “…to engage with the major public policy issues of today as well as make informed everyday decisions.” (NRC, 2012, p. 7); “…critical consumers of scientific information related to their everyday lives.” (NRC, 2012 p. 9); and “…what all students should know in preparation for their individual lives and for their roles as citizens in the technology-rich and scientifically complex world.” (NRC, 2012, p. 10). Citizenship science supports Vision II scientific literacy (Roberts, 2007) that envisions science education as providing students with experiences in the classroom that will allow them to develop knowledge and practices to be used in engaging with science in real world contexts, outside of the classroom. As science and technology become further entrenched in our everyday lives and omnipresent in our media outlets, it is important that students have a repertoire of tools (i.e., arguing from evidence) to navigate the many issues facing citizens in an advanced technological and scientific society. Therefore, a goal for science learning includes a level of scientific literacy, as represented by engaging in the scientific practices recommended by the Framework, which would allow students to navigate these issues.

**Socioscientific Issues Approach**

One such pedagogical or curricular approach that promotes citizenship science is what is now being called Socioscientific Issues (SSI). Socioscientific issues pedagogy makes use of a problems-based approach to science education that incorporates a controversial social issue with conceptual and/or procedural ties to science (Sadler, 2004). Technology and science continue to push society and everyday life into the future at an advanced pace; as a result there are bound to be contentious crossroads of science
and society. Genetically-modified organisms, invasive species, and endangered species are examples of socioscientific issues that have societal and scientific ties. As such, a socioscientific issue requires students to consider different and even competing aspects of the issue, taking into consideration scientific, personal, ethical, moral, and/or economic factors. In real life, many decisions require that citizens consider multiple, and often competing, angles of an issue. Furthermore, for many such issues, the science itself, or dimensions of the science, are contentious and unsettled. If our society expects to produce citizens that actively participate in the democratic process using informed decision-making (i.e. arguing from evidence), then this process must begin within the K-12 education system. The use of socioscientific issues pedagogy in the science classroom is one such method of assisting students in developing the complex decision-making skills needed to make informed decisions on complex socioscientific issues.

Justifying the Study

The changing linguistic landscape (i.e., increase of emergent bilinguals) of the K-12 science classroom combined with the recent calls for science education reform (i.e. inclusion of practices, relevance of curriculum), offer a fruitful avenue for investigating how science education reform, such as the recommendations of the Framework, can be implemented in linguistically diverse classrooms. This research is both timely and relevant as our schools strive to provide meaningful science education to the growing population of emergent bilingual students. Based on my professional experience in culturally and linguistically diverse science classrooms, recent reconceptualization of bilingualism, and considering the recent calls for science education reform, I planned a study that would investigate science education reform recommendations in an
English/Spanish bilingual middle school science classroom. After planning and implementing a curriculum intervention, new research questions emerged after returning from a period of data collection. The research questions follow in the next section.

**Research Questions**

1. How does translanguaging as a pedagogical strategy facilitate teacher framing of scientific argumentation about socioscientific issues?

2. How does translanguaging as a pedagogical strategy facilitate student uptake of scientific argumentation about socioscientific issues?
Chapter Two

REVIEW OF LITERATURE & THEORETICAL FRAMEWORK

Research specific to the individual topics of culturally and linguistically diverse students, scientific argumentation, socioscientific issues, and dual language education is both deep and wide. On the other hand, the literature on emergent bilinguals, dynamic bilingualism, and translanguaging is a growing body of research. While research has been conducted in each of these areas, respectively, little research exists that is a combination of these threads. Furthermore, an in-depth analysis of the recommendations of A Framework for K-12 Science Education (NRC, 2012), in relation to the aforementioned research areas, has not been conducted. In fact, some recent studies (Lee, Quinn, & Valdes, 2013) have explicitly called for research that specifically examines how reform-oriented science education based on the recommendations of the Framework present opportunities and challenges to culturally and linguistically diverse students. A review of relevant literature in each of the above areas will be discussed as it relates to the focus of this research study.

Culturally and Linguistically Diverse Students and Science Education

Culturally and Linguistically Diverse (CLD) students is a term used to describe students in our nation’s schools whose first or dominant language and home culture may differ from those considered to be dominant in the schools and society. While this label is problematic for a number of reasons, it is adequate in that it attends to both language and culture. Previous terminology – Limited English Proficient, English Language Learners, English Learners – to describe this heterogeneous group of students has focused only on
language and has often assumed a deficit model. While these issues are important and any label has its strengths and weaknesses, it is beyond the scope of this essay to attend to the problematic nature of labeling students based on language and/or culture. This section of the literature review will focus on CLD students and science education; it will include literature that uses terminology such as English Language Learners and English Learners. Research on CLD students and science education is important for a number of reasons related to: the underachievement of CLD students in science; the underrepresentation of CLD students in post-secondary science majors; the underrepresentation of CLD students in science and science-related careers; the underrepresentation of CLD students in science teaching careers; and the potential of CLD students to contribute to science.

The United States of America is in a major demographic shift. This shift has manifested itself as a change in the overall demographics of the country, as well as a major shift within the nation’s educational systems. The two fastest growing student populations are the English Language Learner population and the Latina/o population. In fact, the Latina/o student population comprises the majority of all English Language Learners (Batalova & McHugh, 2010). It was estimated that in the 2007-2008 school year, 5.3 million students were considered English Language Learners, or 10.7% of the overall pre K-12 grade students (Batalova & McHugh, 2010). From 1997-1998 to 2007-2008, the overall increase in English Language Learners in the nation’s schools was 53% - with some states (NC, NV, GA, VA) reporting increases of over 200% - as compared to an overall student enrollment increase of 8.5%. As would be expected, an increase in the Latina/o school-age population has also resulted. In fact, in the nation’s public schools, the Latina/o population recently reached new milestones in 2011: one-in-four (24.7%)
public elementary school students were Latina/o and among all pre-K through 12th grade public school students, a record 23.9% were Latina/o (Fry and Lopez, 2012).

An alarming trend is that there are academic performance gaps between the English Language Learner and Latina/o populations and what is often referred to as the mainstream (White, middle class, English-speaking) student populations. English Language Learners and Latinas/os have lower graduation rates, higher dropout (push out) rates, and often experience more academic difficulties than mainstream students. These difficulties are apparent in the science classrooms. As a local example and based on the Pennsylvania state summary report of the Keystone Biology Exam (Pennsylvania Department of Education, 2013), the following results were reported: of the Latinas/os who participated in the assessment, 54.7% scored below basic, 27.1% scored basic, 14.3% scored proficient, and 3.9% scored advanced. Results for English Language Learners were as follows: 76.5% scored below basic, 16.4% scored basic, 5.5% scored proficient, and 1.6% scored advanced. These are compared to White, non-Hispanic students with the following results: 27.3% scored below basic, 33.8% scored basic, 28.8% scored proficient, and 10.0% scored advanced. While the performance on one single assessment may not be cause for alarm, the fact remains that some assessments serve a gate-keeping function that could potentially expand or limit a student’s post-secondary future.

These trends are not specific to Pennsylvania as achievement gaps have persisted at the national level (Lee and Luykx, 2006) for some time. Another trend, specific to science education that has been identified, is that CLD students from are not represented in the sciences - science majors, science teaching careers, and science careers - in a
proportion equal to their overall population percentage (Lee and Luykx, 2006). This problem is sometimes referred to as the science pipeline. In other words, the science pipeline is leaking CLD students (i.e. English Learners and Latinas/os). Chapa and De La Rosa (2006) refer to this as the problematic pipeline as they describe the Latina/o population increase at the K-12 level and the narrowing of Latina/o participation in university STEM programs. As a nation, we have the fastest increasing populations experiencing the greatest amount of challenge in school and particularly with school science. Therefore, the potential exists of having a large portion of our population who has been undereducated in science.

The ramifications of this phenomenon are far and wide ranging, immediate and future: negative or inadequate school science experiences may have effects on the future educational plans of CLD students, including drop out/push out and lack of motivation to matriculate in post-secondary education; the lack of underrepresented students entering science-related careers will continue to maintain the power structure of American society, maintaining and even widening the socioeconomic gap; lack of ethnic and linguistic minority groups in science and science teaching careers sends an implicit message within these cultural groups that science-related careers are unobtainable or even inappropriate for these groups, thus perpetuating a cultural myth; and the production of less-than-scientifically-literate high school graduates that find themselves in an increasingly scientific and technologically complex world. Furthermore, the problematic pipeline will prevent any and all potential contributions made to science by CLD students. In order to prevent some or all of the above from occurring, the science education field needs to understand the causes for the seeming disconnect between these student populations and
the science classroom. In addition to understanding these causes, the science education community needs to target these causes with appropriate pedagogy and curriculum.

Within the field of science education, there are researchers who are specifically investigating the cultural and linguistic aspects of CLD students’ performance within the science classroom. While there was a bit of controversy based on two seemingly opposing theoretical views of students’ home cultural and linguistic practice and the cultural and linguistic practices of the science classroom (Janzen, 2008), both approaches are pursuing the same goal of improving science education for non-mainstream students.

Lee and Fradd (1998) noted that the cultural and linguistic practices of students outside of the science classroom were incongruent with those cultural and linguistic practice that were valued inside the classroom. In response, they proposed the notion of instructional congruence (p. 12) “to indicate the process of mediating the nature of academic content with students’ language and cultural experience to make such content (e.g. science) accessible, meaningful, and relevant for diverse students (e.g. NELB students).” In a later book chapter, Lee and Fradd (2001) explained their framework, illustrate its key aspects using examples of classroom practice, and offer suggestions for establishing instructional congruence. The model of instructional congruence includes four components: students, teachers, science, and literacy. In essence, teachers need to integrate knowledge of students’ language and cultural experiences, science learning, and literacy development (p. 111). In general, their model suggests that teachers must make modifications in curriculum and pedagogy in order to facilitate congruence between home and school science cultural and linguistic practices.
On the other hand, based on the work of Chéche Konnen, research has been conducted that calls for the field to reconsider the logic of everyday sense-making that can be used as a resource for science teaching and learning. Warren et al. (2001) conducted research into culturally and linguistically diverse elementary classrooms and studied diverse students’ cultural and linguistic practices within science lessons. This research resulted in students’ cultural and linguistic practices as being resources for learning and falling along a continuum of everyday language and practices and the languages and practices used by scientists. This view perceives students’ everyday language and cultural practices as being congruent with those of the sense-making activities within the science classroom. As the work of Lee and Fradd (1998, 2001) and Chéche Konnen is situated in educational settings characterized by high percentages of CLD students, one can assume that these settings are bilingual or even multilingual.

Bilingual Education/Dual Language Education

While there is current public and political debate surrounding language policies and bilingual education, many scholars and researchers realize the value of and advocate for bilingual education (Collier and Thomas, 2004; Herrera and Murry, 2011; Ovando and Combs, 2013). As with many constructs within education, bilingual education is an approach to education that cannot be defined by one uniform or stereotypical program model. Bilingual education is a simple label for a complex phenomenon (Ovando and Combs, 2012). While there are many different approaches to bilingual and ESL education, this review will focus on one particular approach that is often called bilingual immersion, two-way bilingual, or dual-language education. Ovando and Combs (2012) provided an excellent summary of dual-language education models. Dual language
education can be generally characterized as offering instruction in two languages for both majority and minority language students. For example, in an English/Spanish dual language program, both English-dominant and Spanish-dominant students will receive instruction in both English and Spanish. Dual language education can vary in terms of the amount of instruction that is conducted in the majority or minority language. Majority and minority language refer to the language more supported by the broader society and the language less supported by the broader society, respectively. In the case of the United States of America, English is the majority language and Spanish is considered the minority language. Dual language education programs also differ by the amount of instruction conducted in the majority and minority languages. While there may be many different models of dual language education and actual percentages are difficult to measure, two models are generally described in the literature: the 50-50 model which is characterized by instruction conducted equally in both majority and minority languages, and the 90-10 model which is characterized by 90% of the instruction being conducted in the minority language and 10% being conducted in the majority language. Both the 50-50 and 90-10 models generally operate under a language separation or language bracketing paradigm in which the use of each language is separate with little to no translation or repetition in the other language (Collier & Thomas, 2004).

In general, language separation in a 50-50 model can be achieved by teaching the different content subjects in different languages. For example, science would be instructed through the use of Spanish (or other non-English target language) and social studies would be instructed through the use of English. The languages are not mixed in individual subject classes and material is not repeated, nor translated in the opposite
language. The rationale for a 50-50 model is that this creates an environment which involves the students in a second language experience, without allowing them to resort to the familiarity of their home language.

While individual models of dual language education may be different, most programs have similar goals for students. The goals of dual language education generally include the promotion of bilingualism and biliteracy, promotion of more positive attitudes towards the opposite language, as well as reducing achievement gaps (Collier and Thomas, 2004; De Jong, 2002; Morales & Aldana, 2010).

**Emergent Bilinguals**

As mentioned in chapter one, the use of the term emergent bilingual is slowly beginning to be used to replace former terms, such as Limited English Proficient (LEP), English Language Learners (ELLs), or English Learners (ELs). The use of emergent bilingual is tied to issues of equity, as well as a critical orientation to educating students who speak languages other than English (García, 2008). The use of this term clearly situates the student in terms of their bilingualism, which presents students as accomplishing more than learning English. Furthermore, the use of this term connotes strength and a developing proficiency in two languages, as opposed to past terms which frame student as deficient or conceptualize non-English languages as barriers or challenges to be overcome. As students enrolled in dual language education programs are in the process of becoming bilingual, it is appropriate to refer to these students as emergent bilinguals, regardless of which language they may have more or less fluency. Emergent bilinguals in dual language education settings are exposed to two languages and indeed are in the process of developing both languages. As these languages are
developing together through use – in both dual language classrooms and bilingual communities – it is necessary to discard theories of bilingualism such as subtractive bilingualism and additive bilingualism in favor of newer theories that take into account how two languages interact and co-develop. One such theory is dynamic bilingualism.

**Dynamic Bilingualism**

Dynamic bilingualism has emerged as a conceptualization of bilingualism as a process in which an emergent bilingual develops a complex repertoire of linguistic practices that includes two or more languages developing together. This theory of bilingualism stands in stark contrast to both subtractive and additive theories of bilingualism. Subtractive bilingualism is described as replacing the home language with the standardized and privileged national language of the society in which students live (Flores & Schissel, 2014), in this case, replacing Spanish with English. Additive bilingualism is a conceptualization of bilingualism in which individuals develop two languages separately, such as learning one language first and then adding a second language. Additive bilingualism assumes that the development of each language is separate and as a result produces bilingual individuals that are essentially two separate monolinguals.

Dynamic bilingualism is described by Flores and Schissel (2014) as the development of the fluid language practices that individuals engage in as they communicate in the many cultural contexts that they inhabit on a daily basis. By framing languages as not being bounded entities, Palmer, Martínez, Mateus, & Henderson (2014) frame bilingualism as being more than simply the combination of two separate linguistic systems. Therefore, these linguistic systems are part of a larger interconnected linguistic
García and Sylvan (2011, p. 388) describe dynamic bilingualism as “the development of different language practices to varying degrees in order to interact with increasingly multilingual communities in a global world.” These practices allow an individual to successfully navigate these complex multilingual communities. Durán and Palmer (2014) frame dynamic bilingualism as reflecting a pluralist discourse around bilingualism or multilingualism, which stands in stark contrast to subtractive or assimilationist discourses which view the home or community language to be discarded in favor of the more socially or politically dominant language. Pluralist discourses around bilingualism presume that two or more languages can be built upon and developed alongside each other, in other words, dynamic bilingualism or multilingualism is “both normal and worth cultivating” (Durán and Palmer, 2014, p. 368). Flores and Schissel (2014) note that viewing bilingualism dynamically frames the language blending, mixing, and co-existing not as a problem to be fixed, but as a legitimate communicative practice that exists in bilingual communities. Furthermore, they frame dynamic bilingualism as the norm and not the exception in bilingual communities. This dynamic approach to bilingualism takes as its starting point the fluid languages practices or translanguaging that bilingual communities engage in on a daily basis (Flores and Schissel, 2014, p. 461, italics in original).

Translanguaging

Translanguaging is, in fact, a rebirth of a previous term first used as a Welsh word in school in Wales in the 1980s particularly by Cen Williams (1994), it was recently popularized, in particular but not exclusively, by two books: Baker’s Foundations of Bilingual Education and Bilingualism (2001, 2006, 2011) and Ofelia García’s (2009)

Canagarajah (2011, p. 1) in a review of the scholarship on translanguaging categorizes it as,

A neologism, it has come to stand for assumptions such as the following: that, for multilinguals, languages are part of a repertoire that is accessed for their communicative purposes; languages are not discrete and separated, but form an integrated system for them; multilingual competence emerges out of local practices where multiple languages are negotiated for communication; competence doesn’t consist of separate competencies for each language, but a multicompetence that functions symbiotically for the different languages in one’s repertoire; and, for these reasons, proficiency for multilinguals is focused on repertoire building – i.e., developing abilities in the different functions served by different languages – rather than total mastery of each and every language.

While translanguaging is a term gaining traction in academic circles, Canagarajah (2011) notes that the practices that it names – the fluid language practices – have existed for quite some time in many areas throughout human history. Regardless of how long this particular practice has existed throughout human history, it is gaining favor with many scholars and researchers who seek to describe and understand the linguistic practices of dynamic bilingualism. Translanguaging differs from code switching in that code switching conceives of each language as a separate code with little relation to the development or functioning of the other code. Code switching can also assume a deficit model and can be conceptualized as a crutch (Zentella, 1997) to be used when particular vocabulary or understanding is lacking in one language and in some cases can be seen as a contamination of “pure” languages – Spanish and English – by each other. The problem with these ideas is that languages are seen as something static and isolated that an individual owns that are not subject to change, whereas translanguaging conceptualizes
language as a verb, as a process, and not as something that one has or does not have. Furthermore, Sayer (2013) suggests that separate first and second language or code designations is an overly simplistic representation of an individual’s linguistic repertoire.

The shift away from the use of code-switching or borrowing to the use of translanguaging as an apt description of the multiple discourse practices in which bilinguals engage in order to make sense of their bilingual communities (García, 2008) indicates a paradigm shift that calls into question the existence of languages as identifiable and distinct systems (Mazak, Herbas-Donos, 2014a). Ofelia García, a key proponent of translanguaging defines the process of classroom translanguaging as the “process by which students and teachers engage in complex discursive practices in order to “make sense” of, and communicate, in multilingual classrooms” (García & Kleifgen, 2010, p. 45). Creese and Blackledge (2010) argue that translanguaging is a flexible bilingualism that is used by teachers as an instructional strategy to link classroom practices with those found in students’ social, cultural, community, and linguistic worlds. Palmer et al (2014) note that translanguaging allows teachers to: model dynamic bilingual practices, like those found in bilingual communities; position students as bilingual (even before they are), thus impacting student identity; and valuing language crossing, thus positioning translanguaging as a normal and valued linguistic practice.

While framed as a practice used by teachers and students in bilingual classrooms, in fact this authentic linguistic practice is found in the community in which these bilingual schools are nested. Emergent bilinguals are part of bilingual communities including their homes, businesses they frequent, playgrounds where they enjoy leisure time or engage in sporting events, and any of the bilingual spaces outside of the
Translanguaging is very much a social accomplishment (Canagarajah, 2011) that comes into practice as an individual draws from his/her full linguistic repertoire in order to accomplish a given communicative function, be it ordering food in a bilingual restaurant or accomplishing a given academic task in a bilingual classroom.

**Translanguaging in Science Classrooms**

While the literature on translanguaging is continuing to grow, there are few studies that have researched translanguaging in the science classroom. Mazak and Herbas-Donoso (2014a) studied the translanguaging practices in a university science course at the University of Puerto Rico-Mayaguez. In their study, they noted the tension between Spanish as the societal language of Puerto Rico and English as the language of science and how these languages are involved in a political struggle. Their study yielded three main translanguaging practices: translanguaging key scientific terms in English during the delivery of scientific content in Spanish, the use of translanguaging in professor-created texts, and text in English, talk-around-text in Spanish. In a follow-up analysis, Mazak and Herbas-Donoso (2014b) found that all translanguaging events at the university setting occurred for the purpose of content acquisition based on previously identified categories of code-switching functions. Through the use of open coding the researchers identified five functions of translanguaging in this science course: using English key terminology in discussion of scientific content in Spanish; reading text in English and talking about it in Spanish; using Spanish cognates while referring to English text; talking about figures labeled in English and Spanish; and pronouncing English acronyms in Spanish. Through further analyses, they found three greater pedagogical purposes of classroom translanguaging: the use of texts entirely in English and
codemeshed texts prompted verbal translanguaging in the classroom; translanguaging activated all students’ meaning-making resources; and translanguaging apprenticed students into the larger scientific discourse community.

In a study of translanguaging middle/high school science teachers, Langman (2014) presented results based on policy documents, interviews, and classroom observations in order to frame science teachers as language planners. The teachers in this study were keeping their classrooms “linguistically real” as opposed to keeping them “linguistically pure” by allowing translanguaging to be used in order to draw on both the teacher’s and students’ full linguistic repertoires. Linguistically real is a way of describing how the linguistic practices in the classroom mirror those found in the community and homes outside of the classroom. While not specifically relating translanguaging to the specific content and practices in the science classroom, this study concluded that teachers who employ a translanguaging approach are framing and modeling an approach to teaching that foregrounds making connections between the linguistic practices outside of the classroom to those inside the classroom.

While the research addressing translanguaging in the science classroom is somewhat limited, other bodies of literature related to scientific argumentation, scientific literacy, and socioscientific issues, are quite extensive. A review of these bodies of literature relevant to my study follows.

**Scientific Argumentation**

Argumentation has become a focal point within the science education research community for numerous reasons. Many researchers have advocated for the inclusion of
argumentation in the science classroom (Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Tiberghien, 2007).

Argumentation in the science classroom has been recommended for inclusion in the science classroom in order to allow students to engage in practices related to learning and doing science (Duschl & Osborne, 2002; Kelly & Takao, 2002; NRC, 2012) and affording students a practical skill for addressing science related to their everyday lives (Sadler, 2004; Evagorou, Jiménez-Aleixandre, & Osborne, 2012). Kolstø and Ratcliffe (2007) noted that there are two main contexts of arguments and argumentation within science education. They classified the two contexts as the following (p. 117):

“Firstly, there are scientific issues which, to some extent, are detached from possible social implications (e.g. when students discuss possible interpretations of their experiments). Secondly, there are issues where the science is involved in a social debate. Typically, such issues concern personal or political decision-making related to health and environmental controversies.”

An in-depth analysis of the contributions of argumentation to science education was conducted by Jimenez-Aleixandre and Erduran (2007). They found that argumentation contributes to the science classroom by (a) supporting the access to the cognitive and metacognitive processes characterizing expert performance and enabling modelling for students, (b) supporting the development of communicative competencies and particularly critical thinking, (c) supporting the achievement of scientific literacy and empowering of students to talk and to write the languages of science, (d) supporting the enculturation into the practices of the scientific culture and the development of epistemic criteria for knowledge evaluation; and (e) supporting the development of reasoning, particularly the choice of theories or positions based on rational criteria.
Tiberghien (2007) has identified three goals for argumentation in science education: knowledge about nature of science, developing citizenship, and developing higher order thinking skills. The goals of, contributions to, and rationale for including scientific argumentation in K-12 science education can also be found in the recent science education reform document, *A Framework for K-12 Science Education* (NRC, 2012). Engaging in argument from evidence is one of the scientific and engineering practices recommended for inclusion in K-12 science education. In considering the aforementioned importance of scientific argumentation, my research study is particularly interested in combining Jimenez-Aleixandre and Erduran (2007)’s contributions of supporting the achievement of scientific literacy and empowering of students to talk and write the languages of science and supporting the enculturation into the practices of the scientific culture and the development of epistemic criteria for knowledge evaluation with Tiberghien (2007)’s goal of developing citizenship through the use of argumentation situated in Kolstø and Ratcliffe (2007)’s second argumentation context, where the science is involved in a social debate or issue concerning personal or political decision-making related to health and environmental controversies.

**Scientific Literacy**

Scientific literacy is a term that carries many different definitions depending on what is often perceived as the end goal of formal science education. Scientific literacy can be framed as thinking like scientists and understanding the canon of science in order to follow a career path in science. Another framing of scientific literacy is the ability to address science as it pertains to an individual’s own life and to society as a whole. While both of these are important with respect to the goals of science education, this study will
focus more on scientific literacy as it relates to the socioscientific issues – to be described fully later – that are part of students’ everyday lives and worlds. As science reports presented through the ubiquitous media outlets constantly bathe the public’s conscious, it is important that citizens have tools that allow them to discern between good and junk science, between fact and fiction, and between opinion and arguments supported by evidence. Global climate change, genetically modified organisms, and hydraulic fracturing are all examples of scientific issues that have gained notoriety in the public eye. As these, and many other, issues are socially, politically, ethically, and morally charged and have serious repercussions for both the living and non-living components of our world, the citizenry needs to be able to make scientifically-informed decisions about these issues. One tool that can be of value when addressing socioscientific issues is argumentation. The use of argumentation will equip citizens with an ability to “make evaluative judgments about the validity of science-related media reports and their implications for people’s own lives and society (NRC, 2012, p. 71).”

**Scientific Argumentation in the K-12 Science Classroom**

The research on implementation of argumentation to foster scientific literacy, broadly defined, in the K-12 science classrooms generally falls into three categories based on the approach to learning of argument: (a) immersion in science classroom argumentation practice, (b) explicit instruction in the structure of argument, and (c) an understanding of the socioscientific aspects of science (Cavagnetto, 2010). While all three of these approaches have relevance to this research, it is the second and third categories that are most salient to the proposed research study that I plan to undertake.
Explicit instruction in the structure and use of argumentation in the science classroom is important (Osborne, Erduran, & Simon, 2004) as argumentation is not a common feature of most science classrooms (Duschl & Osborne, 2002; Jimenez-Aleixandre & Erduran, 2007; Osborne, Erduran, & Simon, 2004). While being an uncommon feature of science classrooms, argumentation is also a difficult process in which students attempt to engage (Sampson & Clark, 2008) and the design of learning environments to foster argumentation is a complex problem (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000). Furthermore, students tend to have naïve conceptions of the structure of an argument, select only evidence that supports their claims, and often ignore evidence that is contradictory to their positions (Driver, Newton, & Osborne, 2000). In addition to the above points, argumentation is a very difficult process to analyze in that the research community has not agreed upon a framework of argumentation analysis.

Generally speaking, Toulmin’s model (1958) has dominated the scientific argumentation landscape (Nielsen, 2013). While providing a starting point for the analysis of argumentation in science, this framework is not without its share of critics (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly, Druker, & Chen, 1998; Kelly & Takao, 2002; Sampson & Clark, 2008).

One such framework, based on Toulmin’s model, is the Claim, Evidence, and Reasoning Framework (CER) as proposed by McNeill, Lizotte, Krajcik, & Marx (2006). The CER framework is an adapted version of Toulmin’s model in order to closely align it with standards and create an instructional model that is accessible to middle school teachers and students (McNeill et al, 2006). The CER framework consists of: a) claim, or an assertion or conclusion that answers the original question, b) evidence, which is the
scientific data that support the claim, and c) reasoning, which is a justification that shows why the data count as evidence to support the claim. The language of the CER framework has been proposed to allow a greater accessibility to the framework, as compared to Toulmin’s language of claim, ground, warrant, backing, rebuttal, and qualifiers.

As mentioned previously, and fully discussed later in this chapter, there are many issues that have both science and societal implications. As these issues can be viewed through various lenses – scientific, economic, personal, ethical, moral, and societal – the type of argumentation used in addressing socioscientific issues usually involves a much more complex process than the alignment of evidence with claims in order to develop conceptual understanding or to argue for or against an explanation of a particular phenomenon, such as a laboratory result.

**Socioscientific Argumentation**

Socioscientific argumentation is a type of scientific argumentation in which students engage as they attempt to reason through an ill-structured problem or respond to an open-ended question, which often includes a decision-making component. One benefit of socioscientific argumentation is that the process allows multiple arguments that originate from alternative, and often, competing vantage points. This type of argumentation can allow students to argue from scientific, economic, moral or ethical, or personal angles. Many studies have been conducted on argumentation within learning environments employing socioscientific issues pedagogy.

Patronis, Potari, & Spiliotopoulou (1999) conducted research on arguments used by 14-year-old students in an activity based on the construction and placement of a new
road in the area where the school was located. In this study, argumentation was defined as “a social process where co-operating individuals try to adjust their intentions and interpretations by verbally presenting a rationale for their actions (pp. 747-748).” The authors classified student argumentation in two dimensions. One dimension was related to the process of argumentation in that arguments were categorized as a defense or attack; the other dimension was related to the different kinds of pragmatic arguments. These were categorized as: qualitative, based on social, ecological, economic, or practical aspects; semi-quantitative, dealing with variable quantities without the complexities of exact relationships; or quantitative, numbers, estimated calculations based on formulas. Furthermore, the researchers were interested in whether or not students’ arguments remained the same, termed stable, or changed in response to others’ positions, termed invented. Results showed that qualitative arguments were the most common argument produced by the students. Along with argumentation, the researchers sought to study student decision, which they defined as an important, but also complex process based on argumentation. Results related to decision-making indicated that students’ choices, both in groups and in the whole class discussion, were influenced by the teacher’s goals, by the students’ personalities, and by the already existing tension in the classroom society. One goal of this research was to have scientific knowledge emerge in cases where it was needed, in support of students’ decision-making. One salient issue that arose in this study was that science content knowledge played a minor role in argumentation and decision-making.

Kolstø (2006) conducted research on students’ informal reasoning about a controversial socioscientific issue: the construction of new power lines and the possible
increased risk of childhood leukemia associated with overhead power lines. In this case, students were prompted to make a decision based on the social question involved and the scientific question involved. The issue also involved the question of how to judge a disputed scientific claim, in that there was doubt within the science community as to whether or not overhead power lines do indeed increase the risk for childhood leukemia. Research focused on identifying the arguments, scientific or other, that hold a central position in student decision-making. Within the Toulmin (1958) argumentation framework, Kolstø (2006) applied the following scheme to argumentation and decision-making: claim (what ought to be done or the student’s decision or personal opinion); data (evidence or facts, as viewed by the arguer that support the decision); and warrants (reasons, values, or principles to justify the connection between data and claims). Results indicated that most student arguments, within this SSI context, were categorized and analyzed based on risk. In constructing each type of argument, students combined decisive knowledge, which included scientific knowledge, economic, or risk, and decisive values, which included values of health, economics, and personal beliefs on risk. Similar to the results reported by Patronis, Potari, and Spiliotopoulou (1999) science content knowledge played a minor role in student decision-making.

Sadler (2004) conducted a literature review of informal reasoning regarding socioscientific issues and found that socioscientific argumentation was a salient theme that emerged from the review. While the findings of the literature review are mixed, he generally found that most learners do not display high-quality argumentation, make claims without adequate justification, and often do not attend to opposing positions. One recommendation from his review is that the most fruitful interventions for educators to
implement would be those that 1) encourage personal connections between students and the issues discussed, 2) explicitly address the value of justifying claims, and 3) expose the importance of attending to contradictory opinions. Furthermore, Sadler (2004) suggests that students need ample opportunity to engage in argumentation and to practice justifying claims, attending to counterpositions, and examining what constitutes well-reasoned arguments and argumentation. His recommendations complement the approaches noted by Cavagnetto (2010) in that immersion in practice, explicit instruction in the structure of argument, and understanding the socioscientific aspects of science are all strategies for promoting student engagement in argumentation in the science classroom.

The use of argumentation in a socioscientific context has the potential to situate the use of argumentation in authentic contexts involving both science and its societal implications. As such, this approach has the potential to offer students the opportunity to engage in an authentic science practice while engaging with relevant science content. A further elaboration of socioscientific issues follows.

