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Exploring Ecology through Science Terms:

A Computer-Supported Vocabulary Supplement to the Science Curriculum in a Two-Way Immersion Program

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy in Education

by

Francisco Javier Herrera Jr.

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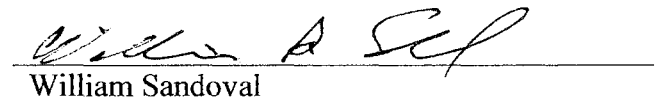

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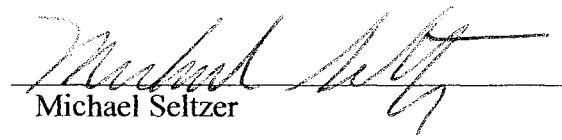

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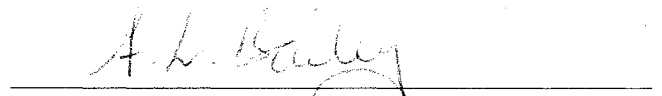

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ABSTRACT OF THE DISSERTATION

Exploring Ecology through Science Terms:

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by

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Doctor of Philosophy in Education

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Professor Alison Bailey, Chair

This study set out to examine how a web-based tool embedded with vocabulary strategies, as part of the science curriculum in a third grade two-way immersion classroom, would aid students' academic vocabulary development. Fourteen students (seven boys, seven girls; ten of which were English learners) participated in this study. Students utilized web pages as part of their science curriculum on the topic of ecology. The study documented students' use of the web pages as a data-gathering tool on the topic of ecology during science instruction. Students were video and audio taped as they explored the web pages. Results indicated that through the use of the intervention web pages students significantly improved their knowledge of academic English target words.

CHAPTER I: INTRODUCTION

This study set out to examine the effect of a computer-supported vocabulary supplement (CSVS) in the development of academic vocabulary for elementary school students in a two-way immersion program. The importance of academic vocabulary development to school success should not be underestimated, especially given the fact that such content-specific words can be vital to reading comprehension as they are often tied to abstract concepts essential for conceptual understanding across academic domains. In fact federal research documents (RAND Reading Study Group, 2002; NICHD Report of the National Reading Panel, 2000) continue to identify vocabulary knowledge as one of the five crucial components of reading ability (Scott & Nagy, 2004). However, comprehensive vocabulary instruction should go beyond simply teaching specific words to students. Researchers have advocated that for vocabulary programs to be most effective they ought to include several aspects intended to develop vocabulary knowledge, including wide reading, teaching word learning strategies in order for students to learn words independently, and fostering word consciousness, so that students develop an appreciation for words, in addition to teaching individual words (Graves, 2000; Graves & Watts-Taffe, 2002; Baumann, Kame'enui, & Ash, 2003; Scott & Nagy, 2004).

The use of vocabulary-enriched content on the computer, allows for students to receive academic language in a contextualized environment where students have additional resources such as definitions, explanations and examples to aid in understanding of specialized vocabulary. This intervention program is based on a

conceptual framework that sees vocabulary development as involving multiple tasks. Specifically, the learner has to acquire knowledge of the concepts the word represents, knowledge of the associations a word evokes, and knowledge of the multiple meanings of the word (McLaughlin, et al, 2000). Thus, this study examines students' use of web pages designed to supplement the science vocabulary on the topic of ecology to increase students' knowledge of specialized academic vocabulary in English and Spanish.

Unlike other forms of vocabulary children encounter in school academic vocabulary can be especially difficult, such as scientific vocabulary, which presents challenges for acquisition (Wilson, 1998). Science terms are particularly challenging, as they are "conceptually complex" and can require an understanding at various levels of abstraction (Vygotsky, 1978; Meyerson, Ford, Ward, & Jones, 1991; Best et al., 2006). As such, children often struggle in the comprehension of scientific terms due to their lack of conceptual knowledge, which in turn can limit their ability to learn the relevant vocabulary (Meyerson et al., 1991). A sufficient understanding of science terms involves the acquisition of deep conceptual knowledge, such as an understanding of physical processes (Wilson, 1998), and a 'deeper' semantic knowledge is needed to use the language of science in a meaningful way and to generalize word meanings (Best et al., 2006).

As science learning is rooted in acquiring understanding of inter-related concepts, which then constitute an organization of knowledge in a specific area (Best et al., 2006), the acquisition of words pertaining to a scientific domain is essential to the acquisition of

domain knowledge. Thus, the acquisition of new words and domain knowledge influence each other (Carlisle, Fleming, & Gudbrandsen, 2000).