**Socioscientific Issues**

Socioscientific issues are controversial social issues with conceptual and/or procedural ties to science (Sadler, 2004). They involve aspects of personal and societal decision-making and the science that is tied to the issue. On one hand, socioscientific issues demand that individual or societal decisions be made that will have ramifications on the future activities of humans. On the other hand, socioscientific issues by nature are heavily laden with scientific concepts that demand a scientific perspective be taken in order to consider the consequences of such decision-making. This is not to suggest that
science and society are normally divorced from each other and each represents an exclusive domain; rather it is to suggest that socioscientific issues represent rather contentious or controversial intersections of science and society. Socioscientific issues therefore involve the mixing of scientific and societal discourses. The complex interaction of the social and scientific factors results in issues that are ill-structured, open-ended, contentious, and often have multiple solutions based on multiple viewpoints.

While not a new phenomenon in the history of science, socioscientific issues have gained prominence in today’s society as technological and scientific innovation, combined with an increasing human population bring about not only progress, but challenges associated with this progress. Many scholars (Aikenhead, 2011; Puig & Jimenez-Aleixandre, 2011; Ratcliffe & Grace, 2003; Sadler, 2011; Zeidler, Sadler, Simmons, & Howes, 2004) have used and argue for the inclusion of socioscientific issues in today’s science classrooms in order to present science as relevant and connected to everyday life. In fact, a pedagogical strategy, appropriately called Socioscientific Issues (SSI), has been defined to refer to the explicit use of socioscientific issues in science classes. In addition, the inclusion of SSI into school science classrooms supports a vision of scientific literacy (Roberts, 2007) that argues for citizen participation in the decision-making processes of a democratic society. Therefore, it is important that students – future decision-makers and participants in the democratic process – are aware of the connections between science and society that exist, demand attention, and necessitate informed decision-making.

While the use of problems or issues in education is not a new method, nor is it sole property of the science education community, a Socioscientific Issues (SSI)
approach represents a fundamentally different approach than other movements in the past. SSI is a more refined and holistic version of past issues-based movements such as Science, Technology, and Society (STS) and Science, Technology, Society, and Environmental Education (STSE). It differs from STS (Zeidler, et al, 2004, p. 359) in that STS

“does not mandate explicit attention to ethical issues within choices about means and ends, nor does it consider the moral or character development of students.” Furthermore, STS(E) does not “necessarily exploit the inherent pedagogical power of discourse, reasoned argument, explicit NOS consideration, emotive, developmental, cultural, or epistemological connections within the issues themselves. Simply put, SSI serves as a pedagogical strategy with clearly defined goals for science education and not merely as an ancillary context for science education.”

A key component in socioscientific issues pedagogy is, obviously, the inclusion of a socioscientific issue. Socioscientific issues are found in nearly all scientific disciplines, although some domains like biology and ecology contain more topics that can be defined as socioscientific. Examples of scientific topics that are found in SSI literature include, but are not limited to: species conservation (Fox-Parrish & Jurin, 2008), invasive species (Evagorou, Jimenez-Aleixandre, & Osborne, 2012), dangers of mobile phones (Albe, 2009), global climate change (Sadler, Klosterman, & Topcu, 2011), genetics (Puig & Jimenez-Aleixandre, 2011; Reis & Galvão, 2009), and air quality and pollution (Simon & Amos, 2011). While not an exhaustive review of the socioscientific topics present in the current literature, the above list shows a general range of issues used in science classroom settings.

While the socioscientific issue component is paramount to the successful implementation of the pedagogy, many research studies reported findings related to educational goals such as understanding nature of science (NOS) issues (Kolstø, 2001:
Zeidler et al., 2002), promotion of student moral and ethical development (Sadler, 2004), promotion of science content learning (Zohar and Nemet, 2002; Sadler & Zeidler, 2005), and the promotion of argumentation (Zohar & Nemet, 2002; Puig & Jimenez-Aleixandre, 2011). One such study (Zohar and Nemet, 2002) on argumentation showed that explicit teaching of argumentation resulted in enhanced student performance in biological knowledge and argumentation. Sadler (2004) through a literature review of informal reasoning and socioscientific issues found that the use of argumentation in socioscientific issues pedagogy was a major theme.

The use of socioscientific issues pedagogy, in addition to developing content knowledge and scientific practices, has proven to be an appropriate instructional strategy in a wide range of grade levels. Studies reported the use of SSI at the elementary (Evagorou, Jimenez-Aleixandre, & Osborne, 2012; Pedretti, 1999), middle school (Simon & Amos, 2011), high school (Albe, 2008; Fox-Parrish & Jurin, 2008). In addition to the level of the educational context, socioscientific pedagogy is being implemented in schools throughout the world. While much literature exists based on research within the United States of America (Fox-Parrish & Jurin, 2008; Pedretti, 1999; Sadler, Klosterman, & Topcu, 2011), there also exists literature on SSI implementation in other countries. Research has been conducted in France (Albe, 2008), in Portugal (Reis and Galvão, 2009), in Israel (Zohar & Nemet, 2002; Tal et al. 2011), in Spain (Puig & Jiménez-Aleixandre) in Norway (Kolstø, 2006) and in Australia (Dawson, 2011). In fact, some countries have even made SSI an explicit part of the national curriculum (Simonneaux, 2007).
One gap that exists in the literature is a specific focus on SSI implementation in bilingual education settings or in schools serving high percentages of Latina/o students within the United States of America. While the implementation of SSI in a Spanish language context was documented by Puig & Jiménez-Aleixandre (2011), there are few studies that specifically focus on Latina/o students in the US school system. Only one study (Sadler & Fowler, 2006) reported on student ethnicity and this was done in order to demonstrate that the population sample was diverse. Therefore, it would appear that research into SSI implementation in high Latina/o population school districts could be a fruitful avenue of research.

In concluding the literature review, I note that translanguaging is an under-researched linguistic practice in the science classroom. Furthermore, the use of translanguaging in engaging in science-specific discourse practices, such as scientific argumentation, has not yet been investigated. As the opportunity to study how translanguaging can be used to frame the practice of scientific argumentation, it is necessary to consider the theoretical underpinnings of teaching and learning.

**Theoretical Framework: A Sociocultural Perspective on Learning**

A sociocultural perspective gives significant weight to the role that social interactions play in the teaching and learning that occurs within any educational setting, be it science or non-science, formal or informal, monolingual or multilingual. Framing translanguaging as an authentic, social accomplishment in which the linguistic interactions of bilinguals play a key role in communication or meaning making in bilingual communities supports a sociocultural theoretical orientation. Likewise, framing argumentation about socioscientific issues as an authentic, social practice of scientists
and other stake holders in which interactions also play a key role in meaning making also supports a sociocultural orientation. Thus, translinguaging and socioscientific argumentation about involve the authentic uses of language in particular ways and both are used to make meaning.

Specific to learning science and according to Lemke (2001, p. 296), a sociocultural perspective, “means viewing science, science education, and research of science education as human social activities conducted within institutional and cultural frameworks.” Therefore, learning science involves engaging in the authentic social activities that are part of science’s cultural framework. These interactions “shape and are shaped by discourses, develop situated definitions of what it means to be a scientist, reader, writer, a group member among other rules and relationships, and construct local knowledge that becomes common knowledge within the group or class.” (Kelly & Green, 1998, p. 147). Learning and meaning-making can be thought of as occurring through interactions – interactions between individuals or as individuals interact with the cultural products of the classroom, such as books, practices, or content (Leach & Scott, 2003). In the case of a translinguaging science classroom, these interactions involve emergent bilinguals interacting with an emergent bilingual teacher, other emergent bilingual students, and classroom materials that are presented in two languages while engaging in the science specific discourse practices.

Furthermore, this perspective also foregrounds the fact that learning environments are influenced by larger entities – society, the educational system, the school, the classroom – and cultural frameworks – science, society, home culture, peer culture – both within the classroom and outside of the classroom. Students are local members, in this
case of a science classroom, but also members of other groups and may bring discourse practices (e.g. translanguaging), experiences, values, and practices that are congruent to or differ from those used within the science classroom (Kelly & Green, 1998). As opposed to a purely individualistic cognitive perspective on learning, a sociocultural perspective on science learning stresses “learning and doing science is primarily the socially learned cultural traditions of what kinds of discourses and representations are useful and how to use them.” (Lemke, 2001, p. 298). Then the analytical focus becomes less on what is occurring inside the mind of an individual student in the science classroom and more on the social and cultural influences that play major roles in how students learn. This approach seeks to answer questions such as “How are meanings constructed through interaction among people and internalized by individuals?” (Kelly & Sezen, 2012), “How is the specialized language of science/science education and its forms of writing and discourse similar to those of other subcommunities and different from them? Why? With what larger-scale social consequences?” (Lemke, 2001, p. 299), and “How does the subculture of science/science education fit into the overall cultural ecology of a larger community? With what other subcultural systems is it allied or in conflict?” (Lemke, 2001, p. 299).

A sociocultural perspective does not dismiss individual cognition, but posits that learning is first accomplished through the use of social activities and then internalized by an individual (Vygotsky, 1978). According to Lemke (2001, p. 304), this approach, “regards our use of language as a socially and culturally contextualized meaning-making, in which language plays the part of a system of resources for meaningful verbal action.” As a sociocultural perspective foregrounds the social aspect of teaching and learning, it
would stand to reason the role of language in the science classroom should be a focal point of this research. It is in and through discourse that cultural practices are constructed and meaning attributed to such practices by social groups.

A key construct in Vygotskian sociocultural theory is that of a tool (Vygotsky, 1978). A tool is generally described as something that helps people – students – learn or make meaning of the world. A tool can be as extensive as language, as a whole, or a particular use of languages, such as translanguaging, and perhaps as small as an individual scientific practice, such as argumentation. In this case, a tool can be conceptualized as a discursive practice that assists students in making sense of scientific information presented to them in class, or perhaps in the larger world outside of the classroom. The analytic tool in this research is a framework for constructing scientific explanations or scientific arguments in response to being presented with a complicated socioscientific issue. Learning, in this case, can be defined as the uptake and implementation of this framework by students. As this tool can be defined as a new type of discourse or language practice that students are attempting to learn and employ, it is appropriate to discuss the language and discourse of the science classroom.

Translanguaging fits well into this perspective of learning, as students are being encouraged to learn science using the same authentic linguistic practices that are present in their communities outside of the science classroom. Translanguaging can also be conceptualized as a linguistic tool in order to help the teacher frame a discourse-intensive scientific practice, as well as a tool for students to learn a discourse-intensive practice. Thus, both socioscientific argumentation and translanguaging would be considered tools for meaning making.
The prioritization of the use of language in the science classroom – as required by reform-oriented science pedagogy and curriculum, such as an argumentation-based, socioscientific issues approach to science education – and the unique cultural and linguistic characteristics of an English/Spanish bilingual middle school classroom would require an analytic approach that takes into account cultural, linguistic, and discursive aspects. Therefore, an overarching sociocultural theoretical framework for researching, describing, and analyzing the authentic language practices in this study is appropriate.
Chapter Three:

DESIGN AND METHOD OF THE STUDY

A Case Study Approach

Qualitative methods lend themselves well to the study and understanding of complex social situations and environments. In order to describe these complex social situations and environments, the researcher “builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (Creswell, 1998, p. 15). Within the qualitative research community, there are many traditions for conducting research. One particular tradition that lends itself well to conducting research in complex social environments, such as schools, is the case study approach. A case study carries many different definitions depending on the theoretical stance of the researcher, but for this study I will define a case study as ‘an exploration of a “bounded system” or a case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context’ (Creswell, 1998, p. 61, quotations in original). Yin (2009) distinguishes three conditions that are appropriate for the use of a case study approach: 1) research questions that ask how or why questions, 2) research that does not require control over the behavioral events, and 3) research that focuses on contemporary events. In further defining what makes a case study, Yin (2009) notes that the case study approach investigates a contemporary phenomenon in depth and within its real life context. In considering these conditions or definitions, it would appear that my proposed study satisfies Yin’s three conditions, in that my research questions ask “how”, the research does not require control over behavioral events, and that it focuses on contemporary events.
Cases can be bound by space and time, and each of these boundaries can be wide or narrow depending on the size and scope of what the researcher defines as “the case”. School districts, schools, individual classrooms, and individual students are excellent examples of cases bounded by space. Similarly, each of these can be bounded by time, such as a school year, a marking period, a curricular unit, a school day, or even an individual class period. Case studies allow for the collection of a variety of data in a variety of ways (Yin, 2009). Data collection methods utilized in case studies often include any or a combination of the following: observations, field notes, audio and visual recording, interviews, and artifact collection. This case study will be informed by an ethnographic point of view and utilize ethnographic data collection methods (Gumperz, 2001; Spradley, 1980).

This case study examined how translanguaging as a pedagogical strategy helps a science teacher frame, and allows students to take up, the practice of scientific argumentation. Field notes, teacher and student artifacts, audiovisual recordings of small group and whole class discussions, and student and teacher interviews were all used to inform this research study, with the majority of analysis focusing on field notes, audiovisual recordings of classroom events, and teacher and student artifacts.

**Context of the Research Setting**

This case study focused on a 7th grade science classroom within a dual language (English/Spanish) charter school located within a small city in the Northeastern United States. The charter school serves students from a larger metropolitan area that has a significant and growing Latina/o population. The majority of the students educated by the school are classified as Hispanic, with a small percentage consisting of Black, non-
Hispanic, White, non-Hispanic, or students from two or more races (National Center for Education Statistics, n.d.b). While the majority of students come from Hispanic backgrounds, each individual student draws from a different linguistic repertoire (e.g., varies in his or her level of fluency in English and in Spanish). An explicit goal of the school is to offer an English/Spanish bilingual education to Spanish-dominant students and English-dominant students. The school applies a 50-50 dual language education model, in which languages are typically separated with equal instructional time for the two languages. According to the school’s charter application, starting in kindergarten, 50% of the daily instruction at the school will be in Spanish and 50% will be in English.

The school strived to employ teachers who are fluent in both English and Spanish, in order to support the bilingual focus of the school’s mission. The majority of the student population was also eligible for free or reduced lunch, which indicated that most of the school’s students came from economically-challenged households. While the school itself could have served as an interesting larger case study, this research was primarily concerned with science education. As such, this case study was be bounded in the following ways: the study took place within a 7th grade science classroom within a dual language charter school, thus bounding it in space; the study took place during the implementation of a reform-oriented curriculum, thus bounding it in time. Therefore, this was a case of an English/Spanish dual language middle school science classroom in the process of implementing new classroom practices.

**Role of the Researcher**

Within qualitative research, the role of the researcher is explicitly defined in order to allow the researcher to define his/her role or activities during the research process,
explain his/her perspective, describe personal interest in the research, and identify any potential biases.

My role in this case study was that of primary investigator. As such my roles included lead curriculum author, participant observer, data collector, interviewer, and data analyzer. As the lead curriculum author, I developed the curriculum intervention following a teaching sequence approach as proposed by Leach and Scott (2002). I consider myself as lead author because there were changes in the curriculum as suggested by the classroom teacher who implemented the curriculum. As a participant observer, my role as a participant included assisting with classroom activities, which entailed lesson planning and evaluation, teaching or co-teaching, and interacting with students. As an observer, my role was to observe the classroom during its normal activities. My role as data collector included taking field notes and conducting interviews with both the teacher and students. Finally, my ultimate role was one of data analysis in which my tasks included analyzing, describing, and explaining this complex social setting. Important to note is that my role as a participant observer in this type of educational setting was not new and most of my pre-service and in-service teaching career, albeit in the role of a teacher, has been situated in science classrooms where both English and Spanish were spoken. It is therefore necessary for me to explain my professional and personal experiences that have led me to this case study.

I planned this study based on my professional experiences of many years of working within formal and informal science learning settings characterized by high populations of Latina/o students. These settings were both domestic and international and ranged from elementary to undergraduate levels. From teaching elementary science to 4th
through 6th grade students in Comayagua, Honduras, to teaching middle and high school science classes in Allentown, PA, to teaching an undergraduate biology course at Reading Area Community College, these experiences have guided my thinking regarding curriculum and pedagogy for culturally and linguistically diverse students. Furthermore, my experiences as a curriculum developer and outreach coordinator afforded me the opportunity to work with Latina/o students in a variety of educational settings and allowed me to use many lenses to view the challenges and opportunities of planning, implementing, and evaluating science education for English/Spanish emergent bilinguals.

As a former elementary, middle school, and high school science teacher, I have always strived, successfully and unsuccessfully, to make science education as relevant to my students’ out of school lives and promote science learning as more than the memorization of scientific terminology, while adhering to the prescribed curriculum and/or academic standards. In remembering my work as a 7th grade life science teacher in a resource-poor, urban school, serving a predominantly Latina/o student population, I recall most of my curricular and pedagogical strategies were teacher-centered: lecture and classroom discussion. While I tried to make the science lessons engaging and relevant, I am hard pressed to remember any lessons which focused on argumentation. I do recall employing a problems-based approach to science teaching in that I encouraged my students to apply classroom science lessons and content to current societal problems or by engaging students with socioscientific issues.

Reflecting on both my past educational experiences as a teacher and my current studies in science education I was able to take a more reflective and deeper look at what I would consider exemplary science curriculum and pedagogy. As such, I had and continue
to have a deep professional relationship, based on past experience and current research, within this science education setting. In addition, nearly all of my professional K-12 teaching experience has been within schools serving high populations of Latina/o, Spanish-speaking students. Through these varied experiences, I learned that while many of these students with whom I worked, expressed interest in science, few followed a post-secondary career path that involved science or science-related careers. I also learned that science as presented in school was often decontextualized and had very little relevance, culturally or linguistically, to their lives outside of the classroom. Furthermore, I often wondered about how students who were struggling with acquiring English fluency were able to engage in science through the Spanish language and how this affected their learning.

In addition to my professional connection, I had and continued to have personal issues connected to my work within this setting: familial and non-familial roots in the Latina/o community. I had and will continue to have many relatives and friends that will be students or have children who will be students in the nation’s science classrooms. It was and is my desire that students are offered a science education that will enable them to use scientific knowledge and practices in ways that are relevant (e.g., culturally, linguistically) to their everyday lives. Therefore, I have advocated and will continue to advocate for an approach to science teaching that draws on students’ cultural knowledge and linguistic practices combined with a socioscientific issues approach that takes into account the relevance of the science content to a student’s life. Taking into consideration my professional teaching and personal backgrounds, it is evident that these professional and personal experiences were used to inform, describe, and analyze this case study.
Related to the curriculum intervention, I chose a socioscientific issues approach, implementing a curriculum focusing on endangered species, because of my professional background as a biologist and biology teacher, my personal background as a naturalist, and the importance of promoting understanding of issues of biodiversity. I chose the three species – the green turtle, the Puerto Rican coqui, and the timber rattlesnake – based on my background as an amateur herpetologist and my affinity for reptiles and amphibians. I also chose these species as they represent iconic species; the green turtle is a globally endangered species; the Puerto Rican coqui is a culturally iconic species, and the timber rattlesnake is a culturally iconic species. Furthermore, I chose a socioscientific approach as it situates science learning in authentic real-world issues that are both timely and relevant.

I chose the AB Language Charter School as it was the only officially recognized dual language school in a metropolitan area that was and is continuing to undergo a rapid increase of Latinas/os in both the community and school populations. I also chose this location as I had intimate knowledge of the community, its population, and its pressures. Finally, I chose this setting as the dual language education movement was gaining momentum and as the members of this particular geopolitical community and other communities, both scholarly and practitioner, have identified the need for and value of dual language education.

I decided to focus on scientific argumentation for numerous reasons. One reason is that recent science education reforms (The Framework, NGSS) and numerous scholars (Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Tiberghien, 2007; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000) have called for the inclusion of
scientific argumentation in K-12 science education. Another reason was that scientific argumentation requires that all students (and the teacher) engage in discourse intensive practices (Lee, Quinn, & Valdes, 2013) that present both opportunities and challenges to both the teacher and students. Finally, the process of argumentation is a practice that can be utilized by students as they navigate the complex socioscientific world outside of the science classroom, thus supporting a particular view of scientific literacy that situates science learning as supporting practices relevant for addressing issues in students’ lives outside of the classroom (Roberts, 2007). Being able to make an evidence-based decision on a relevant socioscientific issue is a practice that our schools should prepare all students to perform.

One concern that was associated with conducting research in familiar settings was that I was already an “insider” and therefore the research would not yield any new contributions to the research field. I have had much experience in middle school science classrooms, although I was clearly not an insider in the school or to the students in this study. While my professional experience has included extensive work with bilingual (English/Spanish) students, I have never conducted research in a classroom with an explicit bilingual focus to subject matter. Furthermore, my primary role was one of participant observer and not classroom teacher.

**Data Collection**

Language use and variation is central to understanding how emergent bilingual students gain access to science (Lee & Fradd, 2001; Lee, Quinn, & Valdés, 2013; Warren et al, 2001). Thus, the case study drew from work in sociolinguistics. Gumperz (2001) described an approach to conducting research in a setting in which discourse is a
prominent feature. The approach is characterized by two stages: an initial stage of ethnographic research designed to provide insight into the norms and expectations of the setting and a second stage in which findings from stage one allow the researcher to select those events for further analysis. In following this general approach, I collected data from a variety of activities utilizing a wide variety of data collection methods. The sequence of data collection activities and corresponding methods of collection are specified in Table 3-1. As displayed in Table 3-1, I collected the following sources of data: classroom observations, ethnographic field notes, student artifacts, teacher artifacts, audio recordings of interviews and audiovisual recording of all classroom activities. This range of data collection supported this case study, as it was important that I cast a broad net in order to fully capture and describe the complex social activities within this middle school science classroom. Casting a broad net also allowed me to determine and develop analytic perspectives supporting purposeful sampling of the video recordings. Furthermore, the use of multiple data sources allowed me to explore new avenues of research related to the setting. While I did conduct multiple interviews with both the teacher and individual students, these did not inform the analysis of this study. Table 3-2 displays the data collection activities as they relate to my research questions.

Table 3-1: Sequencing of Data Collection

<table>
<thead>
<tr>
<th>Data Collection Activity</th>
<th>Method of Data Collection</th>
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<tbody>
<tr>
<td>Pre-Curriculum Implementation Classroom Observations</td>
<td>Ethnographic Field Notes</td>
</tr>
<tr>
<td></td>
<td>Audiovisual Recordings</td>
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<tr>
<td></td>
<td>Collection of Classroom Artifacts</td>
</tr>
<tr>
<td>Teacher Pre-Curriculum Implementation Interview</td>
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<td>How does translanguaging as a pedagogical strategy facilitate teacher framing of</td>
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<td>scientific argumentation about a socioscientific issue?</td>
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</tr>
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<td></td>
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</tr>
</tbody>
</table>

**Classroom Observations**

In any ethnographically informed study, observation is usually one of the first steps of research. Therefore, I observed the classroom in order to determine the normal operations within this setting. As there is no such thing as a “normal” or “traditional”
classroom, these classroom observations allowed me to define what constituted the classroom culture (i.e., linguistic practices of the teacher and students, pedagogical approaches, norms for interaction, etc.) of this particular classroom setting. One concern I had was the consequences of my presence in the classroom. I minimized researcher effect on the normal classroom operations by spending significant amounts of time in the classroom prior to conducting the research of the curriculum implementation. I attended 8 full days of classes prior to the actual curriculum implementation. I was somewhat concerned with the tension between observing and participating in the classroom activities. Unable to fully anticipate the tensions between observing and participating, my classroom behavior fell somewhere on the observation-participation continuum, depending on the different classroom activities (Spradley, 1980). I was often drawn into the lesson by the teacher and/or students and I often inserted myself into the lesson when I felt it appropriate.

For this study, there were three different time periods of observation: observations leading up to the actual curriculum implementation, referred to as pre-study observations; observations that took place during the curriculum implementation, referred to as study observations; and observations that took place after the curriculum implementation, referred to as post-study observations. As mentioned above, I conducted 8 full-day observations of the classroom and school, prior to the curriculum implementation. During the curriculum implementation, I observed consecutive school days – as much as the weather permitted during the winter months – until the curriculum was fully implemented. It was anticipated that the curricular implementation would have lasted approximately 10 days; in fact, the curriculum unit took longer to implement that
originally planned due to modifications and the severe weather of the 2014 winter. I also conducted 2 days of post-study observations. While observation was an important part of my field research, I employed a variety of ways to record observations in order to revisit and analyze my observations. This leads to the next section that will discuss my use of ethnographic field notes.

**Ethnographic Field Notes**

Ethnographic field notes served as a manner of recording my observations throughout the research study. While I did not conduct an ethnography, per se, I used ethnographic field notes as a source of data. Field notes are generally a term used to describe a researcher actively writing some sort of description of an event or activity as it occurs naturally in the field. While an exact, agreed upon definition of field notes is lacking in the literature, I found the following definition as proposed by Emerson, Fretz, and Shaw (1995, p. 5, italics in original) to be useful. They defined ethnographic field notes as “accounts describing experiences and observations that the researcher has made while participating in an intense and involved manner.” In considering the best technique for recording the classroom observations, I decided to keep an informal field notebook to be used during classroom observations and activities, which later served as a source for word-processed formal field notes. Audience was an important factor to consider in writing field notes (Emerson, Fretz, and Shaw, 1995) and each set of field notes had an audience. The audience for my informal field notes was my dissertation committee and me.

Ethnographic field notes are not without problems. For example, tension exists between engaging in authentic participation and research commitments. Taking a
moment to quickly jot a field note could cause any formal or informal classroom interaction to proceed in a different direction than it would if allowed to continue uninterrupted. Furthermore, it was important that I considered that participants could have been distracted by my constant stopping to write down a thought or observation. I addressed these challenges by explicitly identifying to the participants – students, teachers, and school staff – that one of my classroom roles was as a note-taker. I also informed all participants that they were privy to my field notes at any point during the research period. Emerson, Fretz, and Shaw (1995) suggested that explicitly identifying one researcher activity as note-taker may allow participants to identify this as a normal behavior of the researcher in the classroom environment. As with classroom observations, my collection of ethnographic field notes varied according to my role along the observer-participant continuum. In collecting field notes, I recorded descriptions of the moment-to-moment events and interactions as they unfolded in the classroom. My initial attention was to characterize the classroom culture (i.e., major events, routines, language practices, and student-teacher relationships). In relation to the research questions, attention was placed on the use of argumentation in the science classroom, particularly the use of claims, evidence, and reasoning. I also focused on the positioning of science instruction as it relates to the students’ world outside the classroom. My recording of field notes can best be described as variable, as I was often pulled into classroom activities (i.e., classroom discussions, working with individual students, clarifying curriculum materials, and assisting with classroom set-up).

Classroom Artifacts
One important aspect of any science classroom is the artifacts associated with normal activities within that classroom. Artifacts generally include those materials produced in class, such as worksheets, diagrams, and notes, as well as materials produced for class, such as homework, teacher lesson plans, and teacher notes. In order to cast a wide net of data collection, I collected artifacts from both the teacher and students. All artifacts were captured digitally with a digital camera in order to allow these artifacts to be returned to the teacher and students, as well as allowing for my analysis upon return from the research site. Student artifacts that were collected included in-class assignments, homework assignments, notebooks, and classroom assessments. Teacher artifacts included PowerPoint presentations, whiteboard classroom notes, and images of resources displayed on the classroom walls. Many researchers have shown that written artifacts can prove to be excellent sources of data (Kelly and Takao, 2002; Sadler and Donnelly, 2006; Zohar and Nemet, 2002). Such was the case with my work.

**Video Recording**

The use of video recording has become a ubiquitous feature of qualitative research and allows researchers to revisit classroom events in fuller detail. According to Erickson (1992, p. 204), an ethnographically-oriented microanalysis approach has as its goals “the aim of specifying and describing those local process that produce outcomes in educational settings” and “to document those processes in even greater detail and precision than is possible with ordinary participant observation and interviewing”. Furthermore, this approach can be used to “identify how routine processes of interaction are organized, in contrast to what interaction occurs” (Erickson, 1992, p. 204, italics in
original). As with very complex social settings, like a middle school classroom, it is very difficult for a researcher to observe and record all of the discourse events at one moment.

The use of audiovisual recording allowed me to revisit and analyze in depth those discourse events produced in classroom activities during my time at the research site. I used a combination of two digital cameras. One camera was placed in the back of the classroom focusing on the teacher and the majority, if not all, of the students in the class. This camera was set up in the back left of the classroom and remained in this position during my entire time in the classroom. This first camera made use of the built-in microphone to capture the discourse of the teacher and the whole class. Recordings captured by this camera were referred to as “whole class video records”. The second camera was used in conjunction with a remote microphone placed at a specific table in order to record the interactions and discourse of a small group. This camera and remote microphone recorded the activities and discourse of one pair of students in each of the two 7th grade classrooms. The pairs that were recorded by this camera were suggested by the teacher, based on her experience with the language practices (e.g., speaking only English, speaking only Spanish, or speaking a mix of both languages) of particular students in both of her classes. While this “student pair” camera and remote microphone were used in conjunction with the camera recording the whole class, very little analysis was conducted on the events recorded with this camera. Recordings captured by this camera were referred to as “student pair video records”.

Data Analysis

Data analysis drew on a grounded theory approach as described by Strauss (1987). While not a specific method or technique, grounded theory is more of a style of
doing research that has as its goal placing social interaction and social processes at the center of attention (Strauss, 1987). This approach was appropriate as social interaction and social processes – the use of a particular linguistic practice in framing scientific argumentation about socioscientific issues – are driving my research questions. In using this approach, I was aware of the assumptions of a grounded theory approach. First, diverse materials such as interviews, observations, field notes, audiovisual recordings provide data that can answer research questions about social interaction and processes. Second, is that social phenomena, in this case the interactions within a dual language middle school science classroom are complex and need complex grounded theory. Lastly, no hard or fast rules govern qualitative research and each researcher brings different aims, styles, talents, and skills to qualitative research and standardization would stifle research efforts (Strauss, 1987, p. 1). This approach was a way of thinking about conceptualizing data (Strauss & Corbin, 1999) and was easily adaptable to diverse and complex social settings characterizing my research site.

In order to facilitate the collection, cataloging, and analysis of video data, I constructed event maps as described by Kelly (2004), Brown and Spang (2008) and Kelly and Chen (1999). An event map was an instrument I employed for language analysis that organizes summaries of classroom talk based on sequential events occurring in the classroom (Brown and Spang, 2008, p. 714). Event maps were constructed through my viewing and analyzing of the video records in order to identify the micro and macro events of the classroom. Event maps served as “representations of the phases of activity constructed by participants as they work to accomplish their collective and personal goals” (Kelly, 2004, p. 2). I constructed my event maps using a bottom-up approach in
which I coded all classroom activities and interactions at a micro level, and then built an overall picture of the classroom activities and interactions at the macro level. This methodology allowed me to analyze classroom activities at both the micro and macro levels. Macro level analysis allowed me to survey the different types of discourses present in the classroom, while a micro-level analysis offered me insight into how individual speakers used discourse to accomplish classroom activities.

I employed a constant comparative method (Glaser, 1965), which is an approach to the analysis of qualitative data combining an analytic procedure of constant comparison with a style of theory development. While Glaser (1965) delineated four “stages” of analysis – these are not necessarily delineated in a lock-step process – it was expected that data and theory will play off each other throughout the research process, in other words coding, analysis, and theory generation drove each other resulting in theory that was generated against data. This approach made use of coding procedures in which data were collected, coded, and constantly compared until categories have been saturated (Strauss, 1987). Saturation was the point at which no new categories or codes were developed and most, if not all, data had been coded into existing categories. The constant comparison method was a manner of confronting similarities and differences and degrees of consistency between indicators (data) and categories (Strauss, 1987).

The coding procedure began with open coding in order to “open up” (Strauss, 1987) the inquiry. The open coding was a somewhat nebulous stage of the analysis process, as I was unsure as to what I was looking for or what I would find. Open coding was promoted as allowing researchers to leave themselves “open” to all possibilities and to believe everything and nothing (Strauss, 1987). In developing codes, I utilized in-vivo
codes, which generally refer to codes that the actors, teachers and students, themselves are using within their social milieu. I began using in-vivo codes; common words such as “classroom discussion”, “group work”, or “homework review” that arose according to the use of these terms by the teacher. I also employed another type of code referred to as sociologically constructed (Strauss, 1987) in which the researcher her/himself places a label on a code that is not part of the actors’ normal social repertoire. Making claims, providing evidence, constructing arguments, critiquing evidence, providing reasoning, and critiquing explanations represented sociologically or sociocultural codes constructed by the researcher and not part of the teacher’s repertoire.

During the coding process, I also employed the use of analytic or theoretical memos that served as a way of keeping track of theoretical, philosophical, or practical ideas. These memos were used in addressing the temporal and relational aspects of data collection and analysis and allowed me to return and reanalyze older data as the analysis continued to move forward. As I continued to analyze the data I created, merged, and/or deleted categories according to their utility or appropriateness in organizing the data into a meaningful and coherent explanation of the complex social processes and interactions of my research setting.

The final process of my analysis consisted of constructing a coherent narrative about the data in order to present a holistic and thorough analysis of the complex social setting. While this is often the final step in analysis, it was a process that was constantly occurring as I worked through the data, memos, and codes. The details of phases of my data analysis are detailed in the next section.
I conducted various phases of analyses which can be broken down according to two major analytical activities: 1) analysis of classroom video records and 2) analysis of student written arguments. The entire corpus of video records consists of approximately 84 hours – 21 days x two cameras (one whole class angle, one student pair angle) x two 50-minute class periods. Only whole class video records were analyzed, therefore approximately 40 hours of video was analyzed in various phases. Occasionally, the student pair video records were viewed in order to confirm or clarify discourse that was unclear in the whole class video records. In addition to the video records, I collected and analyzed student written arguments generated from classwork and homework. These written arguments will be explained in detail in subsequent sections. Written student argument records consisted of 47 pre-assessment python responses, 45 pre-assessment responses, 44 green turtle responses, 45 Puerto Rican coqui responses, 45 timber rattlesnake responses, 44 post-assessment python responses, and 39 post-assessment rhino responses yielding a total of 309 written responses.

**Phases of Video Record Analysis**

**Phase One: Initial Coding of the Video Records**

The first pass of video records consisted of reviewing all whole class video records. A total of 21 days, and roughly 40 hours, of video were analyzed during phase one. During phase one, I constructed time-stamped event maps, in Microsoft® Word, that allowed me to simultaneously identify: the major events of the classroom; interactional space; artifacts used; and researcher notes. This phase of analysis allowed me to further develop my conception of the classroom culture and the practices of both the teacher and students. Furthermore, this phase allowed me to develop a big picture of the classroom
and identify areas for a more detailed analysis. Table 3-3 shows an example event map of the initial coding of the events on February 3, 2014.

Table 3-3: Event Map, February 3, 2014

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Event (topic)</th>
<th>Interactional Space</th>
<th>Communicative Approach</th>
<th>Artifact</th>
<th>Resources</th>
<th>Researcher Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>000 03.07 7B</td>
<td>Ss work on CER activity from ppt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>T works with S on CER from ppt.</td>
<td>T – S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>253</td>
<td>T works with S on CER from ppt</td>
<td>T – S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>333</td>
<td>T works with S on CER in span</td>
<td>T – S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505</td>
<td>Difficulty with defining afirmacion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>IRE on CER from ppt</td>
<td></td>
<td>T – WC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1046</td>
<td>T has students refer for trifold (GT) in order to dispute evidence – what GT eats in order to prove a scientific explanation is bad.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1300</td>
<td>T reads CER example from ppt in eng and span. Ss need to determine if it is good.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2300</td>
<td>T works with S on CER on computer</td>
<td>T – S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Event Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3244</td>
<td>T gives Ss last CER example from ppt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>T announces end of class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4230</td>
<td>End</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I identified and time stamped the major and minor events of the classroom and any time there was a change in activity. Major events of the class included, but were not limited to: the beginning and ending of the class; teacher providing directions for in-class activities, individual student work; paired work; whole class work; and PowerPoint presentations. Minor events of the class included, but were not limited to: students passing out folders, teacher setting up computer, ESL teacher takes students out of class, and teacher passing out materials for the lesson. These activities were demarcated by the discourse and actions of the classroom participants.

Interactional space referred to the how the members of the class – teacher, students, researcher – were configured among each other and relevant artifacts (Green, 2009; Heras, 1993). These interactional spaces constructed orientations and each afforded particular discourse practices (Kelly & Crawford 1997), with a focus on the teacher. In general, the interactional space fell into the following categories: teacher-whole class; teacher-small group; teacher-student; teacher-researcher, students-students; researcher-whole class; researcher-students; and researcher-student.
Artifacts used referred to the instructional materials available for use by the class. Examples include, but are not limited to: PowerPoint presentations, information trifolds, and information posters on the wall. While this was an original coding, these did not figure prominently into future analyses.

Researcher notes referred to analytical notes or comments that I produced while viewing the video records. These notes were meant to mark instances in the video records that I felt were interesting or warranted further analysis. These notes were varied and ranged from instances of humor in the classroom to questions that I asked myself related to my analysis. For example, I made notes related to the teacher’s choice of words (i.e. opinion) in framing the new practices in the classroom. I also made notes related to the language practices in the classroom.

Phase Two: Coding for Classroom Activities and Scientific Practices

The second pass of video records consisted of reviewing all whole class video records. As with the first pass, a total of 21 days, and roughly 40 hours, of video were analyzed. During phase two, I coded for classroom activities and scientific practices following the constant-comparative method. The purpose of this pass was to identify the larger classroom activities in which the class engaged prior to, during, and after the curriculum intervention. Additionally, this pass allowed me to identify the scientific practices – broadly defined – in which the students were engaged prior to, during, and after the curriculum intervention. These were both added to the event maps constructed during phase one. Table 3-4 shows the classroom activities and scientific practices identified by the second pass of the events on February 3, 2014.
Table 3-4: Classroom Activities and Scientific Practices, February 3, 2014.

<table>
<thead>
<tr>
<th>Date</th>
<th>Classroom Activities</th>
<th>Scientific Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>03.03.2014</td>
<td>Teacher-led review of CER definitions. Review of CER 2 HW. Intro to TR case, individual work with brochure and worksheet. Determining if a scientific explanation is good or bad.</td>
<td>Answering questions Identifying a claim Evaluating evidence Evaluating reasoning Identifying evidence Identifying reasoning Engaging with scientific texts Evaluating a claim Evaluating a scientific explanation Asking questions Discussing questions</td>
</tr>
</tbody>
</table>

Classroom activities were coded using a larger lens. By this I mean there were fewer and larger activities that were coded. These larger activities were a summary of the major and minor events of the classroom. It was important to differentiate between classroom activities and key events. For example, classroom activities included but were not limited to: review of homework; introduction of new content; whole class discussion; teacher-led discussion; small-group work; and individual work. Key events included, but were not limited to: teacher-led review of the original problem; introduction to the green turtle case; review of CER 1 homework assignment; and individual work/paired/group work on Puerto Rican Coqui in-class assignment. Classroom activities were considered larger and more general structures of the class, whereas key events were smaller and more specific activities related to the curriculum intervention.

Scientific practices were broadly defined codes that developed as I reviewed the video records. These codes were developed through open coding: I did not base these codes on any existing literature on scientific practices in middle school science classrooms. These codes represented a mix of in-vivo codes and sociologically
constructed codes (Strauss, 1987). For example, the following represented scientific practices that I identified throughout the curriculum: asking questions; discussing questions; discussing answers; discussing claims; challenging evidence; and constructing scientific arguments. Coding for scientific practices allowed me to see how these practices changed throughout the curriculum and to compare and contrast pre-curriculum practices with those practices brought about by the curriculum intervention.

**Phase Three: Coding for Language Practices**

The third pass of video records consisted of reviewing a portion of the whole class video records. A total of 11 days, and roughly 22 hours, of video were analyzed. These 11 days were purposefully selected based on the introduction and implementation of the scientific argumentation framework in the classroom. During phase three, I coded for the classroom language practices by both the teacher and students. The purpose of this pass was to identify patterns of the use of English and/or Spanish by both the teacher and students. For example, I coded for when the teacher and students were speaking in English, speaking in Spanish, or speaking a mix of both English and Spanish. Additionally, this pass allowed me to identify instances of translanguaging in which the teacher and/or students moved fluidly between English and Spanish during classroom activities. This pass allowed me to make notes regarding any interesting language practices for further analysis. For example, one instance that I identified for further analysis consisted of an interaction in which the teacher began to construct a scientific argument on the board. This interaction between the teacher and a particular student was interesting based on the fact that the teacher was asking questions in Spanish and the
student was responding in English. This coding was added to the event maps constructed during phases one and two.

**Phase Four: Identifying, Transcribing, and Coding Instances of Teacher Translanguaging**

The fourth pass of video records consisted of strategic viewing and transcribing of teacher translanguaging. I transcribed all instance of teacher translanguaging and the surrounding discourse of the students with which she was translanguaging. While I use the phrase “teacher translanguaging” it is important that I remind the reader that translanguaging is an interactional activity. As such, I focused on the teacher’s discourse as she engaged in translanguaging with students in the class. All students were identified in the translanguaging clips. Transcripts were constructed using both English and Spanish, with English translation or rephrasing of Spanish discourse. As with the scientific practices of the classroom, I utilized open coding when analyzing the instances of teacher translanguaging. These open codes were fairly descriptive of the interaction in which the translanguaging occurred. For example, I coded an interaction as “Teacher requesting claim and evidence from student”. This open code was then further described with the following note: “Teacher requesting claim and evidence from student. Teacher, in Spanish, describes what is needed to have a good claim. Teacher then restates the original question, in Spanish. Teacher then gives examples of claims that answer the question. Teacher then asks if students understood, in Spanish. Teacher then asks student in English to state his claim.” This translanguaging occurred as the teacher and students, as a whole class, were collectively constructing a scientific argument on the white board using student responses. The note describing the code allowed me to fully describe the
interaction as well as compare and contrast it to other codes. These codes represented sociologically constructed codes (Strauss, 1987) in which I provided a label for these codes. Open coding allowed me to provide a lengthy descriptive account of each instance of teacher translinguaging. I combined similar codes, collapsed others, until I identified three major themes of translinguaging: maintaining classroom culture; facilitating the academic task; and framing epistemic practices. These themes are discussed in detail in chapter five.

**Phases of Student Written Arguments Analysis**

As the student written arguments were captured digitally, my first work with these arguments was to transcribe student written work from the digital images into a Microsoft Excel® spreadsheet. All student arguments – pre-assessments, green turtle, Puerto Rican coqui, timber rattlesnake, and post-assessment – were transcribed into excel sheets. All student work presented maintained their spelling and language (English or Spanish). Once all of the transcripts were completed I began the process of coding. Throughout the coding process, I conducted weekly meetings with an academic writing group to check my coding of written arguments.

**Phase One: Coding the Green Turtle, Puerto Rican Coqui, and Timber Rattlesnake, Pre- and Post-Assessment Python and Rhino Arguments**

My initial coding of student written artifacts began with the green turtle, Puerto Rican coqui, and timber rattlesnake arguments. I started with these arguments based on the fact that the in-class assignments required that students provide much more text than the pre- and post-assessments. Furthermore, these arguments were constructed during the
introduction and explicit implementation of the CER framework. Arguments were coded considering four dimensions: structural components; coherence; content; and appropriateness. I then coded the pre- and post-assessment python and rhino arguments accordingly.

Structural components referred to the presence of the individual components – claim, evidence, and reasoning – of the argumentation framework (McNeill & Krajcik, 2012). Following this framework, a claim was defined as a statement or conclusion that answers the original question/problem. As will be seen in chapter six, there were claims that did not answer the original, but were coded as claims nonetheless. Evidence was data that supported the claim. I coded evidence as any data that supported the claim, regardless of whether or not it was scientific or if the claim answered the original question. Reasoning was a justification that connected the evidence to the claim using scientific principles. I coded reasoning as any statement that connected the evidence to the claim, regardless of whether or not the principles were of a scientific nature.

Coherence referred to whether or not each of the three components – claim, evidence, and reasoning – were supported by each other to provide a clear argument (Kelly & Bazerman, 2003). In other words, did the evidence support the claim and did the reasoning connect the evidence to claim. It was possible that coherence between the claim and evidence could have been analyzed, but only full coherence of all CER components was analyzed.

Content of the argument referred to the particular angle or vantage point from which the student was arguing. As socioscientific issues can be viewed through multiple lenses – scientific, economic, political, personal, or ethical – I anticipated that students
would present arguments of differing content. Arguments were coded for content based on the content of the evidence as well as the content of the reasoning. I coded the content of student arguments as scientific, drawing on scientific evidence and reasoning, ethical, drawing on ethical evidence and principles, or other, drawing on non-scientific or non-ethical evidence and reasoning. In the beginning analysis, I was only coding for scientific content and then I discovered that some students were employing ethical or other evidence and reasoning. It was after finding many examples of non-scientific content that I decided to code the content as ethical or other.

Appropriateness referred to whether or not the argument responded to the original question. The CER framework (McNeill & Krajcik, 2012) defined a claim as a statement that responds to the original question. Therefore, if a statement did not answer the original question it was not considered a claim. I decided it was more effective to label an argument as appropriate or inappropriate based on whether it responded to the original question. It is possible that students can construct a coherent argument that does not respond to the original question.

**Phase Three: Calculating Percentages of Student Arguments**

In order to compare and contrast overall student performance on argumentative tasks, I calculated the percentages of students: providing the individual structural components of an argument – claim, evidence and reasoning; exhibiting coherence across the three components; providing scientific, ethical, or other arguments; and providing appropriate arguments. These percentages were then analyzed to determine if any patterns existed in student argumentation.
Phase Four: Construction of Concept Maps

Concept maps of selected student arguments were constructed using Inspiration® 9 software. Written arguments were selected to be represented as concept maps based on my desire to show the diversity and complexity of student arguments.

Summary of Design and Method Chapter

This chapter provided a description of the research methods applied in order to address my research questions. Each research question and the corresponding data sources can be found in Table 3-1. Each of the above phases of analyses yielded results which will be presented and discussed in chapters 4, 5, and 6.
Chapter 4

DESCRIPTION OF CLASSROOM PRACTICES AND DESIGN OF INTERVENTION

In this chapter, the reader will first find a description of the established curriculum and practices of the classroom research site. Secondly, the reader will find a description of the curriculum intervention, the process of its construction, and the new practices it brought about. Lastly, the reader will find a discussion regarding the change in classroom practices.

Classroom Practices Prior to the Curriculum Intervention

The descriptions of Ms. Romero’s 7th grade science classroom were based on a series of school visits that I conducted leading up to the curriculum intervention. The school visits were conducted to achieve many goals, including by not limited to: 1) become familiar with the school culture; 2) become familiar with the teacher and the students and the classroom culture, with a focus on the linguistic, academic, and scientific practices of the teacher and students; 3) observe the teacher’s instruction and curriculum; 4) discuss and revise the curriculum intervention; and 5) familiarize myself with the process of being a participant observer. I conducted eight classroom visits, in late 2013 and early 2014, prior to an extended period of data collection beginning in late January, 2014. I observed the classroom twice in September, twice in October, twice in November, once in December, and once in early January, 2014.

Perhaps the most important goal associated with the classroom observations was to characterize the classroom culture (Gee & Green, 1998; Spradley, 1980), paying attention to the scientific practices in which students engage prior to the curriculum intervention. I chose to analyze this, as it was important to understand the practices of the
classroom and how they differed from or were congruent to those being foregrounded by the subsequent curriculum intervention. The description of scientific practices, prior to the curriculum intervention were informed by field notes – collected in September, October, November, and December of 2013, and early January, 2014 – and a combination of field notes and video records collected in late January/early February.

Of the ten days, one day consisted of the students taking an examination on ecosystems. This day was omitted from the data, as individual examinations offer little to the analysis of classroom practices. Student practices included the following: reading texts, answering questions, asking questions, considering an open-ended question, constructing models, making observations, recording observations, mathematical computation, conducting research online, and discussing answers to questions. As can be expected, student practices differed based on the particular activity that was enacted in a given class period. For example, during the October classroom visits students were engaged in constructing dioramas and posters of ecosystems. I categorized this as constructing models, as students were preparing dioramas and posters of particular ecosystems, such as an ocean or tropical rainforest.

Another example was of students constructing information packets or brochures of milkweed bugs. This particular activity consisted of many different practices in which students were engaged and included conducting research online, asking questions, discussing answers to questions, answering questions, and reading scientific texts. In another example, students were engaged in a laboratory activity in which they were dropping matchbox cars down a ramp in order to determine the speed of the moving body. In this exercise, students were engaged in the practices of making observations,
recording observations, mathematical computation, and answering questions. As with many classrooms there were many instances of triadic dialogue (Mehan, 1979) or IRE – initiation, response, evaluation – interactions, with the teacher leading discussions as students answered questions posed by the teacher. Most of these interactions centered on the use of final form scientific knowledge (Duschl, 1990) and less on the construction of knowledge.

In considering the practices in which the students engaged, very little opportunity arose for students to engage in scientific argumentation during these observations (Newton, Driver, & Osborne, 1999). This is not to critique the teacher’s pedagogy, as these activities were not framed in order to foreground scientific argumentation. Rather, these practices indicate that scientific argumentation was not an explicit practice in which students normally engaged or were asked to engage in by the teacher.

Ms. Romero’s 7th grade science classroom can be characterized as an eclectic mix of curricular materials collected from various sources. One source of curriculum was the books from a FOSS kit that focused on ecosystems. Another source of curriculum was the Internet. Based on the ten observations, it appeared as if the curriculum was pieced together according to topics that the teacher thought would be interesting and engaging for the students in combination with the books provided by the FOSS curriculum. Via personal conversation with me, the teacher communicated that the school was awaiting delivery of FOSS kit materials that would serve as the basis for the 7th grade science curriculum. These materials were experiment-based and the teacher was anticipating using the FOSS investigations as an entry point into the study of life science. Based on my visits to the school, the students were studying diverse and marginally connected
science topics that included food webs/food chains, ecosystems, motion, rate/distance/time, and the biology of the milkweed bug. Once again, this is not to criticize the teacher, as the school itself did not have a set 7th grade curriculum and was awaiting the arrival of a FOSS kit. The teacher was attempting to make the science course relevant to what she perceived her students’ interests were.

The two classes immediately before the curriculum intervention had students working on constructing information brochures, similar to those to be used for in the upcoming curriculum intervention, on milkweed bugs. Through personal conversation, the teacher communicated that she thought the information brochures to be used in the curriculum intervention (Appendices E, H, and K), that I created, were an interesting template for students to use as an assignment. Thus, she incorporated this particular representation of information as an assignment for students to undertake. Students were working on finding information about the milkweed bugs through the use of various sources: books and online sources, accessed through laptop computers provided by the school, or through portable smart devices, such as cell phones or tablets. Students were to find information related to all aspects of milkweed bugs, such as reproduction, differences between male and females, predator/prey information, lifespan, etc. in English and then translate this to Spanish in order to produce the brochures in Spanish.

Construction of the Curriculum Intervention/Teaching Sequence

The curriculum intervention that was implemented during this study was constructed based on a pilot curriculum that I implemented during a summer science course, in conjunction with literature on teaching sequences (Leach et al, 2005). I constructed the curriculum unit following the Leach et al (2005)’s approach to
constructing teaching sequences. Teaching sequences are generally innovative approaches to classroom instruction and are evaluated, revised, and implemented with the goals of making the sequence as effective as possible at promoting student learning. In developing the teaching sequence, six steps are recommended: (a) content analysis with attention to grade level and official curriculum; (b) review of literature on teaching and learning content; (c) identification of learning demands; (d) explicit teaching goals; (e) design of teaching activities; and (f) pre- and post-curricular assessment. The teaching sequence that was implemented focused on endangered species and the combination of abiotic and biotic factors responsible for the decrease in an organism’s population. Furthermore, the teaching sequence was formulated with explicit input from the classroom teacher who was responsible for the implementation of the sequence. In following the approach proposed by Leach et al (2005), I will elaborate the curriculum intervention. Therefore, what follows is a description of the literature used to inform the design of the curricular intervention. A brief description of the individual components of the intervention will also be discussed, while acknowledging that individual components and sequencing were altered according to ongoing collaborative work between the researcher and classroom teacher.

**Content Analysis**

The first step of constructing a teaching sequence consisted of content analysis with attention to grade level and official curriculum. In this case, the teaching sequence focused on life sciences curriculum and standards for 7th grade. The Pennsylvania Department of Education (2009) Academic Standards for Environment and Ecology list the following standards for Ecology at the 7th grade level: 4.1.7.A. – describe the
relationships between biotic and abiotic components of an ecosystem: compare and contrast different biomes and their characteristics; describe symbiotic and predator/prey relationships. *Next Generation Science Standards: For States, By States* (NGSS Lead States, pp. 70-71), specify the following life sciences disciplinary core ideas at the middle school level MS-LS2: LS2.A – “Interdependent Relationships in Ecosystems: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.” In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources. Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and non-living, are shared.

In addition to the life sciences disciplinary core ideas, the NGSS also include standards for science and engineering practices. The middle school standard for engaging in argument from evidence (NGSS Lead States, pp. 70-71), states that engaging in argument from evidence in 6 – 8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Similar to the NGSS standards for science and engineering practices, Pennsylvania (PDE, 2009) has science as inquiry
standards for grades 5 – 7. While not all science as inquiry standards applied to this research study, the following are related to argumentation: 1) develop descriptions, explanations, and models using evidence and understand that these emphasize evidence, have logically consistent arguments, and are based on scientific principles, models, and theories and 2) analyze alternative explanations and understanding that science advances through legitimate skepticism.

As a measure of students’ ability to integrate the three dimensions of the NGSS – science and engineering practices, disciplinary core ideas, and crosscutting concepts – performance expectations have also been recommended in order to measure the demonstration of student understanding. The following performance standards applied to this research: MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem; MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems; MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

While there is little attention to the criteria for determining if a species should be classified as an endangered species, nor what constitutes an endangered species, the above content had direct relationship to the practices and content to be considered in the curriculum intervention.

**Review of Literature**

The second step of constructing the teaching sequence was a review of the literature on teaching and learning the content and practices involved in the proposed
teaching sequence. In the case of this teaching sequence, literature on ecosystems, systems thinking, endangered species, and scientific argumentation was reviewed.

**Ecosystems Literature**

The teaching sequence centered on the socioscientific issue of endangered species, but in order to understand the various factors impacting the survivability of species, it was necessary that students have an understanding of ecosystems, in terms of abiotic and biotic, as well as the components and interactions that characterize ecosystems as these affect species survivability. This section will focus on literature related to student understanding of ecosystems.

Hogan (2000) analyzed 5th grade students’ systems reasoning about food web perturbations and pollutant effects within ecosystems. She found that most students reasoned in one-way linear relationships as opposed to more sophisticated two-way or cyclical reasoning, both before and after the instructional unit. She also found that while food webs do convey the idea of networks of relationships, they often do not convey the dynamic interdependencies of populations and students generally find the dynamic behavior of ecosystems difficult to understand.

In a more theoretical article, de Ruiter et al (2005) discussed the fact that over the past decade new issues arising in ecology necessitated a new view of ecosystems and ecological research. They argued that the food web approach, with its focus on stability is inadequate for demonstrating the dynamic nature of ecosystems. They also argued that the traditional approaches to food webs and food chains do not fully account for all species and links that are present and generally ignore spatial and temporal variability.
Westra et al (2007) conducted research on Dutch secondary students’ understanding of the dynamic complexity of an ecosystem. While much of the Netherlands is populated by humans, the researchers used a mussel aquaculture farm as a context to study ecosystem dynamics. Their approach to teaching ecosystem dynamics, defined as a teaching and learning strategy, was broken down into various ordered steps as follows: (a) introduction of an ecological problem of maintaining a stable population of an organism, (b) studying the natural history of the organism, (c) bottom-up approach to biological organization (from individual to the ecosystem), (d) introduction of modelling and models, (e) top-down approach to the effect of an introduced species on the original organism, (f) transfer of knowledge and skills to another problem (fluctuating population of another organism), and (g) final assessment of another ecological dilemma. Their research found that students were able to express ideas about effects on individual, population, and ecosystem levels. The researchers also noted challenges of student motivation, student understanding of why certain practices were selected to address the ecological problem, and student difficulty in formalizing and quantifying ecological relationships.

**Systems Thinking Literature**

In addition to literature related to student understanding of ecosystems, it was important to consider literature on how students generally do or do not engage in systems thinking. Findings from previous studies of K-12 students’ systems thinking point to difficulties that students have in demonstrating systems thinking, even after instructional intervention. Hogan (2000) reported that although 6th grade students constructed, observed, and manipulated mini-ecosystems in her study, their systems reasoning in
ecology was constrained due to limitations in awareness of patterns of systems interactions, as well as naïve and missing domain-specific knowledge. In Evagorou, Korfiatis, Nicolaou, & Constantinou (2009)’s study, 5th and 6th graders engaged in a simulation-based learning environment based on a controversial environmental issue. Based on their framework comprising seven systems thinking skills, the researchers concluded that while the learning environment promoted some systems thinking skills, it was unsuccessful in promoting feedback thinking. Assaraf and Orion (2005)’s research on 8th graders in an Earth systems-based water cycle curriculum found students’ progression up a hierarchy of system thinking skills depended on a) individual students’ cognitive abilities, and b) their level of involvement in the knowledge integration activities in the curriculum. Hmelo et al (2000)’s report on a design experiment conducted to investigate 6th grade students’ systems thinking. They found that complex systems, such as human lungs, are difficult for students to understand. Some parts of the systems that are invisible or that have a time sequence proved to be difficult for students to perceive.

Students also are generally introduced to complex systems in oversimplified static forms and these forms are often difficult to overcome when thinking about systems. In life science, particularly, there is often an emphasis on understanding isolated concepts without introducing learners to the interrelations among various levels of the systems. As ecosystems are composed of levels, this research had implications when contextualizing endangered species within an ecosystem approach.

While the curriculum intervention was not explicitly designed to assess systems thinking, it was important to consider that species are situated in (eco)systems and that a
student’s ability to engage in systems thinking can impact their scientific argumentation. It is in this way that systems thinking literature was relevant to the curriculum intervention.

**Endangered Species Literature**

The literature on teaching and learning about endangered species was a very narrow avenue of research and was often found in conjunction with research on conservation or environmental attitudes. One study by Fox-Parrish & Jurin (2008) investigated student perceptions of a highly controversial keystone species. Their research revealed that students displayed apathy, egocentrism or utilitarianism, and/or naïve conceptions regarding the black-tailed prairie dog. Fox-Parrish & Jurin (2008) noted various suggestions in order to promote a better understanding of a controversial keystone species role in an ecosystem. One suggestion was to engage students in a real-world problem-solving context involving role-play or debate. A second suggestion was to involve an expert in the species in question, as opposed to positioning the teacher as the expert. A final suggestion was to make explicit and coherent connections between the organism of study and the overall biology curriculum. While not a research study on endangered species, Helldén and Helldén (2008) conducted research on 3rd, 4th, and 5th grade students in Sweden. Their research incorporated interviews that focused on students’ life experiences with biodiversity. One suggestion that emerged from their research was the importance of using students’ previous experiences of biodiversity as a point of departure for teaching.

In a cross-cultural study of English and Mexican elementary students, Barraza and Walford (2002) designed and implemented two assessment instruments to determine if
grade 3 students were familiar with some environmental words and to what extent children understood their meaning. Included in the list of ten words were endangered species and extinction. Endangered species and extinction were among the words with which students were most familiar. This research revealed that students’ understanding of the meaning of the words was related to school ethos, teacher, and access to information through books, various media outlets, and social interactions with others. While no definition of endangered species was included in the research study, it was reported that 75-80% of students familiar with the term knew its meaning. One interesting finding that emerged from the research was that Mexican children expressed fear of snakes and spiders as a response shaped by cultural and or biological contexts – in that Mexico is home to many venomous snake and spider species – or the symbolic meaning of an animal. Also salient was that student affiliation for a particular animal affected student reaction to environmental dilemmas.

Kahn and Friedman (1995) investigated inner-city 1st, 3rd, and 5th grade students’ environmental views and values through individual, semi-structured interviews. While not a study that investigated curriculum or pedagogy, this research revealed that even though these students were situated in an urban environment, most were aware of environmental problems, discussed environmental issues with their family, valued aspects of nature, and acted to help the environment.

While there is little research directly investigating student ideas related to endangered species, the above section sought to present relevant literature utilized in constructing the curriculum intervention.

**Argumentation Literature**
The literature review of scientific argumentation conducted in chapter 2 was used to inform the construction of the proposed teaching intervention. Therefore, I will only mention those points that are salient to student use of argumentation in the science classroom. As mentioned previously, the research on implementation of argumentation to foster scientific literacy, broadly defined, in the K-12 science classrooms generally falls into three categories based on the approach to learning of argumentation: (a) immersion in science classroom argumentation practice, (b) explicit instruction in the structure of argument, and (c) an understanding of the socioscientific aspects of science (Cavagnetto, 2010). Each of these three approaches had relevance to and was used in the formation of the proposed teaching intervention. Students were: (a) immersed in the process of argumentation in order to allow the opportunity to become familiar with the practice, (b) given explicit instruction in the structure and use of argumentation, and (c) given the opportunity to engage in argumentation within a socioscientific issues context. Sadler (2004) makes a few recommendations regarding the use of argumentation within socioscientific settings. Recommendations from his review suggest that it is important to encourage personal connections between students and the issues discussed and that students need ample opportunity to engage in argumentation. The proposed teaching sequence made use of a charismatic and well-known endangered species (the green sea turtle), a culturally iconic species in the Caribbean (the Puerto Rican Coqui), and a local candidate species (the timber rattlesnake) in order to promote connections between the students and the issue of endangered species.

Identification of Learning Demand
The third step of constructing the teaching sequence was the identification of learning demands. Learning demand represented the difference between the “everyday” social language that students use and the “scientific” social language that is used in the school science classroom (Leach & Scott, 2002). As this relates to the proposed teaching sequence it was anticipated that the discursive practices – argumentation – may represent a significant learning demand. As the literature review has already revealed the difficulties that students have with the practice of scientific argumentation, this is one area of the teaching sequence that required significant planning. While the use of argumentation, in colloquial terms, may refer to a particular type of verbal “fight” or confrontation outside of the science classroom, scientific argumentation refers to a particular practice – the alignment of claims, evidence, and reasoning – within the science classroom. Furthermore, the objectives of argumentation outside the science classroom may be to win or get one’s way in terms of a power struggle, whereas the objectives of scientific argumentation are knowledge construction, convincing others of the validity of a knowledge claim, or decision-making. One potential solution to this is framing scientific argumentation as constructing a scientific explanation (McNeill & Krajcik, 2012). Having already implemented a similar teaching sequence with high school students, I found it necessary to engage in a discussion related to the similarities and differences of argumentation outside and argumentation inside the classroom. In this discussion with the classroom teacher, it was decided that framing scientific argumentation as constructing scientific explanation was best based on her experience with her students’ understanding and framing of argumentation or arguing.
As one of the goals of the curriculum unit was to construct a coherent argument – an argument in which the claim is supported by evidence and the evidence is justified by reasoning – it was anticipated that constructing a coherent argument would represent a significant learning demand. Literature related to the construction of arguments noted that students tend to have naïve conceptions of the structure of an argument (Driver, Newton, & Osborne, 2000) and most make claims without adequate justification (Sadler, 2004). Furthermore, constructing scientific arguments was not a common practice in the classroom prior to the curriculum intervention. Therefore, having students construct coherent arguments, in which argument components tied together, presented a significant learning demand. This learning demand was addressed by explicit and detailed instruction in the construction of a coherent argument through the use of the CER argumentation framework.