Previous research has indicated that children struggle in acquiring science terms from brief, incidental exposures, due in part to the fact that the acquisition of science terms extends beyond the mere mapping of a word to a referent (Deák & Wagner, 2003). In a study by Braisby et al., (1999) children from 4- to 7-years-old had difficulty acquiring novel science terms from a single science lesson presented on videotape. It was reported that few children provided new terms and only a small portion demonstrated lexical learning on a multiple-choice comprehension task. However, educational studies have demonstrated that when students have extended opportunities to explore the meaning of science terms on multiple occasions, in which word meanings are discussed, have been proven to be much more successful in terms of word learning (Lloyd & Contreras, 1987; McGuigan, 1990; Ogborn, Kress, Martins, & McGillicuddy, 1996). It should be noted however, that when children's representations of science terms are examined in detail, erroneous understandings often continue to exist (Williams & Tolmie, 2000).

Academic English has yet to be the focus in elementary school curriculum, despite the fact that school-based tasks are becoming increasingly complex and academic across content areas (Baker, 2001; Gersten & Baker, 2000; Wong Fillmore & Snow, 2000; Merino & Hammond, 2001, 2002; Scarcella, 2003). According to the National Literacy Panel, only three experimental studies of English vocabulary learning were found that targeted English-language learners (August & Shanahan, 2006). Conversely,

the National Reading Panel found 45 experimental studies of vocabulary teaching with first-language students (National Institute of Child Health and Human Development, 2000, in Shanahan & Beck, 2006). Research on vocabulary attainment with native English speakers, have consistently found a high proficiency rate when instruction leads to deeper processing of word meanings, in addition to incorporating greater repetition and use of words in various formats (Vaughn-Shavuo, 1990; Shanahan & Beck, 2006). These findings are consistent with a recent report by the National Literacy Panel on language-minority children and youth (2006) which suggests that English-language learners' literacy development, specifically vocabulary development, should focus on language skills that are tied to higher order cognitive tasks, such as language for categorizing, reasoning and abstract thought.

Rational

The present study aims to extend our understanding of lexical acquisition as it relates to academic vocabulary in English and Spanish by investigating whether multilingual children in a two-way immersion program can benefit by utilizing a web-based tool to aid in the process of acquiring science terms. Therefore, this study provided students in two-way immersion program with additional computer-assisted vocabulary support in the form of web pages that were created to supplement the science curriculum and aid the acquisition of target words. These web pages served to aid in the acquisition of science terms and their related concepts.

As a complimentary component to the intervention web pages, was an Ecology WebQuest worksheet (see Appendix A) intended to probe students knowledge regarding the target science words and guide students towards the target-word web pages, which were designed to aid academic vocabulary acquisition. A WebQuest as defined by Bernie Dodge allow learners to explore essential questions by using information they gather from the Internet, analyze a body of knowledge, synthesize this knowledge and demonstrate their understanding through creation of a final product that others can react and respond to (Vidoni & Maddux, 2002). However in moving beyond the traditional WebQuest, the web pages created for this intervention utilized a number of research-based vocabulary practices that have shown to be effective, that is strategies which include providing definitional and contextual information about each word's meaning; actively involving students in word learning through comparing, analyzing, and using the target words; in addition to providing multiple exposures to meaningful information about each word in the context of the science topic, in both English and Spanish (August, Carlo, Dressler, & Snow, 2005). This enables students to acquire the target academic vocabulary in the context of explanatory narratives regarding the concepts associated with these science terms.

With greater emphasis being placed on standardized assessment of academic ability and English proficiency since the passage of the *No Child Left Behind* Act of 2001, vocabulary attainment has become even more crucial for academic success. In fact research has demonstrated that teachers often gauge a students' general intelligence or knowledge in a particular domain based on their vocabulary ability (Corson, 1997). This

can have severe consequences for English language learners (ELL) who are still developing their vocabulary, not only in their primary language but also in the second language. As a result, two-way immersion bilingual programs, also known as dual-language, have gained in popularity in recent years. The cause of such popularity can be attributed to the fact that such programs offer English learners and native English speakers the opportunity to develop a second language together, and allows students from varying ethnicities and cultures the opportunity to learn from and about each other. Additionally, research has shown that on standardized tests given in English, both language majority and language minority students in two-way immersion programs do as well as or better than students learning only in English (Lindholm-Leary, 2001; Thomas & Collier, 2002).

While research has shown that English learners are performing well in dual-language programs, the acquisition of academic language (AL) is still a challenge for all students, especially so for English learners. One of the challenges for students acquiring academic language, especially for English learners, is that fact that by its very nature, academic language can be very specialized and therefore decontextualized, in the sense that it is often content-specific which limits the ability for learners to be aided from their immediate environment (Cummins, 1984, 2000). Also making the acquisition of AL difficult is the little to no feedback students receive by others as they attempt to construct meaning, thereby requiring the learner to be vigilant of their performance based on others' perspective as to whether they are being understood (Bailey, 2006). Therefore research is needed to identify the types of instruction, which can aid students' academic

vocabulary attainment, as research has demonstrated vocabulary knowledge to be a stronger predictor of academic performance on tests of reading, than students' content knowledge (Garcia, 1991). Researchers agree that students must acquire not only general vocabulary but also content-specific vocabulary, in addition to various language functions, and complex grammatical and discourse structures to be academically proficient at acquiring new knowledge and skills (Bailey, 2006).

Given this information regarding the challenges of academic vocabulary attainment, especially so for English learners, this study seeks to explore the merging of technology and research-based vocabulary strategies to aid science vocabulary acquisition for students enrolled in a two-way immersion program through the investigation of the following research questions:

- Can a web-based vocabulary supplement aid the acquisition of academic science target words for multilingual students?

- To what extent did students utilization of the web pages contribute to their academic vocabulary growth?

- How did students demonstrate their comprehension of the academic vocabulary targeted in the intervention web pages?

CHAPTER II: REVIEW OF LITERATURE

Overview

The subsequent literature review encompasses research across various domains in order to explore the attainment of academic vocabulary for students in multilingual settings through the addition of technology and its use in supporting the science curriculum in a dual-language setting. I begin by detailing the institutional context in which this study takes place, specifically outlining two-way immersion programs as a dimension of bilingual education. This requires a preliminary detail analysis regarding the history and effect of bilingual education on California educational policy and two-way immersion as one aspect of bilingual education. I proceed with a review of early childhood language development and its relation to second language acquisition, and a discussion of academic language and its importance to school success for all students, in particular for English learners. I conclude with a summary of research on the use of technology and second language acquisition, and how this literature informed the conceptual framework and design of the intervention created for this study. As the goal of the intervention was to aid students' academic vocabulary development in English and Spanish in the content area of science, the following research was synthesized and led to the design of the intervention web pages, which contained embedded vocabulary strategies used to facilitate the academic vocabulary attainment of students participating in this study.

Bilingual Education in California

According to the California Department of Education's 2007 Language Census, English learners (EL) in California have steadily increased from approximately 400,000 students in 1981, to approximately 1,568,661 in 2007 or 25.0% of the total student enrollment. Of the roughly one and half million EL students in California, 85.0% speak Spanish, and approximately 500,199 (29.9%) EL students are currently enrolled in Los Angeles County (Language Census, 2007).

With the increase of English learners throughout U.S. schools, never has there been a greater need for supporting students who do not have English as there first language in developing English fluency and building their academic language. However there is still great debate between educators, researchers and policymakers on the need for such programs and as to which programs and strategies are most effective in teaching children a second language. Advocates against bilingual education, such as Linda Chavez, author of *Out of the Barrio* (1991) and Richard Rodriguez, *Hunger of Memory* (1982) argue for assimilation into "mainstream" English-speaking society while minimizing the recognition of students' native language. They view federal bilingual education programs as perpetuating a victim status, whereby students are encouraged to maintain their language and culture in return for rewards handed out through federal, state and local educational policies that prevent assimilation. Yet prominent educators and researchers come to a very different conclusion regarding bilingual education. They (Hakuta, 1986; Cummins, 1997; Crawford, 1998, 1999; García, 2001), argue that bilingualism is a positive social, linguistic, and educational attribute that should be

encouraged and developed for children who come to school speaking little to no English (García, 2005).

As a result of the continuing debate over bilingual education, numerous programs have been implemented. Two of the most common programs are English-language development/English as a second language (ELD/ESL) and sheltered English immersion (SEI). Though each type of program emphasizes English during instruction, they do take into account the fact that students are limited in English proficiency (García, 2005). Often these bilingual programs are designed and implemented with the goal of teaching language minority children to speak English, though with little regard to maintaining their first language skills and their culture. Nor do most of these programs take into account how students' attitudes of learning a second language, along with the attitudes of their native English speaking peers, influence the acquisition process in order to create a learning environment where all students feel comfortable learning and speaking in two languages. Researchers agree that a "true" bilingual program should seek to cultivate proficiency in both languages, as evidence has shown that students' first language (L1) can be maintained and developed at no cost to the acquisition of the second language (L2) (Christian, 1994).