**Teaching goals**

The fourth step in formulating the teaching sequence was addressing the explicit teaching (learning) goals for students. This teaching sequence had learning goals related to content, as found in the Framework disciplinary core ideas and the Pennsylvania Department of Education (2009) Academic Standards for Environment and Ecology related to ecosystems, and practices, as found in the Framework scientific and engineering practices and PDE inquiry standards related to argumentation. Additionally, the promotion of systems thinking within an ecosystems context was also an explicit learning goal. Finally, there were learning goals associated with a socioscientific approach to this instruction – students being able to recognize and address the various
vantage points (economic, social, ethical/moral, etc.) that can be taken when considering a socioscientific issue.

**Design of teaching activities**

The fifth step in formulating the teaching sequence was the design of the teaching activities. The components of the proposed teaching sequence, or curriculum intervention, are show in Figure 4-1. These were based on a similar sequence that was implemented during an ecosystems-based biology course that I taught during the summer of 2013. The individual components and sequencing did change slightly from the initial construction of the curriculum intervention, but the changes were minimal and based on the teacher’s informal formative assessments, such as whole class or small group discussions, of her students’ progress.

**Pre- and post-assessments**

The final step of the teaching sequence related to the pre- and post- intervention assessments. In this case, both pre- and post- assessments required students to consider socioscientific issues scenarios that required them to engage in scientific argumentation while answering an open-ended question.

**Curriculum Intervention**

The curriculum intervention consisted of nine lessons designed to introduce new content knowledge and scientific practices while foregrounding the use of discourse in the learning on science. All written curriculum materials (assessments, homework assignments, in-class assignments, posters, and PowerPoint presentations) were provided in both English and Spanish. A brief concept map (Figure 4-1) shows the flow of lessons in the curriculum unit. A full description of each lesson follows the concept map.
Table 4-1: Curriculum lessons

Lesson One: Pre-Assessment

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Lesson Two: Endangered Species

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Lesson Three: Impromptu Informal Classroom Debate

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Lesson Four: Setting the Problem

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Lesson Five: Ecosystems

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Lesson Six: The Case of the Green Turtle

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Lesson Seven: Scientific Explanations/Scientific Argumentation (CER Framework)

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Lesson Eight: The Case of the Puerto Rican Coqui

↓

Lesson Nine: Scientific Explanations/Scientific Argumentation (CER Framework Two)

↓

Lesson Ten: The Case of the Timber Rattlesnake

↓

Lesson Eleven: Post-Assessment

Lesson One: Pre-Assessment
The pre-assessment had students work independently on two socioscientific issues: 1) invasive python species in the Florida Everglades and 2) the Dallas Safari Club and the proposed hunting of an endangered Black Rhinoceros. Prior to the pre-assessment, students were shown a brief PowerPoint presentation on each issue, in order to contextualize the assignment. Students were then required to read a short passage about each socioscientific issue and respond to a prompt. The purpose of this lesson was to introduce students to the task of considering a complex open-ended socioscientific issue. The pre-assessment is found in Appendix A.

Lesson Two: Endangered and Extinct Species

At the end of the pre-assessment, students were given endangered species homework designed to have them ask a family member or friend about endangered and extinct species in order to prepare them for the in-class assignment. The endangered and extinct species homework is located in Appendix B. The in-class assignment consisted of a teacher-led PowerPoint with leading questions about endangered species. Students were then shown a PowerPoint that presented information about endangered and extinct species. Following the PowerPoints, students were given an in-class assignment that had them define endangered species, extinct species, and list 5 endangered species and the reasons that they are endangered. The purpose of this lesson was to provide students with vocabulary (endangered species, extinct species) to be used in future lessons while also providing evidence for why certain species are endangered or extinct.

Lesson Three: Informal Science Debate
This was unplanned and occurred due to numerous student absences based on inclement weather. Due to the fact that one of the two school districts served by the AB Language Charter School was closed, only half of the students were in attendance on this date. The teacher and researcher decided to ask the students to engage in an impromptu debate. The topic was whether or not to bring back species that have already gone extinct. Students individually selected yes or no and then engaged in a debate that was neither scripted, nor controlled by either the teacher or researcher. While this lesson was implemented in a very impromptu manner, the purpose was to allow students an opportunity to engage in a debate regarding a socioscientific issue. This impromptu lesson allowed both the researcher and teacher an opportunity to observe how students were able to engage in scientific argumentation.

**Lesson Four: Introduction to the Problem**

Prior to the implementation of this lesson, students were given a homework assignment designed to have them ask a family member or friend about the Puerto Rican coqui and timber rattlesnake. As the Puerto Rican coqui is a culturally iconic species and many of the students in the class were from or have relatives in Puerto Rico, the homework was designed to draw on the funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) in the students’ homes. In order to introduce the students to the curriculum task students were shown a PowerPoint that introduced the problem – determining if two animals should be officially classified as endangered species. The PowerPoint showed images of the two animals that students would study and determine if they should be classified as endangered species – the Puerto Rican Coqui and the Timber Rattlesnake. The presentation then framed the academic task, or job, for the students.
Their job was framed as: 1) to think as a scientist; 2) to make a decision based on evidence; and 3) to talk to others about this problem. To begin considering the task, students, as a whole class, were asked what information was needed in order for them to be able to make a decision about classifying these animals as endangered species. Students were then asked to write their responses in their notebooks. These responses were then recorded by the teacher and posted on the classroom wall to serve as a resources for students as they progressed through the curriculum. The purpose of this lesson was to frame the overall academic task – deciding whether or not two animals should be classified as endangered species – as well as frame the students as engaging in authentic scientific activity. Furthermore, this lesson was designed to signal to students that part of their task included talking to their classmates about the problem. The questions generated from the class are found in Appendix C.

**Lesson Five: Ecosystems**

In order to encourage students to consider the various influences on the survivability of organisms, students were shown YouTube videos of three different ecosystems: ocean, tropical rainforest, and Pennsylvania forest. These videos were also shown in order to present the habitats of the green turtle, Puerto Rican coqui, and timber rattlesnake, respectively. During the video students were asked to observe and record all of their observations of the ecosystem. After the videos, students were asked to talk to a partner to make a master list of both students’ observations. Following the paired work, students were asked to make a whole class list of all observations. Finally students were asked to classify their observations as falling into biotic (living) or abiotic (non-living) categories. The purpose of this lesson was to have students engage in making
observations about three ecosystems, to discuss their answers within pairs and in a whole class setting, and to identify the various biotic and abiotic components in an ecosystem. Furthermore, this activity was designed to introduce students to the think-pair-share activity, which served as the pedagogical strategy in future lessons, in order to have them talk about science. The ecosystems in-class assignment is located in Appendix D.

**Lesson Six: Green Turtle Case**

In order to informally engage students in the process of scientific argumentation, without the explicit use of an argumentation framework, nor the use of specific argumentation terminology, a lesson about the green turtle was presented to the students in order to provide students exposure to an example of an official endangered species. Students were provided with a trifold information packet displaying various information – physical features, adaptive features, adaptive behaviors, terrain/habitat, reproduction, diet, predators, nesting sites, threats, history of its endangered status, and interesting factoids – about the green turtle. The green turtle trifold information brochure is found in Appendix E. Coupled with the trifold, was an in-class assignment composed of three components. The first component required students to individually read the trifold and answer four questions. Question one asked students to identify any interesting information about the green turtle. The purpose of question one was to engage students with the content of the trifold. Questions two and three asked students to respond to a question and provide an explanation of why they answered in a particular manner, respectively. The purpose of these two questions was to ask students to provide a claim and support the claim with evidence (and/or reasoning) without explicitly using the terms claim, evidence, and reasoning.
The second component of the in-class assignment had students pair up and work on three additional questions. Question five required students to record how their partner responded (their claim) to question two from the first component of the in-class assignment. Question six had students record the information – evidence – that their partner used to support their claim. Finally, question seven had students answer if they agreed with their partner’s responses and why or why they did not agree. Questions six and seven were designed to have students evaluate their partner’s claims and evidence. The third component of the green turtle in-class assignment had students engage in a whole class discussion designed to compare students’ answers with others. The green turtle in-class assignment can be found in Appendix F.

Lesson Seven: Claim, Evidence, and Reasoning Framework

The claim, evidence, reasoning (CER) framework was introduced to the students in the form of a PowerPoint. Arguably, this was the key component to the curriculum. The PowerPoint introduced the framework by using student responses generated through the green turtle assignment through the use of the green turtle case and was constructed using the responses (e.g., claims, evidence, and reasoning) generated by the students throughout the green turtle in-class assignment. The full PowerPoint can be found in Appendix G. A brief description of the presentation follows.

In slide one of the presentation the original problem was re-presented to the students – is the green turtle an endangered species? Slide two defined the term claim and students were required to copy this definition into their notebook. Slide three displayed two examples of claims to the students: the green turtle is not an endangered species; the green turtle is an endangered species. This was done in order to present the claim as
answering the original question in addition to being constructed as a full sentence and not solely one word. Slide four defined the term evidence and students were required to copy this into their notebook. Slide five displayed the student claim of “yes, it is an endangered species” and four pieces of evidence that supported this claim. Slide six displayed the student claim of “no, it is not an endangered species” and one piece of evidence that supported the claim. Slide seven defined the term reasoning and students were required to copy this into their notebook. Slide eight displayed an example of reasoning. In this case, the reasoning drew on scientific principles related to the continual decrease in a species’ population and its eventual extinction. Slide nine defined the term scientific explanation and students were required to copy this into the notebooks. Slide ten displayed a scientific explanation in English – composed of claim, evidence, and reasoning – and provided an example of each component using the green turtle. Slide eleven displayed the same scientific explanation in Spanish. All slides displayed the same information in both English and Spanish, except slide 8 and slides ten and eleven.

Lesson Eight: Puerto Rican Coqui Case

In order to engage students in the process of scientific argumentation with a focus on utilizing the CER framework, a lesson about the Puerto Rican coqui was presented to the students as an example of a species that is currently being considered for endangered species classification. Students were provided with a trifold information packet displaying various information – physical features, adaptive features, adaptive behaviors, terrain/habitat, reproduction, prey, predators, population statistics, the coqui as an invasive species, threats, and interesting factoids – about the Puerto Rican coqui. The trifold information brochure is found in Appendix H.
Coupled with the trifold, was an in-class assignment composed of three components and ten questions. The first component required students to individually read the trifold and answer five questions. Question one asked students to identify any interesting information about the Puerto Rican coqui. The purpose of question one was to engage students with the content of the trifold. Questions two required that students provide a claim in order to answer the question of “do you think the Puerto Rican Coqui should be classified as an endangered species?” Question three required that students provide evidence to support their claim. Question four required that students provide reasoning that would connect the evidence to the claim. Questions two, three, and four explicitly used the terms claim, evidence, and reasoning in order to encourage students to uptake and use these terms. Question five asked students to identify the information (evidence) in the brochure that was most important in helping them make their claim.

The second component of the in-class assignment had students pair up and work on four additional questions. Question six required students to record their partner’s claim. Question six had the students record their partner’s evidence and evaluate whether or not the evidence supported their partner’s claim. Question eight had students record their partner’s reasoning and evaluate whether or not the reasoning connected their partner’s evidence to the claim.

The third component of the Puerto Rican coqui in-class assignment had students engage in a whole class discussion designed to compare students’ answers with others. The Puerto Rican coqui in-class assignment can be found in Appendix I.

**Lesson Nine: Claim, Evidence, and Reasoning Framework Two**
The purpose of this lesson was to have students as a whole class: 1) identify the components of the CER framework in a text; 2) evaluate the appropriateness of each component, and 3) evaluate the appropriateness of a scientific argument, as a whole. Students were given a homework assignment that had them engage in the aforementioned tasks that was reviewed in class. The lesson also included a PowerPoint that led students through the process of scientific argumentation. This lesson was designed to reinforce the importance of scientific argumentation as a process. As was done with the introduction of the CER framework, I will present a somewhat detailed description of the PowerPoint. The full PowerPoint can be found in Appendix J. The flow and description of the presentation are as follows:

Slide one displayed the original problem and asked why it is important to understand the question or problem to be answered or addressed. Slide two displayed reasons why it is important to understand the problem. Slide three displayed text in which students had to identify the claim, evidence, and reasoning. Slide four displayed the claim, evidence, and reasoning from the previous slide and asked students to decide if the scientific explanation was good. Slide five displayed text in which students had to identify the claim, evidence, and reasoning, similar to slide three. Slide six displayed the claim, evidence, and reasoning from the previous slide and asked students to decide if the scientific explanation was good, similar to slide four. Slide seven displayed text in which students had to identify the claim, evidence, and reasoning, similar to slides three and five. Slide four displayed the claim, evidence, and reasoning from the previous slide and asked students to decide if the scientific explanation was good, similar to slides four and six.
Lesson Ten: Timber Rattlesnake Case

In order to engage students in the process of scientific argumentation with a focus on utilizing the CER framework, a lesson about the timber rattlesnake was presented to the students as an example of a candidate species or a species that is currently being considered for endangered species classification. Students were provided with a trifold information packet displaying various information – physical characteristics, adaptive features, adaptive behaviors, terrain/habitat, reproduction, prey, predators, timber rattlesnake status in other geographical regions, monthly rattlesnake behavior, rainfall, and temperature table, PA range of the timber rattlesnake, human pressures on the timber rattlesnake, and interesting factoids – about the timber rattlesnake. The trifold information brochure is found in Appendix K.

Coupled with the trifold, was an in-class assignment composed of three components and ten questions. The first component required students to individually read the trifold and answer five questions. Question one asked students to identify any interesting information about the timber rattlesnake. The purpose of question one was to engage students with the content of the trifold. Questions two required that students provide a claim in order to answer the question of “do you think the timber rattlesnake should be classified as an endangered species?” Question three required that students provide evidence to support their claim. Question four required that students provide reasoning that would connect the evidence to the claim. Questions two, three, and four explicitly used the terms claim, evidence, and reasoning in order to encourage students to uptake and use these terms. Question five asked students to identify the information (evidence) in the brochure that was most important in helping them make their claim.
The second component of the in-class assignment had students pair up and work on four additional questions. Question six required students to record their partner’s claim. Question six had the students record their partner’s evidence and evaluate whether or not the evidence supported their partner’s claim. Question eight had students record their partner’s reasoning and evaluate whether or not the reasoning connected their partner’s evidence to the claim.

The third component of the timber rattlesnake coqui in-class assignment had students engage in a whole class discussion designed to compare students’ answers with others. The timber rattlesnake in-class assignment can be found in Appendix L.

**Lesson Eleven: Post-Assessment**

The post-assessment was identical to the pre-assessment and had students work independently on two socioscientific issues: 1) invasive python species in the Florida Everglades and 2) the Dallas Safari Club and the proposed hunting of an endangered Black Rhinoceros. Students read a short passage about each socioscientific issue and responded to a prompt. The purpose of the post-assessment was to determine if students would employ the CER framework to the task of considering a complex open-ended socioscientific issue. The post-assessment is found in Appendix M.

The curriculum intervention necessitated that students (and the teacher) engage in new scientific practices related to socioscientific issues, ill-defined and open-ended questions, and the process of scientific argumentation. These practices included, but were not limited to: discussing claims, challenging evidence, connecting evidence to a claim, evidence, and reasoning, evaluating claims, evidence, and reasoning, and identifying
claims, evidence, and reasoning in a text. While not an exhaustive list, the above practices demonstrate that the curriculum intervention brought about extensive changes in classroom scientific practices. A full list of scientific practices identified prior to and during the curriculum intervention can be found in Appendix N.

**Summary of the description of the classroom and curriculum intervention**

In this chapter I provided a review of the classroom practices prior to the curriculum intervention in order to compare and contrast the established practices of the classroom with those practices introduced by the curriculum intervention. Prior to the intervention, the established curriculum was organized around topics that were drawn from a variety of resources. The organization was marginally coherent and offered minimal opportunity for students to engage in scientific discourse, most particularly scientific argumentation.

Following *Framework* (NRC, 2012) recommendations, and grounded in literature supporting emergent bilingual students, I worked with the classroom teacher to design and implement an intervention to engage students in scientific argumentation around endangered species while foregrounding the use of discourse practices in order to talk science. This approach provided students with the opportunity to engage in new practices related to scientific argumentation – providing and evaluating claims, evidence, and reasoning, constructing scientific arguments as a whole class, and considering open-ended socioscientific issues. Most importantly, this approach allowed for students to engage in discourse about science – to talk science – with the teacher and other students as they attempted to make sense of the questions posed and how to respond to them using a specific argumentation framework.
This chapter summarized the new practices brought about by the curriculum intervention and in the next chapter I provide a description and analysis of how the teacher framed these new practices for students through the use of a translanguaging pedagogical approach.
Chapter 5

DESCRIPTION AND ANALYSIS OF TEACHER TRANSLANGLUAGING

This chapter will focus on analyzing how the teacher through the use of translanguaging, in both verbal and written forms, frames the practice of scientific argumentation for all of the emergent bilingual students in the classroom. Drawing on analysis of video records and images of the classroom white board, I will make a case that the teacher’s translanguaging functioned in a variety of ways, both generally and specifically related to the practice of scientific argumentation. A few points warrant mentioning prior to presenting this chapter. First, I use the term “teacher translanguaging” to describe the discursive moves made by the teacher as she interacted with her emergent bilingual students. Translanguaging is very much an interactive communicative accomplishment as two or more individual engage in a discursive event. Second, it is important to note that the instances of translanguaging presented in this study were identified during the curriculum intervention and not during the pre-curriculum intervention classroom observations. Translanguaging was very much a common practice in the classroom prior to the curriculum intervention. I did note the teacher’s use of English and Spanish during my pre-curriculum classroom visits, but found that an analysis of translanguaging during the curriculum intervention to be most salient to my research questions. Last, while I categorized the teacher’s translanguaging into three main themes, in fact a single instance of translanguaging can function to accomplish multiple purposes.

The following results are presented based on the categorization of the functions of teacher translanguaging as it related to the teacher’s discourse practices during science
class, but most importantly as it related to the facilitation of the teacher framing and student uptake of a scientific argumentation framework. Three major functions of teacher translanguaging were identified: 1) maintaining classroom culture, 2) facilitating the academic task, and 3) framing epistemic practices. Each of these functions will be defined and examples will be given, but framing epistemic practices will be the focus of the results, as these practices are most related to the academic goals of using argumentation to resolve socioscientific issues.

**Maintaining Classroom Culture**

Classroom culture refers to the practices that have been established by the both the teacher and student as related to what it means to be a member of the class. Green and Castanheira (2012, p. 54) referred to this as “what members of a particular class or group need to know, understand, produce, and predict to engage in the social and academic life in culturally relevant and socially significant ways.” The culture of the classroom can be thought of in terms of a community of practice (Lave, 1991) in which activity, learning, and doing are all part of the culture that was and is being constructed, negotiating, and maintained by the participants in a particular setting; in the case, the bilingual 7th grade science class. Therefore, in this study, classroom culture was related to questions such as “What are the established language practices of the class?”, “What are the established academic practices of the class?”, “What does it mean to do science class?”, and “what are the roles of both the teacher and students?” Culture is not static and the use of the word maintaining may suggest it is; I use the word maintaining in order to suggest that there was a particular culture of the classroom and that both the teacher and students have worked and continued to work together in order to establish and maintain this classroom
culture. As this research took place during the second part of the school year, it can be assumed that in the months leading up to the research study, a particular classroom culture had been collectively established and that this was being maintained by both the teacher and students.

“Maintaining classroom culture” refers to teacher translanguaging in order to maintain the established and developing classroom culture. Based on early observations, the classroom culture could be characterized as one in which: English and Spanish were both freely used, separately and together; a caring environment was established; a valuing of participation by all; and both teacher and students learned from each other. As directly related to the teacher’s use of translanguaging in order to maintain the classroom culture, practices included, but were not limited to: responding to non-academic matters, talking informally with students, redirecting student behavior, affirming student identity, supporting a caring classroom culture, promoting bilingualism/biliteracy/biculturalism, and positioning all members of the classroom as both teachers and learners.

The following transcript shows an example of maintaining classroom culture in which the teacher translanguaged with a student in order to explain why students have been paired in order to work together. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-1: Maintaining Classroom Culture Example One

1  Ms. Romero – Ah, ah, ah, ahhhh. Ahah. Mariocito vete pa’ atrás. [Little Mario, move back.]
2  Clara – Miss. They understand each other.
3  Ms. Romero – No. Tú entiendes español también. [No. You understand Spanish too.]
4  Clara – I know but like I
Ms. Romero – Por eso te puse Mariocito por ti. [For this I put Little Mario with you.]
He’s not gonna gain anything by sitting with someone who’s in the same level as him.
You’re not gonna gain anything from his Spanish if you’re sitting with someone who’s at the same level as you.

This transcript illustrates how the teacher was promoting the development of bilingualism, affirming students as emergent bilinguals, and supporting a caring classroom culture. This particular instance occurred as students worked through the timber rattlesnake in-class assignment, in which they were required to work in pairs to discuss their responses in determining if the timber rattlesnake should be classified as an endangered species. In line 1, Ms. Romero requested, in Spanish, that a student, Mario, move his seat in order to work with Clara. In line 3, Clara displayed her displeasure at the seating, in English, to the teacher, noting that the current configuration has students of equal competence together. In line 4, Ms. Romero responded, in Spanish, in order to position Clara as a Spanish speaker, thus promoting bilingualism. Clara responded, in line 5, that she knows she can speak Spanish. In line 6, Ms. Romero explained, in Spanish, why she was pairing Clara with Mario. In lines 7-9, Ms. Romero, in English, further explained why she was pairing the two students in order to promote the use of both English and Spanish with both students.

In Spanish, it is very common to use add “-ita”, “-ito”, “-cito” or “-cita” to names (e.g., the use of diminutives) as a display of affection. In this case, the teacher referred to Mario as Mariocito, thus valuing and promoting the cultural and linguistic practices of the Latina/o community. As can be seen, the teacher freely moved in and out of Spanish and English both intrasentially and intersentially, as she communicated with two emergent bilingual students.
The following transcript shows another example of maintaining classroom culture in which the teacher translanguaged with a student in order to position a student in the classroom as also being a teacher. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-2: Maintaining Classroom Culture Example Two

1 Maria – Miss, isn’t there only one ess I mean one eff in
2 Ms. Romero – Which one?
3 Maria – The first one on the left.

This short transcript illustrates a brief interaction between Ms. Romero and Maria in order to position this student as also being a teacher and contributing to the instruction in the classroom, in this case spelling a word correctly in Spanish. This particular interaction occurred as the teacher continued to discuss a scientific explanation, on the white board, which was previously constructed by drawing on contributions of the whole class. In line 1, Maria initiated a sequence of correcting the teacher’s spelling of a word in Spanish through the use of English. In line 2, Ms. Romero asked for clarification in English. In line 3, Maria clarified, in English, which word needs to be corrected. In lines 4 and 5, the teacher responded to the student in Spanish in order to further clarify the word that needs to be corrected, then validated the student in English, and finally praised the student in Spanish. This particular instance of translanguaging is very interesting for a number of reasons. First, the student was correcting the teacher’s Spanish spelling of afirmación through the use of English. The teacher responded in English, the student responded in English, and finally the teacher closed the interaction with a mix of English and Spanish. This transcript is demonstrating that the teacher was very welcoming of
these corrections of her Spanish, thus positioning her students as teachers in that they were helping the teacher use correct Spanish spelling.

As with transcript one, the teacher was affirming the cultural and linguistic practices of the Spanish speaking community by referring to the student as “mami” or mommy. Referring to children as “mami” or “papi”, or mommy or poppy, respectively is a way of establishing a caring or loving relationship with children, siblings, or friends in the Latina/o community. This interaction affirmed both the student’s and teacher’s affiliation with the Latina/o community, while praising and encouraging the student’s behavior of assisting the teacher with her Spanish spelling. Once again, this illustrates how the teacher’s subtle yet dynamic translanguaging functions to maintain the classroom culture.

The following transcript shows another example of maintaining classroom culture in which the teacher translanguaged with a student in order to position a student in the classroom as also being a teacher. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-3: Maintaining Classroom Culture Example Three

1 Ms. Romero – Está diciendo que el el um cómo se dice shell the shell in Spanish? [It is saying that the the how do you say shell the shell in Spanish?]
2 Emilio – Casco
3 Ms. Romero – No. Shell in Spanish? Ayúdame. [Help me.]
4 Valencia – Shello
5 Ms. Romero – La en al de la tortuga. No se cómo [The on the of the turtle. I don’t know how]
6 Emilio – Caparazón. [Carapace.]
7 Hugo – Ew. What kind of name is that?
8 T – I trust you.
This transcript illustrates a brief interaction with a small group of students in which the teacher was requesting the class to provide the Spanish equivalent of a word in English. In this case, the teacher was translanguaging in order to draw on the collective knowledge of the students in order to provide the Spanish word for shell, more specifically the top portion of the turtle’s shell or carapace. This particular instance took place as the whole class was working through a homework assignment that required students to evaluate a scientific explanation in a text. In lines 1-2, Ms. Romero was explaining a portion of text in a homework assignment in Spanish. She asked the students in Spanish how to say the English word shell in Spanish. In line 3, Emilio responded in Spanish. In line 4, the teacher responded to Emilio in English and then switched to Spanish to ask the class for help. In line 5, Valencia responded with a somewhat uninformed response of “shello”, which indicates that English speakers sometimes assume that Spanish words are cognates of English words with an “-o” added at the end. In lines 6 and 7, the teacher continued her request of the class in Spanish, indicating that she does not know this word in Spanish. In line 8, Emilio responded in Spanish with the correct term (according to the term found in the trifold information pamphlet). In line 9, a third student, Hugo, responded in English to indicate his surprise at the word in Spanish. The teacher then ended the interaction by responding to Emilio that she trusts his translation of the word, thus positioning him as a valuable contributor to the class. This instance is also interesting in that Emilio is a Spanish-dominant emergent and he was able to respond correctly to the teacher’s query, which is a mix of English and Spanish.

Similar to transcript two, the teacher’s translanguaging functioned to reaffirm to the students that the classroom is one in which both English and Spanish are used and
valued equally. This translanguaging also functioned in positioning the students as teachers and offering their expertise to the classroom. As with much of the teacher’s translanguaging, this excerpt demonstrates that translanguaging often accomplishes multiple functions. For example, this excerpt also illustrates that the teacher translanguaged to facilitate a particular academic task. In this case, the academic task was to complete a review of a homework question. This transcript and analysis provides a transition to the next section which will describe the translanguaging function of facilitating the academic task.

These short examples are indicative of the norms for participation in the classroom. While these examples do not characterize the classroom culture as a whole, they illustrate part of the culture dedicated to promoting the use of two languages, encouraging participation by all students, positioning the students as teachers, and the promotion of a caring learning environment. Table 5-1 shows a range of translanguaging instances that functioned to maintain classroom culture.

Table 5-1: Range of maintaining classroom culture teacher translanguaging

<table>
<thead>
<tr>
<th>Range of Maintaining Classroom Culture Teacher Translanguaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions to class related to erasing the board</td>
</tr>
<tr>
<td>Directing students behavior</td>
</tr>
<tr>
<td>Disciplining students</td>
</tr>
<tr>
<td>Explaining student pairings for in-class assignment</td>
</tr>
<tr>
<td>Explaining to student why she is using Spanish</td>
</tr>
<tr>
<td>Praising students for completing homework</td>
</tr>
<tr>
<td>Praising students for in-class work</td>
</tr>
<tr>
<td>Redirecting student behavior</td>
</tr>
<tr>
<td>Requesting students’ attention</td>
</tr>
<tr>
<td>Responding to non-academic question (e.g., students leaving room, etc.)</td>
</tr>
<tr>
<td>Responding to student(s) correcting teacher spelling of words in Spanish</td>
</tr>
</tbody>
</table>
Facilitating the Academic Task

Facilitating the academic task refers to teacher translanguaging in order to assist students engaging in and completing academic tasks. Academic tasks could be generally defined as those tasks students engage in that are part and parcel of the normal operations of a classroom: receiving directions for an in-class assignment or exam, receiving directions for a homework assignment, orienting to a new task, and learning new vocabulary. In simpler terms, academic tasks could be framed as students “doing” school. Therefore, teacher translanguaging associated with explaining directions, reorienting students to questions, assigning homework, clarifying in-class assignments, providing materials for in-class assignments, and defining vocabulary would all fall under this function.

The following transcript is an example of how the teacher translanguaged in order to facilitate the academic task. The academic task in this instance was to define the question or problem to be answered. Text in parenthesis () indicates that words were unintelligible due to particular factors such as low speech volume, interference, or classroom noise. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-4: Facilitating the Academic Task Example One

1 Ms. Romero – Now. We were talking about a problem. What. That we had to find the solution. What was the problem? Do you remember? Not today.
2 Gregorio – (unintelligible) endangered species.
3 Ms. Romero – Yeah.
4 Martin – and extinction.
In lines 1 and 2, Ms. Romero, in English, attempted to (re)orient the whole class to the original question to be solved that was discussed in class the day before. Two students, Gregorio and Martin responded, in English, in lines 3 and 5, respectively. The teacher began to respond in English in line 6 and then switched to Spanish in order to define the problem space in Spanish. The teacher then switched back to English to further define the problem space in English. The translanguaging shown here functioned in bringing all of the students into the problem space. As with transcript three, we see in transcript four that the teacher was freely moving between English and Spanish as she interacted with individual emergent bilingual students and the class as a whole.

The following transcript shows another example of facilitating the academic task in which the teacher translanguaged with the whole class in order to clarify the directions in a particular in-class/homework assignment. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-5: Facilitating the Academic Task Example Two

1 Ms. Romero –…the second question says, answer with a complete sentence. Contesta con una frase completa. ¿Verdad? No con just no o sí. [Answer with a complete phrase, right? Not with just no or yes]
students who arrived late to class, due to English proficiency assessments, and missed much of the in-class assignment. In lines 1-3, Ms. Romero clarified for the whole class, but most importantly those students who arrived late, the directions for a given in-class/homework assignment. As the in-class/homework assignment will be used in subsequent class periods, the teacher was facilitating this particular academic task of receiving directions for completing the assignment, while facilitating future academic tasks that will use this assignment as a resource.

The following transcript shows another example of facilitating the academic task in which the teacher translanguaged with the whole class in order to clarify the directions in a particular in-class assignment. Text in brackets [ ] and italicized indicates English translation of Spanish. Text in parenthesis ( ) indicates that words were unintelligible due to particular factors such as low speech volume, interference, or classroom noise. Text in { } indicates non-verbal actions by the teacher.

Transcript 5-6: Facilitating the Academic Task Example Three

1  Ms. Romero – You’re gonna read it. You’re gonna tell me what the claim is. Just
2  write claim, evidence,
3  {Teacher writes claim, evidence, reasoning on board}
4  Ms. Romero - and reasoning. And you’re gonna tell me what they are. So you’re not
5  copying this, you’re just extracting the information. Okay? Go. Está en español y está
6  en inglés. Puede poner la afirmación, evidencia, o o o razonamiento. [It is in Spanish
7  and it is in English. You can put the claim, evidence, or reasoning.]
8  Zoe – (unintelligible)
9  Ms. Romero – Huh? Yeah. You’re not. What I want you to do is. I want you to read
10  this. Tell me what’s the claim in this. What’s the evidence? And what’s their
11  reasoning. And we’ll discuss if it’s a good one or a bad one.