One of the major events to affect bilingual education programs occurred when California voters passed Proposition 227, "*English for the Children*" on June 2, 1998. This resulted in divisions of pedagogy and class instruction for teaching limited English proficient students. Under Proposition 227, all children are required to be placed into English language classrooms. Limited English proficient students are placed in structured

English immersion program, not to exceed one year, afterwards they are transferred to English-only or mainstream classrooms where teachers are not required to provide native language support or modify their instructional approach even if students are not proficient in English (Amaral, 2001). Parents are allowed to sign waivers if they wish for their children to be placed in traditional bilingual programs. In such cases, when schools receive at least 20 waivers, bilingual educational models can be implemented so long as they use bilingual education methodologies permitted by law. It should be noted that under Proposition 227 teachers, administrators and school board members are personally liable for fees and damages sought out by parents and guardians for improper implementation of instruction (Garcia & Curry-Rodriguez, 2000).

In addition to Proposition 227, of equal importance in terms of the effects for ELs occurred with the passing of the No Child Left Behind (NCLB) Act of 2001, which places a greater emphasis for English-only instruction or alternative English language acquisition programs over bilingual education programs. NCLB support of English-only instruction over bilingual education relied on research, which demonstrated the failure of bilingual programs to increase English proficiency and the academic performance of English learners. It should be noted however, that such research demonstrating the "failure" of bilingual programs frequently rely on only two indicators: (1) redesignation rates of EL students and (2) performance on standardized tests in English. These two criteria point to the flawed reasoning in relation to the developmental continuum of second language acquisition and demonstrates a fundamental misunderstanding of the use of students' native language in the development of their literacy skills and cognition for

English learners (Cummins, 1981; Olivos & Quintana De Valladolid, 2005). Researchers agree that in order to understand the processes by which students become or fail to become bilingual and biliterate must take into account the economic and sociocultural forces, in addition to the educational factors, such as the language policy, size and geographic location of schools and their communities and the economic benefits of knowing two languages, all of which will inevitably affect what occurs in schools and classrooms (Guerrero & Sloan, 2001).

Since the passing of Proposition 227, bilingual education has splintered into various, distinct program types: Transitional bilingual education, maintenance bilingual education, English as a second language, structured English immersion, and mainstream English programs (Garcia, 2005). Despite the variety in bilingual education programs, it is two-way immersion programs (TWI) also known as dual-language programs, which have gained in popularity by educators, researchers and parents alike. TWI programs are typically favored over other bilingual programs such as English as a Second Language (ESL) pullout and transitional bilingual education (TBE) in that TWI programs allow for both minority language (e.g., Spanish) and majority language (e.g., English) students to learn together, thus attempting to eliminate the segregation of EL students by integrating and promoting an appreciation for the languages and cultures of all students in the curriculum (Howard, Christian & Genesee, 2004).

Traditionally bilingual programs in the United States have focused on aiding English Learners achieve English fluency, though they often vary in their implementation

and language outcome goals (see Table 1), such as attempting to preserve student's native language and promoting biliteracy, though not always a priority for all programs.

Table 1. Bilingual Education Programs

Program Type	Child Type	Classroom Language	Educational Aim	Language Outcome
Immersion	Language Majority	Bilingual w/ emphasis on L2	Pluralism & Enrichment	Bilingualism/ Biliteracy
Maintenance/ Heritage Language	Language Minority	Bilingual w/ emphasis on L1	Maintenance, Pluralism & Enrichment	Bilingualism/ Biliteracy
Mainstream Bilingual	Language Majority	Two Majority Languages, Pluralism	Maintenance, Biliteracy & Enrichment	Bilingualism
Two Way/ Dual Language	Mixed Language Minority & Majority	Minority & Majority	Maintenance, Pluralism & Enrichment	Bilingualism/ Biliteracy

Adapted from Baker, C. (2006). *Foundations of Bilingual Education and Bilingualism* (4th Edition). Clevedon, UK: Multilingual Matters.

Two Way Bilingual Immersion Programs

Two-way, or dual language bilingual programs are an attempt to bridge the two language environment in which many students find themselves entering both in and out of school. For example, such programs allow for native English and Spanish speakers to learn together and engage in discourse in both languages, as both languages are used in the classroom for instruction. One of the primary goals of two-way bilingual programs is the ability for students to achieve full bilingualism, including biliteracy.

Research on such programs have demonstrated success for minority language students (e.g., native Spanish speakers) in two-way bilingual programs which have shown increases in academic performance equal to or above same grade peers not enrolled in two-way classrooms, in addition with higher increases in English literacy. The same improvement can't be said for native English speakers in two-way bilingual programs who struggle to develop high levels of Spanish literacy (Alanis, 2000). While the benefits for native English speakers may not reach the proficiency in the second language as compared to their EL peers in dual language programs, that is not to say that there does not exist benefits for these children in such linguistically diverse programs. In fact research supports the fact that native English speakers exposed to more than one language in school can lead to greater metalinguistic awareness, with cognitive advantages existing for those who are equally fluent in both languages (Bialystok, 2001).

Two-way immersion programs are designed to develop 1) high academic achievement, 2) cross-cultural awareness and 3) bilingual proficiency for both Spanish and English speakers. Two-way bilingual programs have annually increased in California from over 20 programs in 1990, to approximately 201 programs in 2007-08 according to the California Department of Education. These programs have been increasing specifically at the early elementary and upper elementary grade levels due to their success in developing bilingualism, biliteracy and cross-cultural awareness in both language minority and majority students which has subsequently led to increases in federal and state funding for TWI programs (Montone & Loeb, 2000).

TWI programs have gained in popularity with both parents and researchers of EL students, due in part to the fact that such programs promote bilingualism for both minority language and majority language students; they are an additive form of bilingualism; and the curriculum is tied to state standards for all students with both academic and literacy instruction provided in both languages.

TWI programs are characterized by the amount of instruction in each language, which varies with the program model. The most common models are 90/10 and 50/50. 90/10 programs start with 90% of the day (typically beginning in kindergarten) in the non-English language, in which content and reading are taught to all in the non-English language first. 50/50 programs are taught equally through the two languages. In terms of reading instruction, reading may be taught in each L1 first or simultaneous reading instruction in both languages may occur. Regardless of the program model, ideally half of the students are from each language group. Programs generally start in kindergarten and continue into middle and high school if possible. TWI programs generally exist as a strand within a school whereby there is only one TWI classroom per grade level. TWI encompasses four critical factors: (a) both native and non-native English speakers are participants, (b) the students are integrated for most content instruction, (c) the program involves periods of instruction during which only one language is used, and (d) where the non-English language is used for a significant portion of the students' instructional day (Alanis, 2000).

The goal of TWI programs is full bilingualism for all students, in addition to biliteracy. As such literacy may initially emphasize native language literacy or focus on

literacy being acquired in both languages simultaneously (Baker, 2001). Research does indicate that minority language students demonstrate higher levels of proficiency in English than EL's in non bilingual programs, with EL's performing on par in English with EL's in English only programs (Thomas & Collier, 1996; Garcia, 2005). It has also been shown that EL's with more exposure to English (50/50) show an initial advantage over EL's with less English exposure (90/10). It also has been found that higher levels of bilingual proficiency among minority language students are associated with higher levels of academic language proficiency (Lindholm-Aclan, 1993). That is students in high quality two-way programs can score around grade level in reading measurement in both Spanish and English by late elementary grades (Lindholm-Leary, 2005).

Extensive research has shown that in developing a successful two way bilingual program one of the key features is understanding the attitudes of second language learners, particularly Spanish speakers learning English (Griego-Jones, 1994). Educators have also known that in order to learn a second language, students must have a desire to learn a new language, and this learning must take place in an environment in which students can interact with speakers of both languages (Griego-Jones, 1994). In addition, for a successful two way bilingual program to work, students of both languages, when placed into a dual-language supported classroom together, need to acquire much more than each other's language but must also embrace and adopt each other's culture, norms and social interactions associated with those cultures and linguistic norms (Griego-Jones, 1994).

Having extensive opportunities to use and hear the language being used in different contexts and thus figuring out the meaning of utterances in certain social settings is essential for second language acquisition (Snow, 1990; Wong Fillmore, 1989). It is also the case that peer interactions have been shown to be more supportive of L2 learning than adult-child interactions (Dejong, 1996).