This transcript also shows the Ms. Romero translanguaging in order to facilitate an academic task. This particular instance occurred as the students were identifying the
components of a scientific explanation – claim, evidence, and reasoning – in a text during an in-class assignment. In lines 1 – 7 the teacher was explaining the directions for the in-class assignment, in English. In line 5 the teacher switched to Spanish in order to inform students that the assignment is in Spanish and English and to explain the assignment. In line 8, Zoe responded to the teacher. In lines 9 – 11, the teacher responded to Zoe’s comment or question and further explains the directions for the assignment. This transcript illustrates the teacher translanguaging in order to respond to the needs of a particular student. As she moved from Spanish in lines 6 – 7 to English in lines 9 – 11, and based on the comment of the student in line 8 we can assume that the student was speaking English. The teacher’s translanguaging here functioned to facilitate the academic task of completing the in-class assignment.

The above transcripts are three examples of teacher translanguaging that functioned to facilitate a range of academic tasks. Table 5-2 shows a range of translanguaging instances that function to facilitate the academic task.

Table 5-2: Range of facilitating academic task teacher translanguaging

<table>
<thead>
<tr>
<th>Range of Facilitating Academic Task Teacher Translanguaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigning, Giving, and/or Clarifying Directions for Homework or In-Class Work</td>
</tr>
<tr>
<td>Asking who has finished work</td>
</tr>
<tr>
<td>Assigning homework</td>
</tr>
<tr>
<td>Clarifying in class assignment</td>
</tr>
<tr>
<td>Clarifying student confusion regarding in class assignment materials</td>
</tr>
<tr>
<td>Defining the problem to be solved by class</td>
</tr>
<tr>
<td>Describing in-class assignment</td>
</tr>
<tr>
<td>Describing in-class materials to students</td>
</tr>
<tr>
<td>Explaining directions for in-class assignment</td>
</tr>
<tr>
<td>Giving students directions regarding choice of language use</td>
</tr>
<tr>
<td>Giving students directions regarding in-class assignment</td>
</tr>
<tr>
<td>Requesting homework from students</td>
</tr>
<tr>
<td>Responding to student's question regarding directions for assignment</td>
</tr>
</tbody>
</table>
Defining, Clarifying, or Reviewing Academic Tasks

- Introducing academic task
- Introducing scientific explanation framework
- Reorienting students to question to be answered
- Reorienting students to task
- Reviewing evidence provided by students in previous class
- Reviewing homework
- Reviewing previous classwork
- Reviewing question from previous class

Translation and Rephrasing

- Defining English word in Spanish
- Requesting Spanish word from class
- Restating student evidence
- Translating content
- Translating student responses

Triadic Dialogue Patterns

Initiate
- Asking if students have in-class materials
- Asking student to define claim
- Asking students if they are able to differentiate between the three components of CER framework
- Asking students to define the function of a claim
- Asking students to identify claim, evidence, and reasoning in a text
- Asking students to recall original question to be answered
- Requesting student read and answer homework question
- Requesting student to explain answer
- Requesting student to identify evidence in a text
- Requesting the definition of claim

Response
- Answering student's question

Framing Epistemic Practices

Framing epistemic practices refers to teacher translanguaging in order to support members of the community learning to propose, justify, and evaluate knowledge claims related to scientific argumentation (Kelly, 2008). Epistemic practices, in this study, center
on scientific argumentation and the construction of scientific explanations. These include practices such as the generation and/or evaluation of claims, evidence, and/or reasoning, the evaluation of the appropriateness of a scientific explanation, or the purpose of the scientific argumentation/explanation framework.

The following transcripts are an example of how the teacher translanguaged in order to construct a coherent scientific explanation with the whole class in which the reasoning justifies why the evidence supports the claim. Transcripts 7 and 8 are both part of a longer instance of classroom discourse, but have been split into two parts to facilitate reading. Text in brackets [ ] and italicized indicates English translation of Spanish.

Transcript 5-7: Framing Epistemic Practices Example One

1 Ms. Romero – Alright. Reasoning is to justify that connects evidence and claim
2 science in scientific principles. Razonamiento. Es una justificación conecta la
3 evidencia a la afirmación principales científicas. [Reasoning. It is a justification that
4 connects the evidence to the claim scientific principles.] It just means cuando tú dices
5 cuando tu dieron claim que me estás diciendo que sí o no vamos a decir que si nada
6 más. [when you say when you gave your claim that you are telling me that yes or no
7 we are going to say yes and nothing more.] If you're having a claim that says yes and
8 then you have an evidence to say well well all the eggs are being eaten by the
9 predator. How does that connect to them being endangered? Can someone tell me
10 how does that connect to being endangered? Ummm Josefina.
11 Josefina – They can’t reproduce. That much.
12 Ms. Romero – So what happens if you can’t reproduce?
13 Josefina – Species die out.
14 Hugo – Then you have a certain amount that will die
15 Lucio – The population starts to decrease.
16 Ms. Romero – Species die out. What else?
17 Lucio – The population starts to decrease.
18 Ms. Romero – The population causes it to incre decrease and then it could become
19 what? What can it become?
20 Valencia – Extinct.
21 Lucio – Extinct.
In line 1 Ms. Romero defined the function of reasoning, in English. In lines 2-3 the teacher switched to Spanish in order to define the function of reasoning in Spanish. In line 4 the teacher began to talk in English and then switched to Spanish to clarify the function of reasoning by referring to a claim that was put forth by a student. In lines 7-9 the teacher switched to English in order to present a claim and evidence that was put forth to support the claim. In lines 9-10, the teacher then asked the class, in English, how the evidence supports the claim. This sequence in lines 1-10 demonstrates how the teacher’s translanguaging operated to define the function of reasoning – to justify why evidence supports a claim – in a scientific explanation. In lines 11-21, the teacher worked with five different students in order develop a line of reasoning that connects the evidence – green turtle eggs being eaten by predators – to the claim that the green turtle is an endangered species.

Transcript 5-8: Framing Epistemic Practices Example Two

22 Ms. Romero – Do you see the connection of how my evidence of where the eggs were being destroyed to how they’re gonna become endangered? Alright. Te lo dice en español. Escuche. Escuchan. La afirmación tuya era que el animal la tortuga estaban en peligro de extinción. ¿Verdad? La evidencia que ponieron que pusieron era que los huevos están están siendo destruidos. ¿Cómo los huevos que están destruyendo está causando la tortuga a ser en peligro está en peligro? [I will tell you in Spanish. Listen. Listen. Your claim was that the animal the green turtle was in danger of extinction. Right? The evidence that you put was that the eggs were being destroyed. How is it that the eggs that are being destroyed is causing the turtle to be endangered?]
23 Emilio – No crecen. [They won’t grow.]
24 Ms. Romero – ¿Que le pasan? ¿Y qué pasa a la población de la tortuga? [What happens to them? And what happens to the population of the turtle?]
25 Josefin – Se mueren. [They are dying.]
26 Ms. Romero – ¿Y qué pasa si siguen muriendo? [And what happens if they continue to die?]
41 dying?]
42 Daniela – There’s not gonna be any more.
43 Emilio – Se van a extinguir. [They will go extinct.]
44 Ms. Romero – Se van a extinguir. ¿Tú viste la conexión de la evidencia a la peligro
45 para de extinción? ¿Entendiste? Eso que es razonamiento razonamiento. ¿Entienden?
46 [They will go extinct. Did you see the connection from the evidence to danger of
47 extinction? Did you understand? That is reasoning. Reasoning. Understand?]

In lines 22-23 the teacher asked if students understand the underlying line of reasoning connecting turtle eggs being destroyed and the green turtle’s status as an endangered species. In lines 23 and 24, the teacher announced that she will explain this in Spanish. In lines 24 and 25, the teacher restated the original claim, in Spanish, and in lines 25-26 the teacher restated the evidence provided. In lines 26 and 27, the teacher then asked students how the evidence that turtle eggs being destroyed is causing the turtle to be in danger of extinction. By asking this question, she was requesting students provide reasoning that ties the evidence to the claim. In line 32, Emilio responded in Spanish that turtles won’t grow and the teacher clarifies the question to ask if destroyed eggs can hatch. Josefina answers in line 36 and the teacher continued the line of questioning, asking what will happen if turtle eggs can’t hatch, in Spanish, in lines 37 and 38. In line 39, Emilio responded in Spanish that they will die. The teacher continued the line of questioning asking what happens if turtles continue to die. In line 42, Daniela responded, in English, that there will be no more turtles and in line 43 Emilio responded, in Spanish, that they will become extinct. In lines 44-47 the teacher restated Emilio’s response, in Spanish, and the followed up with a question related to the connection from eggs being destroyed to an organism becoming extinct. As with transcripts seven and eight, we see the teacher fluidly moving in and out of English and Spanish as she constructed a scientific explanation with the students.
The teacher was modeling or framing the process of using reasoning to demonstrate how evidence supports a claim using scientific principles. The scientific principles she was invoking here relate to the fact that the continual destruction of an animal’s nesting sites and the destruction of eggs will decrease reproduction, thus lowering the population and further causing an organism to become endangered or extinct. The epistemic practices being modeled by the teacher relate to: the function of reasoning in a scientific argument, specifically that it connects the evidence to the claim; that reasoning makes use of scientific principles; presenting a claim and evidence to students and having them develop a line of reasoning; challenging a student’s reasoning; and questioning if the students were able to see how the reasoning connected the claim to the evidence.

The following transcript is an example of how the teacher translanguaged in order to elicit evidence from the students that supports the claim that the green turtle is an endangered species. Text in brackets [ ] and italicized indicates English translation of Spanish. Text in parenthesis ( ) indicates that words were unintelligible due to particular factors such as low speech volume, interference, or classroom noise. Text in { } indicates non-verbal actions by the teacher.

Transcript 5-9: Framing Epistemic Practices Example Three

1 Ms. Romero – …by convincing. How do you convince someone?
2 Hugo – You give them enough reasons
3 Ms. Romero – You give them enough reasons or
4 Lucio – Evidence
6 evidence helped you come up with what you, to say that yes.
7 Duane – Um, the, they have a lot of threats.
8 Ms. Romero – Okay, have a lot of threats.
9 [Ms. Romero writes student response on board]
This particular instance occurred as Ms. Romero and whole class were working through the in-class assignment of determining if the green turtle is an endangered species. The teacher was implicitly introducing scientific argumentation through a whole class discussion without explicitly introducing the CER framework. In line 1, the teacher began by asking the whole class what is used to convince someone that your answer, to a particular question, is the correct one. In line 2, Hugo responded, in English, with reasons. The teacher then responded, in English, in line 3 in order to have students come
up with another word for reason; in this case, evidence. In line 4, Lucio, provided the term evidence and lines 5 – 6 the teacher praised the student’s answer and then elicited evidence from the class that will support their claim of “yes, the green turtle is an endangered species”. In line 7, Duane responded with evidence that the green turtles have a lot of threats. The teacher responded in line 8 and wrote this response on the board. Duane affirmed the teacher’s revoicing of his response in line 10. In lines 11 – 15, there was an interesting back and forth as the teacher rephrased student Duane’s responses in Spanish. The teacher revoiced his response, in Spanish, twice in lines 11 and 14. The student twice affirmed her Spanish revoicing of his English response in lines 12 and 15. In lines 15 – 16 the teacher continued to elicit evidence, in Spanish, and then switched to English in order to then frame an epistemic practice by asking students to consider if one piece of evidence is sufficient to convince someone else of your claim. Furthermore, this functioned to define the purpose of evidence – to convince someone of your claim. In line 18, Maita stated “no” to indicate that the evidence is not sufficient to convince someone. After a brief classroom disturbance related to a cell phone (line 22) the teacher returned to eliciting evidence from the class. In line 23 the teacher continued working with Duane by praising his prior response and then asked him to restate his response. In line 26, Duane restated his response and the teacher clarified the year, 1986, from his response in line 25. In line 27 the teacher revoiced his response in Spanish. In line 30, Ernesto responded, in English, that he had an answer and the teacher responded to this student in Spanish in line 31 with “qué tiene, Ernesto?” or “what do you have, Ernesto?” Ernesto then responded, in English, with evidence and reasoning in lines 32 and 33. The teacher then wrote his response on the board while noting that the student also provided a
reason(ing) for his evidence. In lines 34-41, the teacher and Ernesto clarify his response and then this interaction ends. Throughout this interaction the teacher is writing on the board in both English and Spanish, further making use of translanguaging as she and her students engage in scientific argumentation. This instance of translanguaging is particularly interesting as the students were responding appropriately in English while the teacher was asking them questions in Spanish, as indicated by lines 11 – 15 and lines 31-33. While framing the epistemic practices related to the function of evidence and how much evidence is sufficient in supporting a claim, the teacher’s translanguaging here also maintained the classroom culture by allowing students to draw from their full linguistic repertoire – English and/or Spanish – in order to respond to her questions. This supported a classroom in which both English and Spanish were freely spoken and equally valued.

The following transcript is an example of how the teacher translanguaged in order to engage students in scientific argumentation as they argue for why invasive python species in the Florida everglades should or should not be killed. Text in brackets [ ] and italicized indicates English translation of Spanish. Text in { } indicates non-verbal actions by the teacher.

Transcript 5-10: Framing Epistemic Practices Example Four

1 Neva – Miss, are you gonna write it in Spanish?
2 Ms. Romero – You want me to?
3 Brenda – No.
4 Ms. Romero – Okay. Okay. Debemos. Sorry that looked like a P.
5 {Ms. Romero begins writing Spanish CER components next to or under the English CER components}
6 Ms. Romero – So your your claim would be just answering it. You can say no. Yes doesn’t mean it’s correct. I’m just I’m just showing you one side. You can say no.
7 Yes we should kill the snake. The python. Why? Ella dice que producen [She says that they produce]
8 S? – Rápido. [Quickly.]
This particular instance occurred as the whole class is deciding on whether or not invasive python species in the Florida everglades should be killed. The students were engaged in a whole class discussion with the teacher as she used the board to note student responses and build a scientific argument. Lines 1-6 show the teacher a two students – Nicolasa and Brenda – interacting to decide if the teacher should write on the board in Spanish. In lines 5 and 6, the teacher wrote the Spanish CER components (afirmación, evidencia, razonamiento) next to or under the English CER components (claim, evidence, reasoning), respectively. In lines 7-10, the teacher was explaining, in English, what a claim is (i.e., it answers a question) and that, in this case, there were two different claims that can be used to respond to the question: yes, we should kill the pythons or no, we shouldn’t kill the pythons. The teacher was also sure to mention that just because one answers “yes” does not mean that it was correct and that she was building a scientific
argument using the yes responses. In line 9, the teacher switched to Spanish to demonstrate the evidence that was provided by a student. In line 11, an unidentified student (S3) finished the teacher’s sentence with the word rápido (fast or quickly). The teacher then added another piece of evidence in line 12; y porque matan los otros animales (and because they kill the other animals). In lines 14 and 15, the teacher wrote the evidence provided by the students in Spanish, on the board, next to the evidence, in English, already provided by the students. In line 15, the teacher briefly switched to English, but then quickly returned to Spanish to frame the epistemic practice on connecting the evidence to the claim. In lines 15-18 the teacher was asking the students, in Spanish, how the evidence supported the claim or why this evidence was valid in supporting the claim. In line 19, the teacher then switched, briefly, to English as she asked the same question in English regarding the appropriateness of this evidence. She mentioned that this was the purpose of reasoning. The teacher then switched back to Spanish and began the process of connecting the evidence to the claim in lines 19-23. In line 24, Hector, a Spanish-dominant emergent bilingual responded with “eso sí verdad” (that’s the truth or that’s true) signaling that he was following the teacher. In lines 25-27, the teacher demonstrates how the evidence connects to the claim. In lines, 27-32, the teacher checks for understanding by asking three Spanish-dominant students if they understood.

The epistemic practices being modeled by the teacher in this instance relate to: the function of a claim in scientific argument; the fact that there are often more than one claim for a given question; having students provide evidence to support the claim, the function of reasoning in a scientific argument, specifically that it connects the evidence to
the claim; presenting a claim and evidence to students and developing a line of reasoning; constructing a complete scientific explanation; and questioning if the students were able to see how the reasoning connected the claim to the evidence.

As with the transcripts presented for maintaining classroom culture and facilitating the academic task, transcripts 7-10 illustrate a few examples of how the teacher’s translanguaging functioned to frame the epistemic practices associated with scientific argumentation. Table 5-3 shows a range of translanguaging instances that function to frame the epistemic practices associated with scientific argumentation.

Table 5-3: Range of framing epistemic practices teacher translanguaging

<table>
<thead>
<tr>
<th>Epistemic Practices Related to the Question or Problem to be Solved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing the problem or question that students will be asked to answer</td>
</tr>
<tr>
<td>Requesting for original question to be answered</td>
</tr>
<tr>
<td>Requesting students provide a response of problem or question</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Epistemic Practices Related to Scientific Explanations/Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking students to differentiate between a scientific explanation and an explanation</td>
</tr>
<tr>
<td>Asking student to identify components of a scientific explanation in a text</td>
</tr>
<tr>
<td>Constructing scientific explanation on board</td>
</tr>
<tr>
<td>Constructing a scientific explanation with whole class</td>
</tr>
<tr>
<td>Requesting students evaluate a scientific explanation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Epistemic Practices Related to Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking students if they know what a claim is</td>
</tr>
<tr>
<td>Clarifying what a claim is</td>
</tr>
<tr>
<td>Eliciting a claim from a student</td>
</tr>
<tr>
<td>Leading students to describe function of a claim</td>
</tr>
<tr>
<td>Requesting the definition of claim</td>
</tr>
<tr>
<td>Requesting the definition and function of claim</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Epistemic Practices Related to Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliciting evidence from students</td>
</tr>
<tr>
<td>Requesting evidence from students</td>
</tr>
<tr>
<td>Requesting students to evaluate evidence</td>
</tr>
</tbody>
</table>
Epistemic Practices Related to Reasoning
Asking students to define reasoning
Defining the function of reasoning
Requesting reasoning from students

Epistemic Practices Related to Argument Coherence
Checking for understanding of how CER components connected
Connecting evidence to claim using reasoning
Requesting claim and evidence from student

As stated previously, translanguaging in general can accomplish multiple functions and the above themes are not mutually exclusive. For example, one instance of translanguaging can simultaneously frame an epistemic practice related to scientific argumentation, while facilitating the academic task of reviewing an in-class assignment, while maintaining classroom culture by promoting the use of both English and Spanish. Furthermore, all instances of teacher translanguaging function to maintain the classroom culture in which Spanish and English are both equally valued and freely spoken.

Discussion

The teacher’s translanguaging proved to be a linguistic tool used to frame the practice of scientific argumentation for the range of emergent bilingual students in her 7th grade science class. This translanguaging appeared to serve three major, and interrelated, functions generally related to the dual language setting and specific to scientific argumentation. While three themes emerged related to the functioning of translanguaging, it is important to consider what translanguaging is pedagogically and specifically how teachers can be prepared for a classroom in which translanguaging can be leveraged for teaching and learning. The teacher in this study did not specifically plan
her instruction around the use of translanguaging; her approach is best described as responsive and flexible. This approach was responsive and flexible in that she responded to the linguistic needs of each of her students based on her knowledge of and experience with their linguistic practices in her classroom. Lucas and Villegas (2013) refer to this as linguistically responsive teachers. Their construct of linguistically responsive teachers originated from mainstream teachers working with culturally and linguistically diverse students/English Language Learners and is composed of two components: orientations of linguistically responsive teachers and pedagogical knowledge and skills of linguistically responsive teachers. This approach would seem to apply to a dual language setting as it relates to a bilingual teacher working with emergent bilingual students (all of which would be considered CLD and some classified as ELL). If we examine Ms. Romero’s translanguaging using the constructs proposed by Lucas and Villegas (2013), we see that her responsive approach embodies the orientation and knowledge and skills of a linguistically responsive teacher. Her translanguaging indicates at least two of the three orientations of a linguistically responsive teacher: sociolinguistic consciousness – an understanding that language, culture, and identity are interconnected; value for linguistic diversity – linguistic diversity is worthy of cultivating. These two orientations are embodied by her translanguaging functioning to maintain the classroom culture, facilitate the academic task, and frame epistemic practices. While an argument could be made that maintaining a classroom culture that values and supports bilingualism indicates the third orientation of linguistically responsive teacher: the inclination to advocate for emergent bilingual students – the need to take action to improve emergent bilinguals’ access educational opportunities – the data presented do not necessarily support this inclination.
Her translanguaging also indicates the four knowledge and skills constructs of a linguistically responsive teacher (Lucas & Villegas, 2013): a repertoire of strategies for learning about the linguistic and academic backgrounds of her emergent bilinguals – the importance of knowing about the backgrounds of her students, which is evident as she translanguaged based on her knowledge of her students abilities; understanding of second language learning – applying her personal experience with learning a second language to her teacher; ability to identify language demands of classroom tasks – the ability to translanguage in order to lessen the language demands of a particular task, in this case engaging in socioscientific argumentation; and a repertoire of strategies for scaffolding instruction – translanguaging in both verbal and written forms, as well as providing materials in both languages. This knowledge and skills are also evident in the functions of her translanguaging.

Far from solely presenting an ideal picture of translanguaging as a panacea for teaching science content and practices to emergent bilinguals, it is necessary to consider the importance of examining some of the challenges of translanguaging as it directly relates to the science classroom, and most particularly scientific argumentation. In order to translanguage to present science content and practices in two languages, it is important that teachers have this content knowledge and practices in both languages as part of their linguistic repertoire. The teacher was not a certified science teacher and was tasked with teaching new science content and new discourse-intensive scientific practices; there were some gaps in her use of translanguaging to communicate content (about the species under investigation) and her presentation of the scientific argumentation framework. For example, the biology of the three organisms – the green turtle, Puerto Rican coqui, and
timber rattlesnake – was unfamiliar to the teacher. Furthermore, the argumentation framework (CER) was also a new practice for the teacher and this was made evident by her struggle to pronounce razonamiento throughout the curriculum intervention. As with the introduction of any new curriculum intervention, both teacher and student will be presented with challenges as they attempt to take up and utilize new content and practices. This was to be expected as her teacher preparation was at the elementary level with limited science education preparation. As with English, there are differences between conversation language and academic language (Cummins, 1999) in Spanish. With her formal education in English and her development of Spanish in her home community, it is reasonable to assume that there were gaps in her use of academic language in Spanish as it related to the content and practices foregrounded by the curriculum intervention. This is not meant to criticize the teacher; it is meant to bring attention to the fact that preparing bilingual science educators to work with emergent bilingual students requires much consideration. It is well established that there is a shortage of science teachers in our K-12 school system; it is therefore reasonable to assume that there are far less English/Spanish bilingual science teachers.

While not an indictment on the practice of non-science certified teachers instructing middle level science classes, the unfamiliarity with some science concepts and practices does confirm that teaching science does indeed necessitate formal preparation. Furthermore, the use of a translanguaging pedagogy in a science classroom would require that bilingual science teachers have adequate command of both basic interpersonal communication skills and cognitive academic language proficiency (Cummins, 1999).
This chapter demonstrated how the teacher’s translanguaging framed the practice of socioscientific argumentation, discussed how her translanguaging was responsive and flexible, and discussed some challenges associated with translanguaging in a science classroom. As with the framing of any new practice in a classroom, it is important to also consider how students were able to take up and implement this new practice.

A word regarding parallels between translanguaging and socioscientific argumentation will facilitate the transition between this and the following chapter. Translanguaging is the practices in which bilinguals draw on their full linguistic repertoire in order to engage in a communicative act or make meaning in a given situation. Translanguaging includes the language mixing/blending in a fluid and dynamic manner. The bilinguals – the teacher and students – in this study drew from linguistic repertoires that included English and Spanish. As demonstrated above, the teacher was able to freely and fluidly flow in and out of Spanish and English in order to respond to her emergent bilingual students in appropriate ways to make sense of a given communicative situation. In a parallel set of practices, socioscientific discourse (i.e., socioscientific argumentation) is a particular way of making sense that allows individuals – teachers, students, citizens, scientists – multiple lenses with which to analyze, understand, and argue about a socioscientific issue. In this particular practice, individuals are able to draw from a “conceptual repertoire,” and socioscientific discourse may include the mixing of scientific, economic, ethical, and personal discourses. In other words, socioscientific argumentation involves the mixing of scientific and societal discourses while translanguaging involves the mixing of English and Spanish discourses. Both of these hybrid discourse practices could be considered third spaces (Moje,
Ciechanowski, Kramer, Ellis, Carrillo, & Collazo, 2004) in which first and second
discursive spaces are merged in order to leverage motivation, interest, participation,
and/or learning. A translanguaging classroom can be considered a third space in that
students’ first space – home, peer, community – discourses are merged with their second
space – school, science – discourses in order to create a learning environment that
leverages the use of a student’s full linguistic repertoire. Similarly, socioscientific
discourses can also be considered a third space in that students’ first space – personal,
ethical, moral – discourses about an issue are merged with their second space – scientific
– discourses in order to allow students to use multiple lenses to understand and analyze
the issue. Just as the multiple discursive practices (e.g., translanguaging) in a bilingual
community are used to make sense of the world, so are the multiple discursive practices
involved in socioscientific issues used to make sense of the particular question at hand.

If we consider viewing both of these practices – translanguaging and
socioscientific discourses – through the lens of funds of knowledge (Moll et al., 1992),
more parallels emerge. Funds of knowledge (Moll et al., 1992) refer to the leveraging of
knowledge used in students’ households and out of school communities in order to
promote learning inside the classroom. Students’ linguistic repertoires could be
considered funds of knowledge or perhaps “funds of linguistic practices” that can be
brought to bear on the academic tasks presented in the classroom. Similarly, students’
funds of knowledge (e.g., ethical, personal, moral) related to the conceptual
understanding of a socioscientific issue can also be brought to bear on the academic task
presented in the classroom. In other words, translanguaging and socioscientific discourse
allow students to draw on their funds of knowledge in order to make meaning in science
classrooms. The next chapter will analyze student written artifacts produced throughout the curriculum intervention.
Chapter 6

ANALYSIS OF STUDENT WRITTEN WORK

Throughout the curriculum intervention, students were offered multiple opportunities to engage in socioscientific argumentation, implicitly and explicitly, individually and collectively, and verbally and in writing. Furthermore, these opportunities allowed students to draw from their individual linguistic repertoires, as well as their funds of knowledge, in order to respond to each of the assignments. Students were free to respond to these assignments in either English, Spanish, or both. Furthermore, students were free to respond to these issues through the use of multiple lenses (e.g., scientific, ethical, personal). This section will focus on students’ written scientific argumentation based on the various in-class assignments and will begin with an analysis of student written arguments prior to the introduction of the CER framework and then focus on student written arguments during and after the introduction of the CER framework. Following these analyses, concept maps illustrating student written arguments will be displayed in order to demonstrate the nature, range, and diversity of student arguments. The arguments displayed in this chapter were selected in order to represent the diversity, linguistically and conceptually, in students’ argumentation.

The curriculum intervention offered students two separate opportunities to engage in scientific argumentation prior to the introduction of the CER framework. The pre-assessment offered the first opportunity to engage in scientific argumentation as they responded to two open-ended socioscientific issues. The first issue had students consider whether or not invasive python species in the Florida everglades should be killed. The second issue had students consider if a hunting club should be allowed to hunt and kill
and a member of an endangered species in an effort to raise funds to support the remaining population. Students were given a minimal amount of data regarding the two cases. Students were not prompted to use an argumentation framework in order to respond to the two issues.

The second opportunity for students to engage in scientific argumentation, prior to the introduction of the CER framework, was during the green turtle case, in which students were tasked with determining if the green turtle is an endangered species. In this case, students were provided with a trifold information packet, located in Appendix E, and an in-class activity that required them to respond to written prompts individually, then discuss their responses with a partner, and finally consider the case as a whole class.

While the CER framework was not introduced prior to these two lessons, I used the CER framework in order to analyze the students’ written arguments. I did this to compare and contrast student argumentation prior to, during, and after the introduction of the CER framework. As with many assignments in school, individual students may not have completed or submitted a given assignment. This is the case with my data. Therefore, I will omit uncompleted or missing assignments from this analysis. For example, students may have only responded to one prompt during the pre-assessment. In this case, I have only one pre-assessment written argument for a given student. In other cases, I have other incomplete assignments. Therefore, when commenting on numbers or percentages, these will reflect only those assignments completed.

Each written argument was analyzed structurally for the presence of each of the CER components: claim, evidence, and reasoning. Therefore, I coded student responses based on: the presence of a claim – was there a claim and did it respond to the question;
the presence of evidence – was there evidence; and the presence of reasoning – was there
reasoning. I categorized arguments in two ways: partial and complete. Partial arguments
were those in which only a claim or only a claim and evidence was provided. Complete
arguments were those in which all three components were present. Therefore, my use of
the word argument includes both partial and complete arguments.

It is important to note that the presence of all three components did not
necessarily indicate an argument of high quality, as the components could possibly not
have supported each other, been moot, or not relate to each other. Therefore, I also coded
student arguments for argumentative coherence. Argumentative coherence is a term that I
used to describe whether or not there was a substantive, epistemic tie among the three
individual components of the CER framework. A coherent argument would have
consisted of: a claim that answered the question; evidence that supported the claim; and
reasoning that connected the evidence to the claim. While it was possible that there was
coherence between the claim and evidence in partial arguments, only complete arguments
were be coded for coherence.

In addition to coding for the structural components and coherence, I also
examined student arguments for content by considering the nature of the argument. In
this case, I coded for whether or not students were arguing from a scientific viewpoint or
ethical viewpoint. As is the case with many socioscientific issues, there were multiple
lenses – scientific, ethical, economic, personal, etc. - with which to view the issues
presented to the students. Based on my analysis, arguments – both partial and complete –
were either scientific (drawing on scientific evidence and/or reasoning) or ethical
(drawing on ethical evidence and/or reasoning).
Finally, arguments were analyzed for appropriateness. Appropriateness was determined by analyzing whether or not student arguments responded to the questions asked. As the open-ended prompts presented ambiguity, it was possible that students may have misunderstood and responded inappropriately to the question(s) asked of them. Arguments labeled appropriate were those that responded to the original question. Arguments labeled as inappropriate were those that have not responded to the original question. Inappropriate does not connote a pejorative connotation; rather it indicates a response that did not answer the original question.

Student arguments were coded in various phases according to the methods described in chapter three. In a brief summary of the coding, written arguments were: transcribed into Microsoft excel; structurally coded for the presence of claim, evidence, and/or reasoning; coded for coherence of the claim, evidence, and reasoning; coded for the content of the argument; and coded for appropriateness. These written arguments are presented in this document as originally constructed by the students; all spelling errors were maintained and, if necessary, were corrected in parenthesis ( ) in order to add clarity to the response. Any argument constructed in Spanish will be presented in Spanish and then translated into English, also in parenthesis, during the analysis of that argument. Following the written text of student arguments will be the student’s name.

The following sections will present a description of each task in which students needed to generate an argument, provide the specific prompts for the generation of each argument, provide an overview of aggregate student performance on the argumentation tasks, and provide samples of student arguments for each task.

Pre-Assessment Arguments
The pre-assessment consisted of two open-ended questions: a question about invasive python species in the Florida Everglades, hereafter referred to as the python pre-assessment and a question about an endangered rhinoceros species, hereafter referred to as the rhino pre-assessment. A total of 49 students participated in the pre-assessments.

**Python Pre-Assessment**

The python pre-assessment consisted of a brief PowerPoint presentation displaying images of the Florida Everglades, the python and its prey followed by an individual in-class assignment. The prompt was presented to the students in both English and Spanish; the prompt in English is as follows:

**Directions:** Please read the following scenarios and answer the specific questions. There is one scenario on the front and one on the back of this paper.