Early Child Language Development

As with language learning, children's early capacities to make sense of the world around them and learn from these experiences, through their cognitive development, can have effects on children's learning of one or more languages, which can lead to differences in children's growth trajectories of fluency in each of their languages. For instance, children from birth to the age of five engage in many levels of human interaction: counting and quantification, spatial reasoning, physical causality, problem solving, categorization and language. For example, infants less than a month of age can imitate other's gestures, by six-to-eight-months can represent numbers and begin to understand the properties of physical objects and by 9-12 months of age, can learn new behaviors by watching others (Shonkoff & Phillips, 2000).

While we typical view children at this age as egocentric, research indicates that even two and half year-olds can take on the perspective of another person, and by age 5 this has developed into a mature theory of mind, in which children can predict others' intentions, deceive others successfully, and recognize that beliefs don't always correspond to reality (Shonkoff & Phillips, 2000).

As with cognitive development, language development consists of numerous components, which appear to be affected by children's interaction in various learning environments prior to attending school. Thus children arrive to school with vast individual differences in their understanding of the alphabet, and its relationship to sounds and printed words, and widely varying vocabularies (Shonkoff & Phillips, 2000). Thus, understanding where students are in terms of their early development is crucial, as this sets in motion how children will deal with learning multiple languages and the success or difficulties they may encounter as they balance these languages. The evidence of whether there is a critical period, some say around the ages of 3 to 5 years-old, as not been confirmed, in terms of both cognitive and language development. The evidence for sensitive periods in language development is largely restricted to pronunciation and the complex morphological properties of language, as well as vocabulary, familiarity with letter-sound associations, and language proficiency (Shonkoff & Phillips, 2000).

Hence for typically developing children the age of acquisition of a second language remains an integral factor in determining the degree of fluency children will obtain in their L2. For example, research has shown that for learners of a second language who were first exposed to L2 after puberty find certain aspects of language (often morphological aspects) difficult to master even after decades of use, yet in the domain of word order, L2 learners find this relatively easy to control (Newport, 1991). These findings were also found with adults who experienced difficulty leaning a second language, suggesting that cognitive maturity is not sufficient to guarantee grammatical development (Johnson & Newport, 1989).

To date there has not been a substantial amount of empirical research, through the use of longitudinal studies, which follows children acquiring two or more languages over time, in order to answer what key factors come into play in children's second-language development. As a result there remains no definitive model or framework, which can describe the trajectory of L2 development for children who have English as L1 and are exposed at school to curriculum in two languages. Therefore, to create models that can help to predict and estimate the trajectory of children's L2 development, we must understand how and when children are acquiring multiple languages and at what stage of development (i.e., cognitively and socially) these children are at when they begin to acquire L2, in order to understand how these factors interact and effect children's linguistic growth over time.

Understanding how languages coexist and evolve during children's stages of development may lead to a better understanding of how multiple language learning changes over time. This may be accomplished through instruction based on individual characteristics of children who fall within similar parameters of development, allowing for educators to aid children's development by targeting specific cognitive and/or linguistic skills needed in facilitating multiple language acquisition. Thus, in exploring the developmental factors associated in multiple language development we may begin by examining how children with differing L1 (i.e., children who are native English and Spanish speakers) are learning together in a multilingual curriculum, such as in two-way immersion programs.

Additional research has also shown evidence that child L2 acquisition between 5-10 years of age shares most properties with adult L2 acquisition, indicating that for successful L2 acquisition in terms of both conversational and academic language development may require fully developed cognitive processes observed in older learners (Meisel, 2004). Thus, it is no surprise that to this day, the debate on whether learning and being fluent in more than one language can lead to cognitive benefits still remains unequivocally unanswered and is highly contested.

Nevertheless, understanding the cognitive processes associated with second language acquisition, especially early simultaneous acquisition of multiple languages is crucial not only for the design and implementation for successful bilingual education pedagogy, but human development in general as it relates to language learning and its association with cognitive development.

Second Language Acquisition

In understanding how children come to manage multiple languages and utilize these communicative abilities with proficiency, one must take into account how children acquire multiple languages in order to examine how the type of acquisition can affect language and cognitive development. There are three general types of bilingual acquisition: (1) *simultaneous acquisition of bilingualism* (2L1), in which a child acquires two or more languages during the first three or four years of life; (2) child second language acquisition (L2), where the onset of acquisition of multiple languages happens between the ages of five and ten, and (3) adult L2 acquisition, where the acquisition of multiple languages occurs after the age of ten (Meisel, 2004).

Knowing how, when and to what degree children are exposed to multiple languages is essential in order to characterize children's language development as they are proceeding to becoming multilingual. Research has suggested that the subsequent course of second language (L2) acquisition proceeds through similar developmental phases as first language (L1) acquisition and at a rate in each of these languages, similar to the acquisition in monolinguals (Meisel, 2004). Thus, it stands to reason that the age in which children acquire both languages affects the developmental trajectories of both languages, in terms of fluency (linguistic competence), pronunciation, and cognitive development. For instance, children who simultaneously acquire two or more languages from birth have the ability to differentiate the grammatical systems of their languages very early on. This has lead researchers to believe that the simultaneous acquisition of two or more languages in the beginning of a child's development may indicate an example of multiple first language acquisition. This is due to the fact that children are able to acquire similar linguistic knowledge of both languages, primarily grammatical knowledge of each language, in much the same way as monolingual children (Meisel, 2004).

Research has also found age to be a factor in L2 acquisition, by demonstrating that there are different linguistic and cognitive advantages, depending upon when children began learning two or more languages, which may imply that there are different trajectories of growth of L2 attainment. For example, when L2 is acquired after the age of ten, research has indicated that L2 acquisition resembles adult L2 acquisition, suggesting that children with more fully developed cognitive processes, may be able to draw on

more cognitive resources and their L1 knowledge to aid in L2 acquisition (Meisel, 2004). It must be noted that research has also shown that prior knowledge of L2 learners can have both positive influences (felicitation) on L2 learning and negative influences on L2 learning (interference). This interaction between L1 and L2 may occur due to the cognitive procedures that are employed in the processing of a second language. For instance, if one learns a language that is typologically very different from one's L1, it may take longer to acquire L2 compared with a language that is similar to one's L1, thus the greater the difference between languages the longer it may take to learn (Butler & Hakuta, 2004).

In terms of utilizing prior knowledge and L1 competence to one's advantage, research has demonstrated that academic-related skills developed in L1 are related to those in L2. According to Cummins's *interdependence hypothesis*, academic proficiency in L1 and L2 are interdependent, in the sense that there is a "common underlying proficiency" composed of both conceptual and procedural knowledge and skills, which enables bilinguals to transfer academic skills from one language to another (Butler & Hakuta, 2004).

Due to the conflicting nature of research on second language acquisition, it's of no surprise that the "critical period" in L2 acquisition has yet to be definitively found. It must also be noted that some age effects over performance have been shown to disappear when learner's educational backgrounds were controlled for (Butler & Hakuta, 2004). Therefore, more research is needed in order to understand the age related factors of acquisition and its association with children's language and cognitive development.

In determining how multiple language development is acquired and utilized by children over time, especially in the case of early L2 acquisition, between the years from birth to 5 years of age, considerations in children's cognitive and social development, should factor in contributing to early L2 acquisition and the ensuing trajectory of language fluency. Thus, examination may warrant taking into account children's stage of development and their subsequent cognitive and social abilities (e.g., taking audience into account, their development of theory of mind, social referencing and perspective taking) as they are acquiring L2. Clearly, the developmental stage that a child is in will influence what is learned on any given occasion (Blok et al., 2001).

Academic Language & English Learners

For second language learners the ability to acquire native speaker like skills in their second language (L2), can be incredibly difficult, especially when acquiring academic language in L2. Second language teaching typically does result in second language learners acquiring a large vocabulary in a short period of time. However for these students, acquiring academic language in L2 is often a challenge as most second language teaching materials emphasize the acquisition of high frequency words, especially in the early stages of L2 instruction (Groot, 2000). Research on vocabulary attainment in L2 reading comprehension has shown that a minimum of 5000 word vocabulary is necessary to comprehend non-specialized text, and for adequate comprehension of academic text, this number jumps to between 7000-10,000 words, as readers need to understand and be familiar with 90% of the words used for sufficient comprehension of texts at this level (Groot, 2000; Hazenberg & Hulstijn, 1996; Laufer,

1997). The majority of empirical research suggests that English learners need between five to seven years to fully master academic English discourse (Hakuta, 1986).

The importance of vocabulary knowledge goes beyond knowing the literal meaning of a word, but also implies knowing many other things about the word – its various connotations, syntactic and morphological constructions and options, and the many semantic associations such as synonyms and antonyms; all aspects related to the depth of word knowledge, yet previous research has demonstrated that ELLs know fewer English vocabulary words (breadth of word knowledge) than their monolingual English speaking peers, in addition to also knowing less about the meaning of such words (August, Carlo, Dressler & Snow, 2005).