**Scenario One:** The Florida Everglades is a fragile ecosystem that contains a very unique mix of plants and animals. Recently, people have been releasing large snakes, like the Burmese Python and the African Rock Python, into the Florida Everglades. These snakes were bought by people to have as pets, but then they became too large to keep. These snakes are originally from Africa and Asia and are not normally found in the wild in Florida. These snakes do not have any natural enemies or predators and are also capable of reproducing very quickly. As a result, the populations of these snakes are growing very fast and taking over the natural Everglades ecosystem. These snakes are causing the natural populations of birds, mammals, and reptiles to decrease. In response, local wildlife experts have decided that these snakes should be hunted and killed and that hunters should be paid for killing the biggest snakes.

**Questions:** Do you think this is a good idea? Why or why not? Provide as many reasons why you think it is a good or bad idea to kill these snakes.

Of those 49 students taking the pre-assessment, 47 students responded to the python pre-assessment. Of these 47, 100% provided a claim; 85% provided evidence; and 9% provided reasoning. Of these 47, only 4% of the students provided a coherent scientific argument. Related to the content of the arguments, 68% presented arguments that drew on scientific evidence and 2% drew on ethical evidence. 98% of the students
responded appropriately to the python pre-assessment. The following are examples of student responses:

Argument 6-1: Python Pre-Assessment Example One: An Appropriate Partial Scientific Argument

Yes because there are endangered animals that the snake could kill. – Karen

In example one, the student has responded with a claim of “yes” and supported her claim with evidence of “there are endangered animals that the snake could kill”. The student has provided a partial scientific argument as she has provided a claim and evidence without providing reasoning. While reasoning, or a line or reasoning related to killing the snake to protect endangered species, could be inferred, the student has not provided explicit reasoning in this partial argument. The content of the argument is scientific based on the fact that the evidence provided is scientific in nature.

Argument 6-2: Python Pre-Assessment Example Two: An Appropriate Partial Scientific Argument

Sí, porque son muy peligrosas y pueden morder a muchas personas. – Reina

In example two, the student has responded, in Spanish, with a claim of “sí [yes]” and supported this claim with two pieces of evidence: “son muy peligrosas [they are very dangerous]” and “pueden morder a muchas personas [they can bite many persons]”. In this case, the student has provided a partial scientific argument composed of a claim and two pieces of evidence. The content of the argument is scientific as the evidence is scientific in nature. The first piece of evidence provided can be interpreted in two manners: they are very dangerous can refer to the fact that these snakes are quite large and are dangerous to other animals or that they are dangerous to people. The second piece
of evidence relates directly to humans in that the snakes can bite many persons. Both of these pieces of evidence support the student’s claim that yes they should be killed.

Argument 6-3: Python Pre-Assessment Example Three: An Appropriate Complete Coherent Scientific Argument

Yes, because they kill more than one animal from different species. And if that snake keep killing those animal they are going to be extint. – Karolina

In example three, the student has responded with a claim of “yes”, provided “they kill more than one animal from different species” as evidence, and provided “and if that snake keep killing those animal they are going to be extint (extinct)” as reasoning connecting the evidence to the claim. The reasoning provided draws upon scientific principles in that an organism that continues to kill another organism can cause it to become extinct. This argument is scientific in nature and is classified as a coherent scientific argument, as the student has provided all components in a coherent manner.

Argument 6-4: Python Pre-Assessment Example Four: An Inappropriate Partial Scientific Argument

I think is a bad idea to realiese the python because is killing a lot of speacies and is putting them on danger of extintion. – Gregorio

In example four, the student has responded to the question with a claim that does not answer the original question. In this case, the student is providing a claim that “I think is a bad idea to realiese (release) the python” which is not addressing the original question. The student provides “is killing a lot of speacies (species)” and “is putting them on danger of extintion (extinction)” as pieces of evidence to support the claim. While this response would be classified as a partial scientific argument, it would be considered inappropriate, as it does not respond directly to the question being asked.
The above arguments were presented to show the diversity of student responses to the python pre-assessment question. It is beyond the scope of this dissertation to present full analyses of all student arguments. All students were able to provide a claim to the prompt; the majority of students were able to draw on evidence; although, few students were able to provide reasoning justifying how the evidence supports the claim. Only one student responded in an inappropriate manner, although this student’s argument could have been considered appropriate had the prompt been different. While not directly stated in the prompt, many students mentioned the danger that these large snakes present to humans, particularly human babies. This could be related to the way that snakes are portrayed in popular media in such films as Anaconda and Snakes on a Plane, or news stories about large constrictors. In addition to responding to whether or not killing the snakes is a good idea, many students offered potential solutions to this issue such as making owning these snakes illegal, sending them back to Africa and Asia, and killing the snakes and making “stuff outta the snake’s skin”.

**Rhino Pre-Assessment**

The rhino pre-assessment consisted of a brief PowerPoint presentation displaying images of the black rhinoceros followed by an individual in-class assignment. The prompt was presented to the students in both English and Spanish; the prompt in English is as follows:

**Scenario Two:** The black rhino is an endangered species found in Africa. There are only an estimated 4,000 black rhinos in the wild. Black rhinos are disappearing because humans are killing them for their horns and their habitat is being destroyed by human activities. Recently, the Dallas Safari Club has made arrangements for one hunter to go to Africa and shoot a black rhino. They say that since they have raised $350,000, they should be able to send a hunter to shoot and kill an old, male black rhino. They also say that they will then use the money they raised to help protect other black rhinos.
Questions: Do you think that they should be able to shoot and kill one black rhino if they then use all of the $350,000 to protect other black rhinos? If yes, give reasons why you think it is okay. If no, give reasons why you think it is not okay.

Of the 49 students, 45 responded to the rhino pre-assessment. Of these 45, 100% provided a claim; 67% provided evidence; and 16% provided reasoning. Of these 45, only 2% provided a coherent scientific argument. Related to the content of the arguments, 27% drew on scientific evidence and 22% drew on ethical evidence. 98% of the students responded appropriately to the rhino pre-assessment. The following are examples of student responses:

Argument 6-5: Rhino Pre-Assessment Example One: An Appropriate Partial Argument

Yes I think they should shoot and kill one black rhino to protect the other black rhinos. – Brenda

In this example, the student has only provided a claim to the original question. No evidence or reasoning has been provided. The content of the argument is unable to be ascertained, as the student has not provided any evidence.

Argument 6-6: Rhino Pre-Assessment Example Two: An Appropriate Partial Ethical Argument

No, porque son tranquilos segun pienso yo y son pobres animales. – Reina

In example two, the student has responded with a claim of “no” and provided two pieces of evidence: “son tranquilos (they are tranquil)” and “son pobres animales (they are poor animals)”. These responses are interesting in that they are drawing on evidence not presented in the prompt. The pieces of evidence are drawing on how the student perceives the animals to be: tranquil and poor. These responses can be considered ethical in that the student is drawing on ethical principles related to their belief that tranquil and
poor (or perhaps lowly) animals that are doing no harm to humans should not be killed.

Based on this evidence, the content of this partial argument would be considered ethical.

Argument 6-7: Rhino Pre-Assessment Example Three: An Appropriate Partial Scientific Argument

No it wouldn’t be right you would just be lowering the population of the black rhino. – Esteban

In example three, the student has responded with a claim of “no, it wouldn’t be right” and provided evidence of “you would just be lowering the population of the black rhino”. This student has provided a partial scientific argument as he has provided a claim and evidence. The content of the argument is scientific based on the fact that he is referring to the lowering of the rhino’s population as evidence. This argument is interesting in that the student uses the word “right” in his claim, which suggests an ethical judgment between right and wrong, so this argument seems to suggest a combination of ethical and scientific content.

Of the two pre-assessment questions, the rhino prompt seemed to be present the most difficulty to students. Many students were confused by the scenario and responded with “how are they going to save rhinos but kill one for fun” or mentioned that it doesn’t make sense to kill one in order to save the others. Many students drew on ethical evidence, stating that humans don’t care about nature, are only interested in money, or that it is wrong to kill an animal for money, in order to support their claim of no. As with the python question, all students were able to provide a claim and most were able to provide some form of evidence, and few were able to provide reasoning. As with
example three, we see that it is possible for students to draw on both ethical and scientific principles while responding to an ill-defined and open-ended question.

**Green Turtle Arguments**

The green turtle case was the second opportunity for students to engage in scientific argumentation prior to the introduction of the CER framework. The green turtle in-class assignment consisted of a worksheet that was to be completed using information about the green turtle provided in an information brochure. This assignment made use of the think-pair-share approach in which students answered questions individually, then discussed their answers in pairs, and finally discussed the questions as a whole class. All materials for this assignment were presented to students in both English and Spanish.

Two questions prompted students to provide an argument. Without explicitly asking students to use the terms claims, evidence and reasoning, question 1 prompted students to provide a claim and question 2 prompted students to provide evidence and reasoning. The full green turtle in-class assignment can be found in Appendix F.

1. **Is the green turtle an endangered species?** (Answer this in a complete sentence) ¿Es la tortuga verde una especie en peligro? (Contesta en una frase completa)
2. **If you answered, “Yes, the green turtle is an endangered species.”** explain why you think it is an endangered species. If you answered, “No, the green turtle is not an endangered species.” explain why you think it is not an endangered species. Si contestaste, “Sí, la tortuga verde es una especie en peligro.” Explica porque tú piensas una especie en peligro. Si contestaste, “No, la tortuga verde no es una especie en peligro.” Explica porque tú piensas que no es una especie en peligro.

A total of 44 students responded to the green turtle assignment. Of these 44, 100% provided a claim; 98% provided evidence; and 5% provided reasoning. Of the 44 responses, only 2% were considered coherent scientific arguments. Related to content of the arguments, 93% drew on scientific evidence and 0% drew on ethical evidence. 100%
of the arguments were considered appropriate. The following are examples of student responses:

Argument 6-8: Green Turtle Example One: An Appropriate Partial Argument

*Sí es una especie en peligro.* – Ana

In this example, the student has only provided a claim of “*sí es una especie en peligro* (yes, it is an endangered species)” to answer question one. As the student has provided a claim that answers the original question, this would be considered appropriate. The student has not provided any evidence and therefore it is not possible to determine if this partial argument is scientific or ethical in nature.

Argument 6-9: Green Turtle Example Two: An Appropriate Partial Scientific Argument

*Yes they are a endangered species. Yes because they are them for there shell, meat, skin.* – Reynaldo

In example two, the student has provided the claim “*yes they are a (an) endangered species*” and then again stated “*yes*” and followed with “*they are (killing) them for there (their) shell, meat, skin.*” In the case of this evidence, “*they*” refers to people killing turtles for their shell, meat, and skin. This partial scientific argument would be classified as appropriate.

Argument 6-10: Green Turtle Example Three: An Appropriate Complete Coherent Scientific Argument

*Yes it is endangered because it says it is illegal to hunt them or kill them. That is usually for endangered species. I think yes because it says, it is illegal to hunt or kill them and they only do that for endangered species and they had years that they were endangered already.* – Juana

In example three, the student has provided a complete and coherent scientific argument in which the claim “*yes it is an endangered species*” is supported by the evidence “*it is illegal to hunt or kill them*”. The student has provided reasoning noting
that “that is usually for endangered species” in reference to it being illegal to hunt or kill the green turtle. The student then reiterates the same claim, evidence, and reasoning while adding “they had years that they were endangered already” as additional evidence. This additional evidence is not supported with reasoning, so this would be considered a partial argument. So in fact, this response could be coded as two separate arguments: one complete; one partial.

Student arguments about the green turtle case were generally more robust than the pre-assessment arguments in terms of evidence, as the students were provided with the information trifold with which to study and use to address the prompt. In addition, the majority of student responses were coded as scientific, as opposed to ethical. This is also related to the fact that the information trifold contained mostly scientific information and students were instructed to draw from it. As with the pre-assessment arguments, most students did not provide reasoning in their responses. This is to be expected as the students were not yet introduced to the CER argumentation framework.

**Puerto Rican Coqui Arguments**

The Puerto Rican coqui assignment was the first assignment that required students to explicitly utilize the CER framework in responding to the open-ended prompt. This assignment is also the first assignment students engaged with after direct instruction of the CER framework. As with the green turtle assignment, students were provided with an information trifold about the Puerto Rican coqui to draw from in order to answer the in-class assignment worksheet. The think-pair-share approach was also implemented for this lesson. All materials for this assignment were presented to students in both English and Spanish. Two questions were analyzed for the presence of an argument. Question 2
prompted students to provide a claim and question 3 prompted students to provide evidence and reasoning. The numbering of these questions represents the actual numbering of the in-class assignment questions. The full Puerto Rican coqui assignment can be found in Appendix I.

2. Do you think that this Puerto Rican Coqui should be classified as an endangered species? (Answer this in a complete sentence). This is your CLAIM. Remember that a claim answers a question.

¿Piensas que el Coqui Común debería ser clasificado una especie en peligro? (Contesta en una frase complete). Esto es tu AFIRMACIÓN. Recuerda que una afirmación contesta a una pregunta.

3. If you answered, “Yes, the Puerto Rican Coqui should be classified as an endangered species.” explain why you think it is an endangered species. If you answered, “No, the Puerto Rican Coqui should be classified as an endangered species.” explain why you think it is not an endangered species. This is the EVIDENCE and REASONING part of your explanation. Remember that evidence is data that supports your claim. Remember that reasoning is a justification that connects the evidence to the claim using scientific principles.

Si contestaste, “Si, el Coqui Común debería ser clasificado una especie en peligro.” Explica porque tú piensas que debería ser clasificado una especie en peligro. Si contestaste, “No, el Coqui Común debería ser clasificado una especie en peligro.” Explica porque tú piensas que el Coqui Común no debería ser clasificado una especie en peligro. Esto es la evidencia y el razonamiento parte de tu explicación. Recuerda que la evidencia es datos que apoyan a tu afirmación. Recuerda que razonamiento es una justificación que conecta la evidencia con la afirmación con principales científicas.

A total of 45 students responded to the Puerto Rican coqui assignment. Of these 45, 100% provided a claim; 100% provided evidence; and 58% provided reasoning. Of the 45 responses, 47% were considered coherent scientific arguments. Related to the content of the arguments, 96% drew on scientific evidence and 0% drew on ethical evidence. The following are examples of student responses:

Argument 6-11: Puerto Rican Coqui Example One: An Appropriate Partial Scientific Argument

Yes I think they are endangered. climate change, habitat loss. Yes I think is endangered because of their threats, habitat loss, and climate change. – Maita
In example one, the student has provided a claim and three pieces of evidence. This argument would be considered partial, as only the claim, “Yes, I think they are endangered.”, and evidence, “their threats, habitat loss, and climate change.” have been provided. This would also be considered as a scientific argument as the student has provided scientific evidence, drawn from the information trifold. As with many arguments, it is possible to infer a line of reasoning by the evidence provided.

Argument 6-12: Puerto Rican Coqui Example Two: An Appropriate Complete Coherent Scientific Argument

No, I don't think it should be classified as an endangered species. Los coquis no estan en peligro porque ahora estan en hawaii no hay predadores. Si no tienen predadores en Hawaii la poblacion va a subir y [no] van a desminuir. – Clara

In example two the student has provided a claim in both English – “No, I don’t think it should be classified as an endangered species” – and in Spanish – “Los coquis no estan en peligro.” The student then provides evidence that “ahora estan en hawaii no hay predadores (now they are in Hawaii there are not predators)” as evidence. The student then provides reasoning, “Si no tienen predadores en Hawaii la poblacion va a subir y (no) van a desminuir (if they don’t have predators in Hawaii the population will increase and not decrease)” that justifies why the evidence supports the claim. This argument is complete in that it has all three CER components (e.g., claim, evidence, and reasoning); coherent, in that there is coherence between the three CER components; and scientific, in that the student drew on scientific evidence and reasoning in order to construct her argument. Furthermore, this would be considered appropriate as it does respond to the question asked. This example is also interesting in that the student begins to answer the
question in English and then switches to Spanish to continue constructing her scientific argument.

Argument 6-13: Puerto Rican Coqui Example Three: An Appropriate Complete Coherent Scientific Argument

Yes, I do think that the Puerto Rican coqui should be classified as an endangered species. I think so because of: habitat loss, climate change, people take them out of their natural ecosystem. If all these things are major threats to the coqui most likely its going to get endangered. – Lucio

In example three, the student has provided a claim – “Yes, I do think that the Puerto Rican coqui should be classified as an endangered species.” – and then supported this claim with three pieces of evidence – “habitat loss, climate change, people take them out of their natural ecosystem.” The student has provided reasoning – “If all these things are major threats to the coqui most likely its going to get endangered.” – that connects all three pieces of evidence to the claim, by grouping all of the evidence as threats to the coqui. This argument would be considered complete, coherent, and scientific as all of the CER components are present, there is coherence between the CER components, and the evidence and reasoning are scientific in nature, respectively.

Perhaps the most interesting finding related to the Puerto Rican coqui arguments, as compared to the prior assignments, would be the increase of students providing reasoning and constructing coherent arguments. Fifty-eight percent of students provided reasoning for their arguments, which represents a significant increase from prior assignments. This should not be a surprise, as this assignment occurred immediately after the introduction and framing of the CER framework by the teacher. Furthermore, this assignment explicitly prompted students to provide reasoning. Forty-seven percent of
students constructed coherent arguments suggesting that students also improved in aligning their claim, evidence, and reasoning while responding to the prompt.

**Timber Rattlesnake Arguments**

The timber rattlesnake assignment was the second assignment that required students to explicitly utilize the CER framework in responding to the open-ended prompt. As with the green turtle and Puerto Rican coqui assignments, students were provided with an information packet about the timber rattlesnake to draw from in order to answer the in-class assignment worksheet. The think-pair-share approach was also implemented for this lesson. All materials for this assignment were presented to students in both English and Spanish. Three questions were analyzed for the presence of an argument. The numbering of these questions represents the actual numbering of the assignment questions. Question 2 prompted students to provide a claim question 3 prompted students to provide evidence, and question 4 prompted students to provide evidence and reasoning. The timber rattlesnake questions differ slightly from the Puerto Rican coqui questions in that question four explicitly asks for students to provide separate reasoning. The full timber rattlesnake assignment can be found in Appendix L.

2. Do you think that the Timber Rattlesnake should be classified as an endangered species? This is your CLAIM. Remember that a claim answers the original question in a full sentence.
   ¿Piensas que la Serpiente Cascabel debería ser clasificado una especie en peligro? (Contesta en una frase complete). Esta es tu AFIRMACION. Recuerda que una afirmación contesta a una pregunta en una frase completa.

3. Provide EVIDENCE that supports or backs up your claim. Remember to include enough evidence to support your claim.
   Provee EVIDENCIA que apoyo a tu afirmación. Recuerda que incluir tanta evidencia para apoyar tu afirmación.

4. What is your REASONING? Remember that reasoning is a justification that connects your evidence to the claim using scientific principles.
¿Qué es tu razonamiento? Recuerda que el razonamiento es una justificación que conecta la evidencia a la afirmación usando principales científicas.

The timber rattlesnake assignment was the second assignment that required students to explicitly utilize the CER framework in responding to the open-ended prompt. A total of 45 students responded to the timber rattlesnake assignment. Of these 45, 100% provided a claim; 98% provided evidence, and 58% provided reasoning. Of the 45 responses, 58% were considered coherent scientific arguments. Related to the content of the arguments, 91% drew on scientific evidence and 0% drew on ethical evidence. The following are examples of student responses:

Argument 6-14: Timber Rattlesnake Example One: An Inappropriate Partial Scientific Argument

*Rattlesnakes should be classified as an endangered species because it is poisons to animals and people.* – Diana

In this example, the student has misunderstood the prompt and has responded with a claim of “rattlesnakes should be classified as an endangered species” as a way of stating that they feel the snake is a dangerous species. “It is poisons (poisonous) to animals and people” is the evidence that supports their claim that they should be classified as dangerous species. While an inappropriate partial scientific argument, this could be considered an appropriate partial scientific argument if the question asked if the timber rattlesnake is a dangerous species.

Argument 6-15: Timber Rattlesnake Example Two: An Appropriate Complete Coherent Scientific Argument

*Yes they are endangered. there habitat are being destroyed because there using there habitat to make buildings like houses for roads too. they are endangered because losing there habitat could [cause] them they have to get used to a new habitat and then they cannot find there prey so they cant get food.* – Nicolas
In example two, the student has provided a complete coherent scientific argument. He has provided a claim – “yes they are endangered” – and supported this claim with evidence and reasoning. He provides evidence in the first sentence – “there(they) habitat are (is)being destroyed to make houses and roads for people.” He then restates his claim and provides reasoning for why losing their habitat is appropriate evidence for his claim. In this case, his reasoning is that an organism losing their habitat may cause them to get used to a new habitat and not be able to find food.

Argument 6-16: Timber Rattlesnake Example Three: An Appropriate Partial Scientific Argument

No, the timber rattlesnake is not an endangered specie. in pensilvania they have a high poblacion, they also have a long life 20-30 years, and they can reproduce every 3 years. the timber rattlesnake is not an endangered species because it could live 20-30 years and the reproduce every 3 years. – Gregorio

In this example, the student has provided and restated a claim – “the timber rattlesnake is not an endangered species” – and provided three pieces of evidence – “in pensilvania (Pennsylvania) they have a high poblacion (population), they also have a long life span, and they can reproduce every 3 years.” This would be considered an appropriate, partial scientific argument: appropriate, in that it responds the question; partial, in that it consists of only claim and evidence; and scientific, in that it draws on scientific data as evidence. Interesting to note in this argument is that the student has written in both English and Spanish as he responds to the prompt. Similar to other partial arguments, we can infer the student’s line of reasoning. In this case it is related to timber rattlesnake’s lifespan and reproductive frequency.

As with the Puerto Rican coqui assignment, this timber rattlesnake assignment required students to respond to prompts using the CER components. In this case, there
were separate questions for evidence and reasoning. While the same percentage (58%) of students provided reasoning in their arguments, the percentage of students providing a coherent argument increased to 56%. An interesting finding is that some students responded inappropriately to the prompt. A few students misinterpreted the question and responded that the timber rattlesnake should be considered a dangerous species, based on its venomous nature and the danger it presents to humans and other animals. It is also possible that students were confused about this socioscientific issue as it related to the invasive python species case.

**Post-Assessment Arguments**

The post-assessment consisted of the same two open-ended questions employed in the pre-assessment: a question about invasive python species in the Florida everglades and a question about an endangered rhinoceros species. A total of 46 students participated in the pre-assessments.

**Python Post-Assessment**

The python post-assessment consisted of an individual in-class assignment without the corresponding PowerPoint presentation. The prompt was the same one used in the pre-assessment and will not be shown in this section.

Of those 46 students who participated in the post-assessment, 44 students responded to the python pre-assessment. Of these 44, 100% provided a claim; 91% provided evidence; and 41% provided reasoning. Of these 44, 30% of the students provided a coherent scientific argument. Related to the content of the arguments, 80% presented arguments that drew on scientific evidence and 5% drew on ethical evidence.
100% of the students responded appropriately to the python post-assessment. The following are two examples of student responses:

Argument 6-17: Python Post-Assessment Example One: Two Appropriate Complete Coherent Scientific Arguments

*I think killing and hunting and hunters getting paid for killing snakes it's a good idea. It is good, because they reproduce very quickly, and they are making the populations of birds, mammals, and reptiles decrease. If they reproduce quickly, they would become big and more and eating more animals and even people. Also, if the they are causing the natural populations of birds, mammals, and reptiles to decrease, then they will become extinct, and the snakes will get hungry and will also start to eat people.* – Nadia

In this example, the student has provided two coherent complete scientific arguments based on the presence of all three components: claim, evidence, and reasoning. One argument is related to the snake’s reproduction and the second argument it related to the snake making populations of animals decrease. The first argument consists of: the claim, “*I think killing and hunting and hunters getting paid for killing snakes it’s a good idea.*”; evidence, “*they reproduce very quickly*”; and reasoning, “*If they reproduce quickly, they would become big and more and eating more animals and even people.*”

The second argument consists of: the claim, “*I think killing and hunting and hunters getting paid for killing snakes it’s a good idea.*”; evidence, “*they are making the populations of birds, mammals, and reptiles decrease.*”; and reasoning, “*if the they are causing the natural populations of birds, mammals, and reptiles to decrease, then they will become extinct, and the snakes will get hungry and will also start to eat people.*”

These arguments both point to the student’s perception of snakes being or becoming dangerous to people. In this example, the student has provided two coherent complete scientific arguments based on the presence of all three components: claim, evidence, and reasoning.
Argument 6-18: Python Post-Assessment Example Two: An Appropriate Partial Scientific Argument

Yes, I think this a good idea because they don’t have any natural predators or enemies and their population is increasing too quickly and are taking over florida everglades and eating all the animals. – Valencia

In example two the student has provided a partial scientific argument consisting of a claim with four pieces of evidence. It is somewhat difficult to determine the student’s line or reasoning, as each piece of evidence could be connected to the claim with the same line or separate lines of reasoning.

Python Pre- and Post-Assessment Comparison

The python pre- and post-assessments were compared in order to determine student learning. The python pre- and post-assessments do indicate that after the introduction and implementation of the CER framework, students’ scientific argumentation has improved. Most notable is the increase in the percentage of students (41%) who provided reasoning when responding to the python post assessment as compare to the percentage of students (9%) who provided reasoning when responding to the python pre-assessment. Furthermore, the percentage of students providing coherent arguments increased from 2% to 30% from the pre- to the post-assessment, respectively. The increase in reasoning and subsequent increase in coherent arguments from the pre- to the post-assessments indicates that students did in fact learn how to provide complete and coherent arguments through the use of this curriculum intervention.

Rhino Post-Assessment

The rhino pre-assessment consisted of an individual in-class assignment without the corresponding PowerPoint used in pre-assessment. The prompt was the same one used in the pre-assessment and will not be shown in this section.
Of the 46 students who participated in the post-assessment, 39 responded to the rhino post-assessment. Of these 39, 100% provided a claim; 64% provided evidence; and 31% provided reasoning. Of these 39, 15% provided a coherent scientific argument.

Related to the content of the arguments, 28% drew on scientific evidence and 13% drew on ethical evidence. 97% of the students responded appropriately to the rhino post-assessment. The following are examples of student responses:

Argument 6-19: Rhino Post-Assessment Example One: An Appropriate Partial Ethical Argument

No because the black rhinos are not doing anything to harm anyone or anything. – Joshua

The student has provided a partial ethical argument consisting of a claim and one piece of evidence. In this case, the student has not drawn on scientific principles to support his claim.

Argument 6-20: Rhino Post-Assessment Example Two: A Complex Socioscientific Argument

I think it is a good idea that they should be able to shoot and kill one black rhino if they then use all of the $350,000 to protect other black rhinos. I think that because the black rhino is old and it can't reproduce anymore, plus you are getting 350,000 to protect the others. If they kill the one old black rhino that can't reproduce, it won't matter, because the rhino is too old to reproduce and he will also eventually die. Also if the are getting 350,000 to protect the other ones. some of the other will be young and they can reproduce, and make more rhinos. – Nadia

Of the majority of arguments analyzed and coded, this example is clearly one of the most complex arguments. In this case, the student has provided one claim, which she then supports with two pieces of evidence. Each piece of evidence is supported by its own reasoning and then she supports both pieces of evidence with one reasoning. One line of reasoning could be considered economic – “you are getting 350,000 to protect others” – as it draws on evidence based on the money to be provided for allowing the
rhino to be hunted. The other line of reasoning could be considered scientific – “the black rhino is old and cant reproduce” – as it is drawing on scientific evidence related to the age of the rhino and that it is a non-reproductive member of the population. The third line of reasoning – “if the (they) are getting 350,000 to protect the other ones. some of the other will be young and they can reproduce, and make more rhinos” – is a combination of the other lines of reasoning in that the student is attempting to reason that killing one non-reproductive rhino and using the money to protect other younger reproductively viable rhinos is justified.

**Rhino Pre- and Post-Assessment Comparison**

As with the python pre- and post-assessment comparisons, the rhino pre- and post-assessments were compared in order to determine student learning. The rhino pre- and post-assessments do indicate that after the introduction and implementation of the CER framework, students’ scientific argumentation has improved. Most notable is the increase in the percentage of students (31%) who provided reasoning when responding to the rhino post-assessment as compared to the percentage of students (16%) who provided reasoning when responding to the rhino pre-assessment. Furthermore, the percentage of students providing coherent arguments increased from 2% to 30% from the pre- to the post-assessment, respectively. Similar to the python pre- and post-assessment comparison, the increase in reasoning and subsequent increase in coherent arguments from the pre- to the post-assessments indicates that students did in fact learn how to provide complete and coherent arguments through the use of this curriculum intervention.

**Concept Maps**
While the above textual representation of students’ arguments is one way of representing the analysis of the presence of components and the content of student arguments, the following concept maps is a way of representing the complexity and variety of student arguments. These concept maps were constructed as the final phase of analysis of student written arguments. These concept maps are named based on the above student arguments. Not all of the above examples will be represented by concept maps.

![Concept Map Example One: Python Pre-Assessment Example One](image)

**Figure 6-1: Concept Map Example One: Python Pre-Assessment Example One**

In this example, we see that the student has provide a claim and one piece of evidence. The dotted line represents that the evidence is loosely tied to the claim as no reasoning has been provided. While one could infer the line of reasoning that the student may be using, this diagram shows how this is an example of a partial argument.
In concept map example two we see that the student has provided a claim and two pieces of evidence. Once again, the dotted lines represent that the evidence is loosely tied to the claim as no reasoning has been provided. It could be argued that the student is developing either one line of reasoning in which the two pieces of evidence could be tied to the claim with one reasoning or that she is developing two separate lines of reasoning. As no reasoning has been provided, it is difficult to determine the line of reasoning and this argument is considered partial.
In this concept map we are able to visualize a complete, coherent scientific argument. The student has provided a claim, evidence, and reasoning thus constructing a complete scientific argument. The solid lines in this concept map represent coherence in that the reasoning is justifying why the evidence is supportive of the claim. In this case, the line of reasoning is related to the snake causing the extinction of more than one animal species by continually killing them.
In this concept map we are able to visualize another example of a complete, coherent scientific argument. The student has provided a claim, three pieces of evidence, and reasoning thus constructing a complete scientific argument. The solid lines in this concept map represent coherence in that the reasoning is justifying why the evidence is supportive of the claim. In this case, the student has provided reasoning, in that an organism with many threats is most likely to become endangered, that ties all three pieces of evidence to the claim. While this student chose to tie all three pieces of evidence together through the use of one reasoning, in fact there exists an opportunity for the student to develop three lines of reasoning, each connecting the individual pieces of evidence to the claim.
In this concept map we are able to visualize a complete, coherent scientific argument coupled with an incomplete argument. The student has provided a claim, one piece evidence, and reasoning thus constructing a complete scientific argument in which the line of reasoning is related to the fact that it is generally illegal to hunt or kill endangered species. The solid lines in this concept map represent coherence in that the reasoning is justifying why the evidence is supportive of the claim. In this case, the student has also provided evidence that is not connected to the claim through the use of the reasoning provided. It can be inferred that the student was developing another line of reasoning related to the fact that the green turtle has been listed as an endangered species for many years.
In the final concept map, we are able to visualize the complexity of this student’s argument(s). While she provided one claim, she supported it with two pieces of evidence. Each piece of evidence is supported by separate reasoning (in the left and right ovals) and both pieces are tied together using one reasoning (in the middle oval). In the argument on the left, she is arguing from an economic viewpoint, as she is drawing evidence and reasoning related to the money being provided. On the other hand, in the argument on the right she is arguing from a scientific viewpoint as she draws on evidence and reasoning related to the fact that the male rhino to be hunted is a non-reproductive member of the population. In the middle argument, she provides reasoning that ties evidence from both the economic and scientific viewpoints to her single claim.

The above textual and concept map representations of student written assignments were used to demonstrate the variety and complexity of student arguments. In some cases, students provided partial arguments that: consisted of only a claim; consisted of a claim and one piece of evidence; or consisted of a claim and multiple pieces of evidence.
In other cases, students provided complete arguments that consisted of a claim, one piece of evidence, and reasoning; or consisted of a claim, multiple pieces of evidence, and reasoning. In other cases, students provided a complete argument coupled with a partial argument. Still in other cases, students provided complex arguments that employed evidence from scientific and economic angles.

**Discussion**

This chapter presented an analysis of student argumentation before, during, and after a curriculum intervention designed to have students take up and utilize a specific scientific argumentation framework in order to respond to various open-ended socioscientific issues. As analyses for each of the individual socioscientific issues assignments were provided above, this discussion will focus on student performance across the curriculum, as well as present some findings specific to overall student argumentation.

As would be expected, student performance in constructing scientific arguments improved throughout the curriculum, specifically in areas associated with reasoning. I will begin with pre- and post-assessment comparisons. The percentages of students providing claims and evidence for both pre-assessment and post-assessment questions essentially remained the same: 100% of students provided claims for both pre- and post-assessment prompts; 85% of students provided evidence for the python pre-assessment and 91% of students provided evidence for the python post-assessment; 67% of students provided evidence for the rhino pre-assessment and 64% of students provided reasoning for the rhino post-assessment. While percentages of students providing claims and evidence were fairly consistent in both the pre- and post-assessments, we see that the
major areas of improvement were in providing reasoning, as well as providing coherent arguments. For example, on the pre-assessment 9% and 16% of students provided reasoning for the invasive python and rhino questions, respectively. On the post-assessment, 41% and 31% of students provided reasoning for the invasive python and rhino questions, respectively. Furthermore, only 2% and 4% of students provided coherent arguments on the python and rhino pre-assessment questions, respectively. On the post assessment, 30% and 15% of students provided coherent arguments for the python and rhino questions, respectively. As argumentative coherence is tied to providing reasoning, the increase of students providing reasoning should naturally increase the percentage of students providing coherent arguments. These percentages indicate that through the use of the curriculum intervention, students learned how to apply the CER framework to complex socioscientific issues.

In analyzing student performance in scientific argumentation across the curriculum, it is evident that providing reasoning was the most challenging aspect for students. In looking at the percentages of students providing reasoning across the curriculum, we see the following: 9% provided reasoning on python pre-assessment; 16% provided reasoning on rhino pre-assessment; 5% provided reasoning on green turtle assignment; 58% provided reasoning on Puerto Rican Coqui assignment, 58% provided reasoning on timber rattlesnake assignment; 41% provided reasoning on python post-assessment; and 31% provided reasoning on the rhino post-assessment. Students struggling with providing reasoning is well documented in the literature (McNeill & Krajcik, 2012). In considering the assignments in which the highest percentages of students provided reasoning – Puerto Rican coqui (58%) and timber rattlesnake (58%) –
we see that students were explicitly prompted to provide reasoning in these assignments. The explicit prompting for students to provide reasoning resulted in these higher levels of students providing reasoning in their arguments. This is consistent with the literature that recommends that students be offered explicit instruction in the structure of scientific argumentation (Cavagnetto, 2010; Osborne, Erduran, & Simon, 2004; Sadler, 2004;).

While providing explicit reasoning proved to be a challenge for most students throughout the curriculum, there were many instances of student argumentation when reasoning could be inferred by the claim and evidence provided by the students. The task here is then to have students fully develop this line of reasoning in order to construct a coherent scientific argument.

Also supported by the literature related to arguing about complex socioscientific issues (Sadler, 2004) is that students often only argue from one vantage point – be it scientific, ethical, or other – while not considering opposite positions or competing vantage points. Most of the arguments only suggested one vantage point, although a few arguments did contain competing claims or contradictory evidence. The overall results of this study support results presented by Patronis, Potari, & Spiliotopoulou (1999) in that most students at the middle level argue from a qualitative perspective constructing their arguments from social, ecological, economic, or practical aspects. In the case of my results, most students argued from scientific (ecological) or ethical vantage points. This result should not be surprising based on the nature of the curriculum and its assignments.

While an analysis of translanguaging or language use was not a focus of this chapter, it was interesting to see a few instances of students using a mix of English and Spanish in their written work. Students were instructed that they were free to use either
English or Spanish when completing all assignments. Therefore, students generally chose either English or Spanish in order to respond to the prompts. The majority (82% - 90%) of students chose to respond in English while a smaller percentage (10% - 18%) responded in Spanish. While students were not instructed to respond through the use of translanguaging, it was interesting to see that some of the emergent bilinguals did respond using both English and Spanish. In fact, one student constructed two arguments in English, two arguments in Spanish, and one argument using a combination of English and Spanish. This unique instance seems to support the use of translanguaging in order to have students develop their academic discourses (e.g. scientific argumentation) in both English and Spanish (Mazak & Herbas-Donoso, 2014). The scientific discourses in this case, specifically scientific argumentative discourse, of each emergent bilingual were not assessed in both languages. Regardless, it is clear that each emergent bilingual was able to develop their scientific discourse, be it in English, in Spanish, or a mix of both.

Perhaps most noticeable is the value of providing students with appropriate scaffolding in the uptake and utilization of argumentation, as well as providing sufficient information about the particular issue. If we look at the overall quality of student arguments during the Puerto Rican coqui and timber rattlesnake lessons, we can infer that the teacher’s verbal framing of and working through the process of scientific argumentation allowed students to construct more coherent written scientific arguments. In addition to the verbal framing of argumentation by the teacher, the Puerto Rican coqui and timber rattlesnake in-class assignments were explicit in requiring students to consider and respond to each of the CER components. Furthermore, the information trifolds used
during these two assignments provided students with a plethora of information from which to choose as evidence to support their claims.

In summarizing this chapter in terms of argumentation, it is evident that argumentation is a very complex phenomenon for students to engage in, but also a very challenging practice for me, as a researcher, to characterize. Student arguments are varied in terms of structure and which components were represented; in terms of complexity and how much evidence was provided and whether or not reasoning was employed to justify the evidence; in terms of content and whether or not students argued from a scientific, ethical, or other vantage point; and in terms of coherence and whether or not students were able to provide arguments that demonstrated a clear line of reasoning while linking all three CER components. Each argument required me to determine how students were attempting to respond to each issue presented to them, without the benefit of being able to discuss their responses with the students. My intention in presenting argumentation through the CER framework, was not to suggest that argumentation should be taught lock-step to students. Rather, the CER framework was one tool designed to have students make meaning of and respond to complex socioscientific issues. Regardless of the challenges presented of analyzing and characterizing middle school student arguments, above all, the results were promising in that students at the middle level were able to respond to very complex socioscientific issues in appropriate and complex ways in both English and Spanish. As mentioned previously, if we want students to engage in evidence-based decision making processes related to issues outside the science classroom we must engage them in this process in the classroom.
While argumentation performance is one analytic focus of this research, there are interesting philosophical parallels between the linguistic practices of translanguaging and socioscientific argumentation that demand attention. First, each of these linguistic practices are framed as authentic practices not commonly found in the classroom; translanguaging is framed as an authentic linguistic practice in the bilingual communities outside of the classroom, and scientific argumentation is framed as an authentic linguistic or discursive practice in the scientific community. Second, both translanguaging and socioscientific argumentation can be considered third spaces (Moje et al., 2004) in which discourses mix in order to afford access to content or practices inside the classroom. Third, translanguaging and socioscientific argumentation allow students to draw on particular linguistic or conceptual funds of knowledge (Moll et al., 1992) in order to participate in the meaning making process. Furthermore, both translanguaging and scientific argumentation are ways of making sense of the world. As educators, researchers, and scholars seek to present school as authentic both linguistically (e.g. mirroring linguistic practices in bilingual communities) and according to disciplinary practices (e.g. mirroring discursive practices in scientific communities) parallels between translanguaging and scientific argumentation could shed new light on providing emergent bilinguals access to authentic science learning opportunities through the use of authentic linguistic practices.

The next chapter will discuss the implications of this research study, as well as providing suggestions for future directions.
Chapter 7

CONCLUSIONS AND IMPLICATIONS

The K-12 school system in the United States of America is continuing to diversify both culturally and linguistically. As our schools become more culturally and linguistically diverse (NCELA, 2007), it is important that teachers and researchers acknowledge this diversity and become aware of the linguistic practices that can be drawn upon to positively impact student participation in and learning of science and other subjects. Coupled with the continual diversification of our schools, is the call for reform in how science is taught in K-12 settings. These recommendations represent a shift in science education towards a greater use of discourse to engage students with the subject matter (practices, crosscutting concepts, disciplinary ideas) in new ways that may facilitate learning science. Based on the convergence of these two factors in our science classrooms, one opportunity presents itself to educators and researchers: how to plan science learning environments that embrace cultural and linguistic diversity as a resource for teaching and learning as opposed to seeing it as a challenge to be overcome.

A growing body of literature is emerging that reconceptualizes bilingualism, redefines the linguistic practices of bilinguals, and reframes students who are in the process of learning two languages. Dynamic bilingualism is a conceptualization of bilingualism as a dynamic process that positions the two or more languages in an individual’s repertoire as working together to co-develop (García & Sylvan, 2011; Flores & Schissel, 2014). This contrasts to other theories which view bilingualism in which one language is “added” to an existing language or one existing language is “subtracted” in order to replace it with another socially dominant language. Closely related to dynamic
bilingualism is the practice of translanguaging which is a normal linguistic practice in communities in which bilinguals live and interact and refers to the fluid linguistic practices as they draw from their full linguistic repertoire in order to communicate in a given situation (Garcia, 2008; Celic and Seltzer, 2011; Hornberger & Link, 2012). In addition to new theories of bilingualism and bilingual practices, the use of the term emergent bilingual is slowly beginning to replace terms such as Limited English Proficient (LEP), English Language Learners (ELLs), or English Learners (ELs) to refer to students in the process of learning two languages. The use of the term emergent bilingual clearly situates the student positively in terms of their bilingualism, connotes strength, and foregrounds the developing proficiency in two languages, as opposed to past terms which frame student as deficient or conceptualize non-English languages as barriers or challenges to be overcome. The thinking from bilingual education can provide guidance as science educators think about how to plan positive science learning environments for emergent bilinguals.

Recent calls for science education reform, such as A Framework for K-12 Science Education (NRC, 2012), recommending the inclusion of scientific practices represent a shift in science education requiring both the teacher and students to engage in new and demanding scientific discourse practices. One practice recommended for inclusion in K-12 science education is scientific argumentation which requires students to engage in a suite of discursive practices as they attempt to justify their responses to scientific inquiry. One such use of argumentation is situated in socioscientific issues which requires students to respond to and make decisions about open-ended questions that have ties to both society and science. The use of socioscientific issues in science education situates
science as relevant to the world outside of the classroom and requires students to struggle with open-ended questions with no clear answer. Making an informed decision about these multifaceted issues allows students to argue from multiple vantage points and often results in a complex mix of scientific and societal discourses (e.g., socioscientific argumentation).

Some researchers (Lee, Quinn, & Valdes, 2013) have explicitly called for research that specifically examines how reform-oriented science education (i.e., the inclusion of discourse intensive scientific practices) presents opportunities and challenges to culturally and linguistically diverse students (e.g., emergent bilinguals). Their work notes that four of the eight scientific practices being recommended by the Framework are language intensive and will require special attention for teachers working with culturally and linguistically diverse students. In an attempt to answer this call I set out to investigate the challenges and opportunities for both the teacher and students, in an English/Spanish dual language middle school science class, as they engaged in a curricular unit framed around investigating socioscientific issues and employing a scientific argumentation framework. Through phases of data analysis including the construction of event maps (Kelly & Chen, 1999), open coding (Strauss, 1987), and iterations through the ethnographic research cycle (Spradley, 1980), and based on my initial analyses, I did uncover and describe some relevant challenges and opportunities, but found that my attention was drawn to the particular bilingual practices in this science learning environment. In this case, I found the translanguaging, or dynamic bilingual practices, of the school community members to be particularly interesting and worthy of further investigation.
Translanguaging was a common linguistic practice in this classroom and my attention was drawn to how the teacher’s translanguaging moves, within the overall interactions with students in her classroom, framed the culture and learning in her science classroom. Three main themes of teacher translanguaging emerged: maintaining the classroom culture, facilitating the academic task, and framing epistemic practices. Although these three themes were based in a context of teacher’s and students’ engagement in a socioscientific issues, scientific argumentation curriculum intervention, the functions of translanguaging speak to multiple audiences, including the bilingual education and science education research communities, as well as larger educational policy communities.

**Translanguaging and Bilingual Education**

In considering the impact of this work for educating emergent bilinguals, I return to the theoretical constructs of emergent bilinguals, dynamic bilingualism, and translanguaging. By changing the framing of culturally and linguistically diverse students from a deficit view (e.g. Limited English Proficient, English Language Learner, English Learner) to a view that positions students as competent learners in the process of becoming bilingual (e.g., emergent bilingual) and developing a complex linguistic repertoire, educators can position linguistic diversity as a resource for learning and less as an obstacle to be overcome. This reframing casts new light on the complex resources of emergent bilinguals’ linguistic repertoires and how these repertoires can be leveraged in order to contribute to the learning process.

Related to this is conceptualizing bilingualism as a dynamic process that involves the two or more languages in an individual’s repertoire as working together to co-develop
each other, as opposed to theories of bilingualism in which one language is “added” to an existing language or one existing language is “subtracted” in order to replace it with another socially dominant language. As language, culture, and identity are closely tied to one another (Riley, 2007) viewing bilingualism as the norm, and not the exception, positions emergent bilinguals as being competent and able to draw on their full linguistic repertoire in order to make sense of their world, both in and out of the classroom. Shifting the conceptualization of this group of students and bilingualism is but one way of rethinking education for emergent bilinguals. This reconceptualization must be accompanied by a complementary shift in the practice of educating the growing population of emergent bilinguals that recognizes the value of dynamic bilingualism in education.

Translanguaging is a normal linguistic practice in the bilingual communities (Garcia, 2008; Celic and Seltzer, 2011; Hornberger & Link, 2012) in which emergent bilinguals live and interact and refers to the fluid linguistic practices as bilinguals draw from their full linguistic repertoire in order to communicate in a given situation. This authentic meaning making practice, while prevalent in bilingual communities, should be further researched to uncover how it can best be leveraged by our schools in order to allow emergent bilingual students to be able to utilize the same tools for making meaning inside the classroom. Moje et al., (2004) suggest that academic fields, such as bilingual education, need more information about how to integrate students’ out-of-school discourses in order to construct learning spaces accessible to emergent bilinguals. Their work employs the concept of third space, which suggests a combination of students’ first space, or their out-of-school discursive practices, and second space, or school discursive
practices. As it relates to the concept of third space, the results from this study contribute by framing translanguaging classrooms as linguistic third spaces, in which discursive practices from outside of school are valued and leveraged to engage students in academic discourses inside the school. Moje et al., (2004) also push researchers to resist the binary representations of school and home discourse practices and instead think about how to plan learning environments that combine these two spaces. This idea can also apply to the binary representations of English and Spanish. This research is also suggesting that the linguistic practices outside the classroom must be drawn upon to allow bilingual students a third space in the school similar to the English/Spanish third space found within bilingual communities.

As our schools become more culturally and linguistically diverse (NCELA, 2007), it is important that pre-service and in-service teachers acknowledge this diversity and become aware of particular linguistic practices that can be drawn upon to positively impact student participation in and learning of science and other subjects. In conjunction with other strategies, such as CALLA (Chamot & O-Malley, 1996) and SDAIE (Genzuk, 2011), translanguaging has potential to afford teachers strategies for providing equitable education to emergent bilingual students. Thus, translanguaging by both the teacher and students can serve as another tool to facilitate meaning making in the (science) classroom. Hornberger (2012, p. 240) states, “As school populations become increasingly linguistically diverse, refusing to acknowledge the language resources of students and their families limits the possibilities for their educational achievement.” In considering the findings from this study, it is apparent that the teacher not only acknowledged, but leveraged the language resources of her students to open up the possibilities for their
educational achievement and meaning making in her science class. Translanguaging as a pedagogical strategy, as it relates to student learning, seems to indicate that this linguistic practice can and should be employed in providing emergent bilingual students with equitable science learning opportunities. Thus, as demonstrated by this study, translanguaging as a pedagogical strategy can be leveraged by teachers to construct a positive learning environment that emergent bilingual students to draw from their linguistic repertoires to engage in science practices.

This study is not suggesting that pre- and in-service teachers be provided with a particularly rigid formula for the use of translanguaging in the classroom. Rather, this study is suggesting that translanguaging, if used in the classroom, should be employed in a linguistically responsive manner (Lucas & Villegas, 2013) in which the teacher and students draw from their full linguistic repertoires in order to make meaning in science and other classrooms. Dual-language education programs (i.e., 50-50, 90-10) generally operate under a language separation paradigm in which the use of each language is separated with little to no translation or repetition in the other language (Collier & Thomas, 2004). While not a comparative study between bilingual and monolingual classrooms, nor between models of dual language education programs, this study suggests that free and dynamic language integration is a linguistically responsive pedagogical strategy that affords emergent bilinguals access to the knowledge and practices of the classroom.

On the other hand, this study also poses questions regarding language separation and the use of translanguaging. How does translanguaging fit into current conceptualizations of dual language education that operate under a language separation
paradigm? If we consider that the main models of dual language education (e.g., 50-50, 90-10) suggest language bracketing, then we see that translanguaging as a pedagogical strategy or classroom practice does not fit very well into current dual language paradigms. Translanguaging seems to suggest that dual language education paradigms could be informed by the free and dynamic language integration and how these practices can and should be leveraged for teaching and learning purposes.

Another question that arises is, do these current conceptualizations of dual language education support the theory of dynamic bilingualism? In other words, does language bracketing support or impede the development and utilization of an integrated linguistic repertoire? I would suggest that language bracketing does not support such development and actually impedes the type of authentic linguistic development common in bilingual communities. It is beyond the scope of this paper to fully address these types of questions, but the results produced from this study support the value of a flexible bilingual pedagogy in working with emergent bilingual students.

**Translanguaging and Science Education**

While translanguaging as a general pedagogical strategy can inform the field of bilingual education, in fact there are implications related to science education in light of the recent recommendations for reform. This study presented findings related to translanguaging as a pedagogical strategy and how translanguaging facilitated teacher framing and student uptake of scientific argumentation about socioscientific issues. In fact, translanguaging emerged as a key pedagogical strategy leading to the engagement in epistemic practices related to scientific argumentation. While my research questions were fairly specific in regards to one particular scientific practice (e.g., argumentation)
recommended by the *Framework*, the use of translanguaging as a pedagogical strategy has implications beyond this one scientific practice. As science education reform recommendations place attention on the increased use of discourse, it can be reasonably assumed that translanguaging could prove beneficial in framing other language intensive scientific practices recommended by the *Framework*. Furthermore, as evidenced by the unpacking of language practices around scientific argumentation in this study, there are other epistemic practices not mentioned in the *Framework* that may be relevant to developing student learning of and about science. I not suggesting that translanguaging only has the potential to assist students engage in language intensive scientific practices, rather I am suggesting that one of the benefits of using authentic linguistic practices found outside the classroom is assisting students to engage in language intensive scientific practices inside the classroom. I will make a few comments about the broader application of translanguaging in the science classroom and then discuss how the parallels between translanguaging and socioscientific argumentation can provide an interesting lens with which to view science education for emergent bilinguals.

Discourse practices inside and outside the science classroom are often perceived and framed differently by different researchers. Lee and Fradd (1998, 2001) reported these discourse practices as being incongruent and requiring that the teacher establish instructional congruence in order to create a smooth transition from outside to inside school. On the other hand, Warren et al. (2001) envision these discourse practices as congruent and falling on a continuum of practices which link the everyday language and practices of students to the language and practices of science. This research speaks to both of these vantage points of science instruction for culturally and linguistically diverse
students. My study adds to the research on instructional congruence (Lee & Fradd, 1998, 2001) by positioning translanguaging as providing instructional congruence by leveraging the authentic linguistic practices prevalent outside the classroom for use inside the classroom. Teachers, by knowing and understanding their students’ linguistic and cultural worlds, can link students’ in- and out-of-school worlds by constructing a learning environment in which translanguaging provides congruency between these two spaces.

On the other hand, translanguaging also supports the logic of everyday sense making (Warren et al., 2001) by using out-of-school linguistic practices as resources for learning inside the classroom. By framing the discursive practices outside (e.g., everyday sense-making) and inside the science classroom (e.g., scientific sense-making) as falling on a continuum, translanguaging can be used to provide a link between the authentic discursive practices outside the classroom to the scientific or school discursive practices inside the classroom. In other words, translanguaging can be used to draw from students’ full linguistic repertoires that have developed outside the classroom in order to leverage these as sense-making tools in science teaching and learning.

This research also has implications for science education scholars who call for curriculum and pedagogy that offer relevant experiences for students. In this case, translanguaging can be considered linguistically relevant. Relevance of science education is not solely conceptual, but also linguistic as it relates to students’ discursive practices outside of school. Much like students who are engaged by curricular materials that are relevant to their conceptual world outside of the classroom, translanguaging could be used to engage students in science through linguistically relevant practices. Using the same discursive practices (e.g., translanguaging) inside the classroom that are prevalent
outside the classroom has potential to provide emergent bilingual students linguistic relevance linking their in- and out-of-school worlds. By drawing on the same linguistic practices found outside of the science classroom, translanguaging inside the science classroom can position emergent bilinguals as communicatively competent across these in- and out-of-school contexts. Mazak and Herbas-Donoso (2014), noted the tension between the everyday language practices (e.g., Spanish) and the language of the university science class (e.g., English) and how translanguaging provided a linguistically-relevant classroom in which both English and Spanish were used to learn science. By removing language barriers, translanguaging positioned students as competent members of this particular scientific discourse community.

**Translanguaging and Socioscientific Discourses**

One interesting finding from this study relates to the parallels between translanguaging and socioscientific discourses. These parallels offer a lens with which to view the use of a socioscientific issues approach in teaching emergent bilingual students. Translanguaging in my context is an authentic mixing of English and Spanish discourses in order to make meaning of life in bilingual communities. Only considering the use of English to understand life in a bilingual community would negate any understanding of the Spanish component of a bilingual community; only considering the use of Spanish to understand life in a bilingual community would negate any understanding of the English component of a bilingual community. Drawing on the full linguistic repertoire, including English and Spanish discourses, allows individuals a range or repertoire of sense making tools in order to fully understand bilingual communities. A parallel of this idea is found within socioscientific discourses.
Socioscientific discourses involve the authentic mixing of scientific and societal discourses in order to make meaning of socioscientific issues. Socioscientific discourses are neither fully scientific nor wholly societal and require individuals to draw from multiple conceptual frameworks in order to make sense of an issue. Only considering the scientific side of an issue would negate any societal considerations or implications; only considering the societal (e.g., ethical, economic, personal) side of an issue would negate any scientific considerations and implications. Drawing on the full conceptual repertoire, including the scientific and societal discourses allows individuals a range of sense making tools in order to fully understand and argue about a socioscientific issue. This would frame socioscientific discourses as a third space (Moje et al., 2004) in which scientific discourses interact with societal discourses, much like translanguaging is a third space in which Spanish and English discourses interact in bilingual communities. Therefore, providing students with opportunities to analyze an issue with multiple (scientific, personal, ethical, economic) lenses is analogous to providing students with the opportunity to draw on their full linguistic repertoire to make sense of this issue.

As the field of science education pushes for science education reform (The Framework, NGSS) that encourages the inclusion of discourse intensive scientific practices (e.g. arguing from evidence; obtaining, evaluating, and communicating information; constructing explanations) while also arguing for equity-based practices, it is important to consider curricular and pedagogical strategies that would allow emergent bilinguals to productively engage in these practices. The use of a socioscientific approach that positions emergent bilinguals as active participants in debates of importance to them is one way addressing this call for reform. By framing science education around issues
related to the world, both local and global, outside of the science classroom, has the potential to position emergent bilinguals as citizens, both local and global, in order to engage with scientific issues in active, relevant, and meaningful ways. In addition, allowing emergent bilinguals to draw on their full linguistic repertoire has potential to facilitate participation in these scientific practices. Furthermore, the use of a translanguaging pedagogy by the teacher can be used to leverage these emergent bilinguals’ linguistic repertoires as a means of engaging in these practices. A socioscientific issues approach coupled with translanguaging has the potential to place attention on engaging with science content and practices, without positioning learning English as the most important goal of education for emergent bilinguals. As the science education profession and research community continue to be concerned with educating all students in an equitable manner, classroom curricula (e.g., a socioscientific issues approach) and pedagogy leveraging students’ full linguistic repertoires (e.g., translanguaging) should be further researched for their potential and promise.

Limitations of the Study

I acknowledge the small scale, both in scope and duration, of this research in that it investigated a curriculum intervention engaging one bilingual science teacher and forty-six emergent bilingual students in one bilingual science classroom serving two smaller sized urban areas. I also acknowledge that the setting was very unique for various reasons. First, this science classroom was in an English/Spanish dual language school; very few science classrooms are in dual language education settings. Second, the teacher was an English/Spanish emergent bilingual; bilingual science teachers are rare. Third, while English and Spanish were the two languages spoken in this class, I also
acknowledge that there are classrooms characterized as multilingual and the use of translanguaging in a multilingual setting would require teachers to have a rather extensive linguistic repertoire in order to effectively address the full linguistic diversity in a multilingual classroom.

This study referred to students as Latinas/os and my aim was not to suggest that Latinas/os are a monolithic cultural and linguistic group. This study was limited in accounting for the linguistic and cultural facets of each of the ethnic groups composing the overall student population. Participants in the study were recent immigrants from Caribbean and Central American nations, as well as individuals born in the United States of America with familial roots in those nations. While it is beyond the scope of this study to consider differences or similarities in performance based on countries of origins, I can offer some suggestions for research in this domain both from the literature. For teachers and researchers concerned with planning and implementing linguistically and culturally responsive pedagogy and curricula, I suggest drawing on the work of Villegas and Lucas (2002) and Lucas and Villegas (2013). Both of these papers suggest ways in which pre-service teachers can be prepared to work in culturally and linguistically diverse classrooms. The curriculum I co-planned with the classroom teacher drew on her knowledge of her students’ linguistic and cultural backgrounds in combination with my knowledge of science education for culturally and linguistically diverse students. Therefore, the implemented curriculum and pedagogy were both culturally and linguistically responsive to her students.

While each of these limitations does minimally constrain the implications of this research, I believe that the findings are applicable to the larger discourses of preparing
In considering the results obtained and the limitations of the study, there are myriad directions in which to proceed. Biliteracy and bilingualism are the goals of all English/Spanish dual language schools and researching the effects of translanguaging on student performance in both Spanish and English could yield interesting and informative results for dual language education. Another research direction is to conduct a long-term study, such as the course of a year, in which teacher translanguaging is studied as it relates to more than one scientific practice as recommended by current science education reform. As many of the science and engineering practices are discourse intensive (Lee, Quinn, & Valdés, 2013) the use of a translanguaging pedagogy for teaching science to emergent bilinguals could yield informative results. Assessing students’ bilingual scientific literacy (scientific literacy in both English and Spanish) and the potential of schools in the United States of America producing bilingual scientists could also prove to be another exciting avenue of research related to the practice of translanguaging. Another interesting avenue of research related to this study is to determine what it means to be a bilingual science teacher and how to effectively prepare bilingual science teachers. In addition to further research into translanguaging and science education, research into translanguaging in other content areas (i.e., history, mathematics, geography) could provide insight into effective strategies for educating emergent bilinguals.

While this study made minimal reference to the sociopolitical policies related to language use in our nation’s schools, there is much to be said from this research. First, I
believe that our nation’s school system needs to consider what our educational goals are and how such goals relate to which languages and language practices are legitimate for use in our schools. As a nation, we need to consider the potential of dual language education as well as the value of producing bilingual, biliterate, and bicultural citizens. As local becomes global, and vice versa, our schools need to keep pace with the changing demographics of our society. Bilingual communities are more common than ever and translanguaging is an authentic linguistic practice within these communities. As such, translanguaging frames bilingualism as the norm, which is in itself a sociopolitical action (Mazak, Herbas-Donoso, 2014a, p. 3). English only policies are a relic of the past. I acknowledge the theoretical restructuring of bilingualism as well as the resultant structural and political overhaul of our educational system that this is suggesting.

Second, as it relates to non-deficit conceptualizations of culturally and linguistically diverse students, the positioning of students as emergent bilinguals is a needed paradigm shift as our nation’s school address the need for equity in the K-12 schools. Instead of seeing linguistic diversity as an obstacle to be overcome, this diversity needs to be seen as a resource to learning. Far from the simple renaming of students from Limited English Proficient, English Language Learner, or English Learner to emergent bilingual, our K-12 system needs to consider which language(s) is/are legitimate for use inside the classroom. Authentic linguistic practices (e.g. translanguaging) found in the bi- and multi-lingual communities can and should be leveraged for use inside the classroom, if indeed the ultimate goal of our schools is learning.

Third, this research also has ramifications for the use of these authentic linguistic practices and how such practices could support an emergent bilingual student’s affiliation
with science in school and potentially as a career choice. Given the current trends of the underrepresentation of culturally and linguistically diverse students in science careers (Lee and Luykx, 2006), any and all tools used to recruit and retain underrepresented groups into science are welcomed. As English is generally the language of science, the promotion of science as a bi- or multi-lingual pursuit could prove to be advantageous for culturally and linguistically diverse groups, as well as for science itself. Diversity in language, culture, and thought is similar to biodiversity in maintaining a strong and vibrant ecosystem. A multilingual approach to science increases the likelihood of bringing diverse individuals, diverse views, and diverse methods to science as a discipline. This has the potential to improve applications of science in our communities and the disciplines themselves.

In conclusion, while translanguaging research is emerging, the use of translanguaging in K-12 science education, and other content areas, warrants attention and future research into its potential in providing accessible and equitable education for emerging bilinguals in our growing bilingual communities.
Works Cited


Appendix A

PRE-ASSESSMENT IN ENGLISH AND SPANISH

Pre-Assessment
Name: _____________________
Date: _____________________

Directions: Please read the following scenarios and answer the specific questions. There is one scenario on the front and one on the back of this paper.

Scenario One: The Florida Everglades is a fragile ecosystem that contains a very unique mix of plants and animals. Recently, people have been releasing large snakes, like the Burmese Python and the African Rock Python, into the Florida Everglades. These snakes were bought by people to have as pets, but then they became too large to keep. These snakes are originally from Africa and Asia and are not normally found in the wild in Florida. These snakes do not have any natural enemies or predators and are also capable of reproducing very quickly. As a result, the populations of these snakes are growing very fast and taking over the natural Everglades ecosystem. These snakes are causing the natural populations of birds, mammals, and reptiles to decrease. In response, local wildlife experts have decided that these snakes should be hunted and killed and that hunters should be paid for killing the biggest snakes.

Questions: Do you think this is a good idea? Why or why not? Provide as many reasons why you think it is a good or bad idea to kill these snakes.

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**Scenario Two:** The black rhino is an endangered species found in Africa. There are only an estimated 4,000 black rhinos in the wild. Black rhinos are disappearing because humans are killing them for their horns and their habitat is being destroyed by human activities. Recently, the Dallas Safari Club has made arrangements for one hunter to go to Africa and shoot a black rhino. They say that since they have raised $350,000, they should be able to send a hunter to shoot and kill an old, male black rhino. They also say that they will then use the money they raised to help protect other black rhinos.

**Questions:** Do you think that they should be able to shoot and kill one black rhino if they then use all of the $350,000 to protect other black rhinos? If yes, give reasons why you think it is okay. If no, give reasons why you think it is not okay.
Pre-Evaluacion:
Nombre: ____________________
Fecha: ______________________

**Direcciones:** Por favor lea los siguientes escenarios y responda a las preguntas. Utilice la parte posterior del papel si usted necesita más espacio para contestar las preguntas.

**Escenario Uno:** Los Everglades de Florida es un ecosistema frágil que contiene una mezcla única de plantas y animales. Recientemente, la gente ha ido liberando grandes serpientes, como la pitón de birmano y la pitón roca africana, en los Everglades de Florida. Estas serpientes fueron compradas por la gente a tener como mascotas, pero luego crecieron a ser demasiado grandes para mantener en casa. Estas serpientes originalmente son de África y Asia y no se encuentran normalmente en estado silvestre en Florida. Estas serpientes no tienen enemigos naturales ni los depredadores y también son capaces de reproducirse muy rápidamente. Como resultado, las poblaciones de estas serpientes están creciendo muy rápidamente y están causando mucho daño al ecosistema natural en los Everglades. Estas serpientes están causando las poblaciones naturales de aves, mamíferos y reptiles disminuir. En respuesta, expertos en biología local han decidido que estas serpientes deben ser cazadas y matadas y que los cazadores deben ser pagados por matar a las serpientes más grandes.

**Preguntas:** ¿Crees que esta es una buena idea? ¿Por qué sí o por qué no? Por favor, provea tantas razones como puedas por qué crees que es una buena idea o mala idea matar a estas serpientes.

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**Escenario Dos:** El rinoceronte negro es una especie en peligro de extinción en África. Hay sólo un estimado 4.000 rinocerontes negros en su hábitat natural. Rinocerontes negros están desapareciendo porque los seres humanos están matando por sus cuernos y su hábitat está siendo destruido por las actividades humanas. Recientemente, el Club Safari Dallas hizo los arreglos para un cazador ir a África y cazar, disparar, y matar a un rinoceronte negro. El Club Safari dice que ellos han recogido $350.000, para enviar un cazador a África para disparar y matar a un varón rinoceronte negro viejo quién no es capaz de reproducir. También dicen que luego usarán el dinero que han recogido para ayudar a proteger otros rinocerontes negros.

**Preguntas:** ¿Crees que el Club debería enviar un cazador a África para disparar y matar a un rinoceronte negro si luego usan todos los $350.000 para proteger otros rinocerontes negros? Si Ud. cree que sí, dar razones por que crees que está bien. Si Ud. cree que no, dar razones por que crees que no está bien.
Appendix B

ENDANGERED SPECIES HOMEWORK ASSIGNMENT

7th Grade Science Homework

Name: _________________________________________
Date: __________________________________________

Ask a family member (Mom, Dad, Brother, Sister, Uncle, Aunt) or friend the following questions and then write down his/her answer. If you cannot ask another person these questions, you may answer them yourself.
Pregúntale a un miembro de tu familia (madre, padre, hermano, hermana, tío, tía) o un/una amigo/amiga las siguientes preguntas y anota las respuestas. Si no puedes preguntarle a alguien, tu puedes proveer las respuestas tú mismo/tú misma.

Question One: Do you know what an endangered species is? Please define endangered species.
Pregunta Uno: ¿Sabes lo que significa una especie en peligro? Por favor, provea una definición de especies en peligro.
Answer/Respuesta:
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Question Two: Name as many endangered species that you know.
Pregunta Dos: Provee tantas especies en peligro de que tu sabes.
Answer:
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Appendix C

STUDENT QUESTIONS

• Where are they found?
• How many species are left?
• Population (decreases)
• What are their prey's (food source)?
• Are they losing their habitat?
• Are they being hunted?
• Reasons why they are endangered.
• How many die a year?
• Are they dangerous?
• What are their predators?
• What are their diseases?
• If they are hard to find
Appendix D

IN-CLASS ECOSYSTEMS WORKSHEET

Ecosystems Worksheet

Name: _______________________________
Date: _______________________________

**Part One: Individual Work - Work by yourself and make a list of all the “things” that you observe in the YouTube videos of ecosystems.**

**Parte Uno: Trabaja solo/sola y haga una lista de todas las “cosas” que observas en los videos de ecosistemas.**

Ocean Observations/Observaciones del video del océano:
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Rainforest Observations/Observaciones del video de bosque tropical:
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Pennsylvania Forest Observations/Observaciones del video de Bosque en Pensilvania:
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**Part Two: Work in Pairs - Talk to your partner and make a combined list of all the “things” that you observed in the YouTube videos of ecosystems**

**Parte Dos: Trabaja en parejas – Habla con tu compañero/a y hagan una lista combinada de todas las cosas que Uds. vieron en los videos de ecosistemas.**

Combined Ocean Observations/Observaciones combinadas del video del océano:
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________________________________________________________________________
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Part Three: Whole Class Discussion – Make a list of all the “things” that the whole class has discussed about the videos.

Parte Tres: Discusión de toda la clase – Haga una lista de todas las cosas que todos/todas en la clase han discutido sobre los videos.

Total Ocean Observations/Todas las observaciones del océano:

Total Rainforest Observations/Todos los observaciones del bosque tropical:
Part Four: Whole Class Discussion – Put all of the “things” that were observed into either the biotic (living) or abiotic (non-living) categories below.

**Parte Cuatro: Discusión de toda la clase – Clasifica todas las cosas observadas en la categoría biótico (vivo) o abiótico (no vivo).**

**Biotic**

**Abiotic**
Folleto de Información
(Tortuga Verde)

Tortuga Verde

Información sobre la tortuga verde

- La tortuga verde es una especie de tortuga marina.
- Se encuentra en las costas de América Central y Sur.
- Son conocidas por su color verde característico.
- Se alimentan principalmente de larvas de moluscos.
- Las tortugas verdes son importantes para el equilibrio ecológico.

Especies de tortugas marinas

- Tortuga Verde
- Tortuga Caretta (Caretta caretta)
- Tortuga de las Malvinas
- Tortuga de las Islas Galápagos

Acciones para la conservación

- Protección de las áreas de cría.
- Reducción de la caza de tortugas.
- Educación en programas de conservación.
- Participación en proyectos de restauración.

Centros de Conservación

- Reserva Internacional de Tortugas Verdes, Costa Rica
- Parque Nacional de las Tortugas Verdes, México
- Reserva de la Biósfera de las Islas Bahía de los Ángeles, México
- Reserva Federal de losсу Anfíbios y Reptiles, Argentina

Contacto

- Oficina de Conservación Marítima
- Teléfono: 123-456-7890
- Correo electrónico: conservacionmaritima@pnn.com
Appendix F

IN-CLASS GREEN TURTLE WORKSHEET

The Green Turtle/La Tortuga Verde

Nombre/Name: _________________________________________
Fecha/Date: ____________________________________________

Read and follow all the directions. Lee y sigue todas las direcciones.

Part One: Individual Questions.
Parte Uno: Preguntas individuales.

Read the brochure about the Green Turtle and then answer questions 1-4 by yourself. Lee el folleto sobre la tortuga verde y contesta individualmente preguntas 1-4.

1. What information did you think is interesting about the green turtle? ¿Qué información piensas es interesante sobre la tortuga verde?

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2. Is the green turtle an endangered species? (Answer this in a complete sentence) ¿Es la tortuga verde una especie en peligro? (Contesta en una frase completa)

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3. If you answered, “Yes, the green turtle is an endangered species.” explain why you think it is an endangered species. If you answered, “No, the green turtle is not an endangered species.” explain why you think it is not an endangered species. Si contestaste, “Sí, la tortuga verde es una especie en peligro.” Explica porque tú piensas una especie en peligro. Si contestaste, “No, la tortuga verde no es una especie en peligro.” Explica porque tú piensas que no es una especie en peligro.
4. What information in the brochure do you think was the most important in helping you answer question 2? ¿Qué información en el folleto fue más importante en contestar pregunta 2?

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Part Two: Pair Work. 
Parte Dos: Trabajo en parejas

Discuss your answers with your partner. Explain your answers to your partner and then have your partner explain his/her answers to you. When you are done discussing your answers to questions 1-4, answer questions 5-7. 

Habla con tu compañera/o de tus respuestas. Explica tus respuestas a tu compañera/o y tu compañera/o te explicará sus respuestas a ti. Cuando terminen de hablar de sus respuestas para preguntas 1-4, contesta individualmente a las preguntas 5-7.

5. How did your partner answer question 2? ¿Cómo contestó tu compañera/o a la pregunta 2?

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6. What information did your partner use to answer question 2? ¿Qué información usó tu compañera/o a contestar a la pregunta dos?

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7. Do you agree with your partner’s answers? Why or why not? ¿Estás de acuerdo con las respuestas de tu compañera/o? ¿Por qué sí o por qué no?

Part Three: Whole Class Discussion
Parte Tres: Discusión de Toda la Clase

8. After the whole class discussion, compare your answers to others’ answers in class. Are any of their answers different than yours? Write down any answers that were different than yours. Después de la discusión de la clase, compara tus respuestas con las de tus compañeras/os. ¿Son diferentes las respuestas de ellas/ellos comparado de las tuyas? Anota las respuestas que son diferente de las tuyas.
Appendix G

CLAIM, EVIDENCE, REASONING FRAMEWORK POWERPOINT

The Green Turtle Question
- Claim, Evidence, and Reasoning
La Pregunta de la Tortuga Verde
- Afirmación, Evidencia, Razonamiento

The Problem (Question)/El Problema (Pregunta)

¿Es la tortuga verde una especie en peligro?
Is the green turtle an endangered species?
A claim is a statement or conclusion that answers the original question or problem.

Una afirmación es una declaración o una conclusión que contesta la pregunta original o problema.

**Two Examples of Claims/Dos Ejemplos de Afirmación**

Claim/Afirmación -
The green turtle is not an endangered species/La tortuga verde no es una especie en peligro

Claim/Afirmación -
The green turtle is an endangered species/La tortuga verde es una especie en peligro

**Evidencia/Evidence**

Evidence is used to support “back up” your claim.

Evidencia es usada para apoyar la afirmación.
Ejemplo Uno de Evidencia/Example One of Evidence

**Claim** – Yes, it is an endangered species. **Afirmación** – Sí, es una especie en peligro.

**Evidence**
- Have a lot of threats/tienen mucho peligro
- Have been endangered since 1986/estaban en peligro desde 1986
- It’s illegal to hunt the green turtle/es ilegal para cazar la tortuga
- Pollution is destroying them/la contaminación está destruyéndolas

Ejemplo Dos de Evidencia/Example Two of Evidence

**Claim** – the green turtle is not an endangered species. **Afirmación** – la tortuga verde no es una especie en peligro.

**Evidence**
- Lays 100-200 eggs/ponen 100-200 huevos

Razonamiento/Reasoning

Razonamiento es una justificación que conecta la evidencia a la afirmación usando principios científicos

Reasoning is a justification that connects the evidence to the claim using scientific principles
The Scientific Explanation/Una Explicacion Cientifica

A scientific explanation consist of a claim, evidence, and reasoning and is used to answer a scientific question.

Una explicación científica esta compuesto de una afirmación, evidencia, y razonamiento y esta usada para contestar una pregunta científica.

Claim ➔ Evidence ➔ Reasoning

Claim – the Green Turtle is an endangered species

Evidence – they don’t have a place to reproduce.

Reasoning – if a species can’t reproduce then their population will decrease causing them to become endangered or even extinct.

Afirmacion ➔ Evidencia ➔ Razonamiento

Afirmación – la tortuga verde es una especie en peligro

Evidencia – no tienen lugares para reproducir

Razonamiento – si una especie no puede reproducir, su población disminuirá causando que ellos estén en peligro o ser extinto
### Physical Characteristics
- 1 - 2 inches in length
- Weigh 2 - 4 ounces
- Brown, gray-brown, yellow, or green in color
- Females are larger than males

### Adaptive Features
- Have special discs, or toe pads, that allow them to climb up and down trees and other vertical structures
- Camouflage (colors and patterns) serve to protect the coqui from predators

### Adaptive Behaviors
- Male coquis produce a loud call that is used to attract females during mating season
- During the day coquis are active on the ground, then move to trees during the night
- Coquis jump, hide, and urinate when escaping predators
- Larger coquis can kick themselves free of predators
- Are “hit and wait” predators

### Coqui Data
- There are 17 known coqui species in Puerto Rico, of which the common coqui is one.
- Three coqui species have not been seen since 1990 and are assumed to be extinct.
- Coquis are named by their characteristic call that males make at night.
- Males “call” to attract females or defend their territory.
- Eleutherodactylus means “free toes” because the coqui does not have webbed feet.
- Very popular in Puerto Rican culture – songs, poems, and stories are written about the coqui.
- Over 90% of adults don’t live longer than a year.
- Some wild coquis live up to 6 years.
- Do not have a tadpole stage – tiny frogs hatch from eggs.

---

**Puerto Rican Coqui, Coqui Común**
*(Eleutherodactylus coqui)*

**Information Pamphlet**

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Peter Licosa
Pennsylvania State University
College of Education
Department of Curriculum and Instruction
prl3046@psu.edu
The cute little tiger frogs are a type of frog that is popular among pet owners. They are known for their striking appearance and friendly behavior. In this image, we can see a tiger frog sitting on a leaf, showcasing its signature dark stripes and spots. These frogs are known to be good pets for beginners due to their relatively low maintenance needs. They require a terrarium with proper humidity and a temperature range of 65°F to 75°F. Tiger frogs do well in captivity and can make excellent additions to any pet collection. They are preyed upon by a variety of predators, including cats, snakes, lizards, and birds. It is important to provide a safe and secure environment for these animals to thrive. Tiger frogs are also known to have a distinct call, which is a series of short croaks. They are native to the Americas, with species found in Mexico, Central America, and the Caribbean. In terms of reproduction, tiger frogs lay their eggs in water, and the eggs develop into tiny tadpoles. The tadpoles then develop into mature frogs, completing their life cycle. Overall, tiger frogs are fascinating creatures that bring joy and entertainment to pet owners around the world.
Appendix I

IN-CLASS PUERTO RICAN COQUI WORKSHEET

The Puerto Rican Coqui/El Coqui Común

Nombre/Name: ________________________________________
Fecha/Date: ____________________________________________

Read and follow all the directions. Lee y sigue todas las direcciones.

Part One: Individual Questions.
Parte Uno: Preguntas individuales.

Read the brochure about the Puerto Rican Coqui and then answer questions 1-4 by yourself. Lee el folleto sobre El Coqui Común y contesta individualmente preguntas 1-4.

1. What information did you think is interesting about the Puerto Rican Coqui? ¿Qué información piensas es interesante sobre el Coqui Común?
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2. Do you think that this Puerto Rican Coqui should be classified as an endangered species? (Answer this in a complete sentence). This is your CLAIM. Remember that a claim answers a question. ¿Piensas que el Coqui Común debería ser clasificado una especie en peligro? (Contesta en una frase completa). Esto es tu AFIRMACION. Recuerda que una afirmación contesta a una pregunta.
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   ______________________________________
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3. If you answered, “Yes, the Puerto Rican Coqui should be classified an endangered species.” explain why you think it is an endangered species. If you answered, “No, the Puerto Rican Coqui should be classified as an endangered species.” explain why you think it is not an endangered species. This is the EVIDENCE and REASONING part of your explanation. Remember that evidence is data that supports your claim. Si contestaste, “Sí, el Coqui Común debería ser clasificado una especie en peligro.” explica por qué piensas que es una especie en peligro. Si contestaste, “No, el Coqui Común no debería ser clasificado como una especie en peligro.” explica por qué no piensas que es una especie en peligro. Esto es la EVIDENCIA y REASONING parte de tu explicación. Recuerda que la evidencia es los datos que apoyan tu afirmación.
Remember that reasoning is a justification that connects the evidence to the claim using scientific principles.

Si contestaste, “Sí, el Coqui Común debería ser clasificado una especie en peligro.” Explica porque tú piensas que debería ser clasificado una especie en peligro. Si contestaste, “No, el Coqui Común debería ser clasificado una especie en peligro.” Explica porque tú piensas que el Coqui Común no debería ser clasificado una especie en peligro. Esto es la evidencia y el razonamiento parte de tu explicación. Recuerda que la evidencia es datos que apoyan a tu afirmación. Recuerda que razonamiento es una justificación que conecta la evidencia con la afirmación con principales científicas.

4. What information in the brochure do you think was the most important in helping you answer question 2? ¿Qué información en el folleto fue más importante en contestar pregunta 2?

Part Two: Pair Work.
Parte Dos: Trabajo en parejas

Discuss your answers with your partner. Explain your answers to your partner and then have your partner explain his/her answers to you. When you are done discussing your answers to questions 1-4, answer questions 5-7.

Habla con tu compañera/o de tus respuestas. Explica tus respuestas a tu compañera/o y tu compañera/o te explicará sus respuestas a ti. Cuando terminen de hablar de sus respuestas para preguntas 1-4, contesta individualmente a las preguntas 5-7.

5. How did your partner answer question 2? ¿Cómo contestó tu compañera/o a la pregunta 2?
6. What information did your partner use to answer question 2? ¿Qué información usó tu compañera/o a contestar a la pregunta dos?
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7. Do you agree with your partner’s answers? Why or why not? Estás de acuerdo con las respuestas de tu compañera/o? ¿Por qué si o por qué no?
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**Part Three: Whole Class Discussion**  
**Parte Tres: Discusión de Toda la Clase**

8. After the whole class discussion, compare your answers to others’ answers in class. Are any of their answers different than yours? Write down any answers that were different than yours. Después de la discusión de la clase, compara tus respuestas con las de tus compañeras/os. ¿Son diferentes las respuestas de ellas/ellas comparado de las tuyas? Anota las respuestas que son diferente de las tuyas.
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Appendix J

CLAIM, EVIDENCE, REASONING FRAMEWORK POWERPOINT TWO

Claim, Evidence, and Reasoning
Afirmacion, Evidencia y Razonamiento

Problem/Problema
Is the green turtle an endangered specie?
¿Es la tortuga verde una especie en peligro de extinción?

Why is it important to understand the posing question or problem?
Por que es importante para entender la pregunta o el problema?
Understanding the Problem

You are able to make a good claim.
( Puedes hacer una buena afirmacion)
You know what type of evidence you are looking for. ( Support your claim)
(Sabes qué tipo de evidencia buscas. (Apoyo de su afirmacion)
You are able to explain how your evidence connects to your claim.
( Puedes explicar cómo las evidencias es conecta a la afirmacion.)

1st What is the claim, evidence and reasoning?
Que es la afirmacion, evidencia, y razonamiento?

The green turtle is an endangered species because it has a shell that won’t let it grow fast. Turtles with shells that can’t grow quickly are unable to eat quickly. The shell also makes the turtle very slow in the water. If the turtle can’t eat or move quickly, it will die and then all of the turtles will die and it will become extinct.

La tortuga verde es una especie en peligro de extinción porque tiene una cáscara que no lo deja crecer rápido. Las tortugas con las cáscaras que no pueden crecer rápidamente son incapaces de comer rápidamente. La cáscara también hace la tortuga moverse muy lento en el agua. Si la tortuga no puede comer ni moverse con rapidez, las tortugas morirán y ser extinto.

1st claim, evidence, and reasoning
afirmación, evidencia, y razonamiento
Is this a good scientific explanation?

Claim/ Afirmacion
The green turtle is an endangered species?
La tortuga verde es una especie en peligro?

Evidence/ Evidencia
Turtles with shells that can’t grow quickly are unable to eat quickly. Las tortugas con las cáscaras que no pueden crecer rápidamente son incapaces de comer rápidamente. The shell also makes the turtle very slow in the water. La cáscara también hace la tortuga moverse muy lento en el agua.

Reasoning/ Razonamiento
If the turtle can’t eat or move quickly, it will die and then all of the turtles will die and it will become extinct. Si la tortuga no puede comer ni moverse con rapidez, las tortugas morirán y ser extinto
2nd What is the claim, evidence and reasoning?
Que es la afirmación, evidencia, y razonamiento?

Green turtles are reptiles (Cold blooded). They leave the water to bask and stay warm, which increases their metabolism. When they get too warm, they can go into the water or shade to cool off, but makes them sluggish. The green turtle being a reptile (cold-blooded) means that their bodies react to the temperature of their surroundings, so the turtles leave the water when they are too cold and go back to the water when they need to cool down.

Las tortugas verdes son reptiles (a sangre fría). Dejan el agua para tomar el sol y calentarse, lo que aumenta su metabolismo. Cuando se ponen demasiado calientes, se puede entrar en el agua o a la sombra para refrescarse, pero les hace lento. La tortuga verde ser reptil (sangre fría) significa que sus cuerpos reaccionan a la temperatura de su entorno, así que las tortugas dejan el agua cuando son demasiado frío y regresar al agua cuando necesitan enfriarse.

---

Claim/ Afirmación

Green turtles are reptiles (Cold blooded)  
Las tortugas verdes son reptiles (a sangre fría)

Evidence/ Evidencia

Leave the water when it becomes to cold.  
Goes into the water when the turtle needs to cool off.

Reasoning/ Razonamiento

Their bodies react to the temperature of their surroundings, so the turtles leave the water when they are too cold and go back to the water when they need to cool down.  
Sus cuerpos reaccionan a la temperatura de su entorno, así que las tortugas dejan el agua cuando son demasiado frío y regresar al agua cuando necesitan enfriarse.

---

3rd claim, evidence, and reasoning  
afirmación, evidencia, y razonamiento

The green turtle is an endangered species because their population is decreasing. Their population is decreasing for a number of reasons. One reason is that humans are destroying beaches, which is where the green turtles lay their eggs. Since they don’t have enough beaches to lay their eggs, the turtles can’t reproduce and their population will decrease. If they can’t reproduce, they will eventually go extinct.

La tortuga verde es una especie en peligro de extinción porque su población está disminuyendo. Su población está disminuyendo por una serie de razones. Una razón es que los seres humanos están destruyendo las playas, donde las tortugas verdes ponen sus huevos. Porque no tienen suficientes playas para depositar sus huevos, las tortugas no pueden reproducirse y su población disminuirá. Si no pueden reproducirse, eventualmente se irán extintas.
3rd claim, evidence, and reasoning
afirmacion, evidencia, y razonamiento
Is this a good scientific explanation?

Claim/ afirmación
The green turtle is an endangered species
La tortuga verde es una especie en peligro

Evidence/ Evidencia
humans are destroying beaches, which is where the green turtles lay their eggs.
humanos están destruyendo las playas, que es donde las tortugas verdes ponen sus huevos.

Reasoning/ Razonamiento
They don’t have enough beaches to lay their eggs, the turtles can’t reproduce and their population will decrease. If they can’t reproduce, they will eventually go extinct.
Porque no tienen suficientes playas para depositar sus huevos, las tortugas no pueden reproducirse y su población disminuirá. Si no pueden reproducirse, eventualmente se irán extintos.

Good and Bad Scientific Explanation
Una Buana y Mala Explicación Científica

<table>
<thead>
<tr>
<th>Claim Afirmacion</th>
<th>Evidence Evidencia</th>
<th>Reasoning Razonamiento</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer the question based on information.</td>
<td>Pick information that supports the claim.</td>
<td>It connects the evidence to the claim</td>
</tr>
</tbody>
</table>

How can you have a bad claim?
How do you know you have bad evidence?
How do you know your reasoning is bad?
TIMBER RATTLESNAKE TRIFOLDS

Appendix K

(Crotalus horridus)

Cascabel Serpiente de cascabel

Be careful when handling and releasing these creatures. Always keep your distance and use proper safety precautions.

Common Names:
- Cascabel
- Serpiente de cascabel

Description:
- Venomous snake
- Brown or black scales
- Rattle at the end of the tail

Habitat:
- Forests
- Grassy areas
- Open fields

Behavior:
- Preferentially hunting during the day
- Active during warm weather

Conservation Status:
- Endangered

Collection Sites:
- Temperate grasslands
- Semi-arid areas

Notes:
- Rattle can be heard up to 50 yards away
- Venoms are highly toxic

References:

To use this information:
- Always wear protective gear
- Contact local authorities before releasing
- Observe from a safe distance

Contact:
- Local wildlife authorities
- State environmental agencies

Rising to the challenge of protecting the cascabel serpiente de cascabel.
Appendix L

IN-CLASS TIMBER RATTLESNAKE WORKSHEET

The Timber Rattlesnake/La Serpiente Cascabel
Scientific Explanation/Explicación Científica

Nombre/Name: ________________________________________
Fecha/Date: ____________________________________________

Read and follow all the directions. Lee y sigue todas las direcciones.

Part One: Individual Questions.
Parte Uno: Preguntas individuales.

Read the brochure about the Timber Rattlesnake and then answer questions 1-5 by yourself.
Lee el folleto sobre la Serpiente Cascabel y contesta individualmente a las preguntas 1-5.

1. What information did you think is interesting about the Timber Rattlesnake?
¿Qué información piensas es interesante sobre la Serpiente Cascabel?
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2. Do you think that the Timber Rattlesnake should be classified as an endangered species? This is your CLAIM. Remember that a claim answers the original question in a full sentence.
¿Piensas que la Serpiente Cascabel debería ser clasificado una especie en peligro? (Contesta en una frase completa). Esta es tu AFIRMACION. Recuerda que una afirmación contesta a una pregunta en una frase completa.
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3. Provide EVIDENCE that supports or backs up your claim. Remember to include enough evidence to support your claim.
Provee EVIDENCIA que apoyo a tu afirmación. Recuerda que incluir tanta evidencia para apoyar tu afirmación.
4. What is your REASONING? Remember that reasoning is a justification that connects your evidence to the claim using scientific principles.

¿Qué es tu razonamiento? Recuerda que el razonamiento es una justificación que conecta la evidencia a la afirmación usando principales científicas.

5. What information in the brochure do you think was the most important in helping you make your claim? ¿Qué información en el folleto fue más importante en hacer tu afirmación?

Part Two: Pair Work.
Parte Dos: Trabajo en parejas
Discuss your answers with your partner. **Explain** your answers to your partner and then have your partner explain his/her answers to you. When you are done discussing your answers to questions 1-5, answer questions 6-9.

Habla con tu compañera/o de tus respuestas. **Explica** tus respuestas a tu compañera/o y tu compañera/o te explicará sus respuestas a ti. Cuando terminen de hablar de sus respuestas para preguntas 1-5, contesta individualmente a las preguntas 6-9.

6. **What is your partner’s claim?** ¿Qué es la afirmación de tu compañera/o?

7. **What evidence did your partner use? Does this evidence support the claim?** ¿Qué evidencia usó tu compañero/a? La evidencia apoya a la afirmación?

8. **What reasoning did your partner use? Does the reasoning connect the evidence to the claim?** ¿Qué razonamiento usó tu compañero/a? ¿El razonamiento conecta la evidencia a la afirmación?

9. **Do you agree with your partner’s scientific explanation? Why or why not?** ¿Estás de acuerdo con la explicación científica de tu compañero/a? ¿Porque sí o porque no?
Part Three: Whole Class Discussion
Parte Tres: Discusión de Toda la Clase

10. After the whole class discussion, compare your answers to others’ answers in class. Are any of their answers different than yours? Write down any answers that were different than yours. Después de la discusión de la clase, compara tus respuestas con las de tus compañeras/os. ¿Son diferentes las respuestas de ellas/ellos comparado de las tuyas? Anota las respuestas que son diferente de las tuyas.
Appendix M

POST-ASSESSMENT IN ENGLISH AND SPANISH

Pre-Assessment
Name: _____________________
Date: ______________________

Directions: Please read the following scenarios and answer the specific questions. There is one scenario on the front and one on the back of this paper.

Scenario One: The Florida Everglades is a fragile ecosystem that contains a very unique mix of plants and animals. Recently, people have been releasing large snakes, like the Burmese Python and the African Rock Python, into the Florida Everglades. These snakes were bought by people to have as pets, but then they became too large to keep. These snakes are originally from Africa and Asia and are not normally found in the wild in Florida. These snakes do not have any natural enemies or predators and are also capable of reproducing very quickly. As a result, the populations of these snakes are growing very fast and taking over the natural Everglades ecosystem. These snakes are causing the natural populations of birds, mammals, and reptiles to decrease. In response, local wildlife experts have decided that these snakes should be hunted and killed and that hunters should be paid for killing the biggest snakes.

Questions: Do you think this is a good idea? Why or why not? Provide as many reasons why you think it is a good or bad idea to kill these snakes.

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**Scenario Two:** The black rhino is an endangered species found in Africa. There are only an estimated 4,000 black rhinos in the wild. Black rhinos are disappearing because humans are killing them for their horns and their habitat is being destroyed by human activities. Recently, the Dallas Safari Club has made arrangements for one hunter to go to Africa and shoot a black rhino. They say that since they have raised $350,000, they should be able to send a hunter to shoot and kill an old, male black rhino. They also say that they will then use the money they raised to help protect other black rhinos.

**Questions:** Do you think that they should be able to shoot and kill one black rhino if they then use all of the $350,000 to protect other black rhinos? If yes, give reasons why you think it is okay. If no, give reasons why you think it is not okay.

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**Pre-Evaluacion:**
Nombre: ____________________
Fecha: ______________________

**Direcciones:** Por favor lea los siguientes escenarios y responda a las preguntas. Utilice la parte posterior del papel si usted necesita más espacio para contestar las preguntas.

**Escenario Uno:** Los Everglades de Florida es un ecosistema frágil que contiene una mezcla única de plantas y animales. Recientemente, la gente ha ido liberando grandes serpientes, como la pitón de birmano y la pitón roca africana, en los Everglades de Florida. Estas serpientes fueron compradas por la gente a tener como mascotas, pero luego crecieron a ser demasiado grandes para mantener en casa. Estas serpientes originalmente son de África y Asia y no se encuentran normalmente en estado silvestre en Florida. Estas serpientes no tienen enemigos naturales ni los depredadores y también son capaces de reproducirse muy rápidamente. Como resultado, las poblaciones de estas serpientes están creciendo muy rápidamente y están causando mucho daño al ecosistema natural en los Everglades. Estas serpientes están causando las poblaciones naturales de aves, mamíferos y reptiles disminuir. En respuesta, expertos en biología local han decidido que estas serpientes deben ser cazadas y matadas y que los cazadores deben ser pagados por matar a las serpientes más grandes.

**Preguntas:** ¿Crees que esta es una buena idea? ¿Por qué sí o por qué no? Por favor, provea tantas razones como puedas por qué crees que es una buena idea o mala idea matar a estas serpientes.
**Escenario Dos:** El rinoceronte negro es una especie en peligro de extinción en África. Hay sólo un estimado 4.000 rinocerontes negros en su hábitat natural. Rinocerontes negros están desapareciendo porque los seres humanos están matando por sus cuernos y su hábitat está siendo destruido por las actividades humanas. Recientemente, el Club Safari Dallas hizo los arreglos para un cazador ir a África y cazar, disparar, y matar a un rinoceronte negro. El Club Safari dice que ellos han recogido $350.000, para enviar un cazador a África para disparar y matar a un varón rinoceronte negro viejo quién no es capaz de reproducir. También dicen que luego usarán el dinero que han recogido para ayudar a proteger otros rinocerontes negros.

**Preguntas:** ¿Crees que el Club debería enviar un cazador a África para disparar y matar a un rinoceronte negro si luego usan todos los $350.000 para proteger otros rinocerontes negros? Si Ud. cree que sí, dar razones por que crees que está bien. Si Ud. cree que no, dar razones por que crees que no está bien.

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### Appendix N

**SCIENTIFIC PRACTICES PRIOR TO AND DURING THE CURRICULUM INTERVENTION**

<table>
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<th>Prior to Curriculum Intervention</th>
<th>During Curriculum Intervention</th>
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<td>Answering questions (orally)</td>
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<tr>
<td>Answering questions (writing)</td>
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VITA

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