In comparison to oral language, the language found in text is typically characterized by low frequency vocabulary and complex grammatical structures, all of which can place greater demands on memory and other cognitive processes. Academic language is often distinguished by the fact that it is cognitively demanding and relatively decontextualized (Cummins, 1984, 2000). It should be of no surprise that academic language could be difficult for language minority students to acquire when they are required to carry out cognitively demanding tasks in context-reduced situations (Solomon & Rhodes, 1995). Beck, McKeown, and Kucan (2002) divide vocabulary words into three tiers. They define Tier 1 as basic words (i.e., clock, baby, happy) which rarely require instruction; Tier 2 words that have importance and utility and appear frequently across domains; and Tier 3 words, which are not frequently used across a variety of

domains, these words are also referred to as specialized Tier 3 words (i.e., isotope, continent) which require concept knowledge in order to fully understand such words.

Academic language involves knowing an increased number of language functions, such as signaling, cause and effect, hypothesizing, generalizing, comparing, contrasting, explaining, describing, defining, justifying, giving examples, sequencing, and evaluating. Academic English builds upon and extends a student's prior and developing knowledge of words, grammar, and pragmatic conventions to understand and interpret academic English (Scarcella, 2003). Academic vocabulary can vary among academic disciplines, ranging from specialized words used in specific academic fields to non-specialized words used across academic fields (see Table 2).

Table 2. Words Occurring in Academic Settings

Type of Words	Meaning	Domain	Examples
General Words	Non-specialized	Across fields	already, busy
Technical Words	Specialized	In specific fields	fulcrum, pivot
Academic Words	Non/Specialized	Across fields	assert, research

Scarcella, R. (2003). *Academic English: A conceptual framework* (Tech. Rep. No. 2003-1). Santa Barbara, CA: The University of California Linguistic Minority Research Institute.

Unfortunately, academic English has been given little attention in elementary schools, at a time when school-based tasks are becoming increasingly complex and academic in nature in the later elementary school years (Baker, 2001; Gersten & Baker, 2000; Wong Fillmore & Snow, 2000; Merino & Hammond, 2001, 2002; Scarcella, 2003). According to a recent report by the National Literacy Panel on language-minority

children and youth (2006) suggests that for English-language learners' literacy development, specifically vocabulary development, focus on language skills that are tied to higher order cognitive tasks, such as language for categorizing, reasoning and abstract thought. Due to evidence in support of cross-language effects in vocabulary development, this language support can be provided in either the first or second language, so long as higher order language skills, otherwise known as academic language skills remains the focus of such support (August & Shanahan, 2006).

Although in recent years teachers have been trained to teach phonics, many academic English problems revolve more around the students' deficiencies in academic English than around their ability to decode single words (Wong Fillmore & Snow, 2000). Researchers agree that "literacy" goes beyond the ability to read and write (decoding and encoding), but also includes higher-order thinking, such as conceptualizing, inferring, inventing, and testing (August & Hakuta, 1997; Wong Fillmore & Snow, 2000; Scarcella, 2003). Therefore to develop academic English, students must have already acquired a large amount of basic proficiency in the grammar of English, as academic English requires the development of advanced grammar and vocabulary (Scarcella, 2003). Literacy experts continue to find a link between vocabulary knowledge and the ability to comprehend text, with research showing the breadth and depth of student's vocabulary to be a key predictor of their ability to understand a wide range of texts, with this being true for both native speakers of English and second language learners (Wood, 2001).

Technology and Second Language Acquisition

Traditionally multimedia learning has focused on the areas of science, math, social studies, and language arts. It is only recently that multimedia has been used in learning to acquire a second language, as educators begin to utilize technology as a teaching tool in bilingual programs to capture students interest and aid students in the area of second language acquisition (Bishop, 2000). For example, teachers of English learners are finding novel and creative ways of the using the technology they have available to them, to aid their students, by using computers to capitalize on student interest in this medium as both a motivational and learning tool which allows for student, peer and teacher interaction around computers (Meskill, 2005). As a result of such interest in using technology in second language acquisition, studies have focused on building students vocabulary, word translations, reading comprehension, and listening comprehension. Such research has found success in using multimedia to aid students learning of a new language (Plass, Chun, Mayer, Leutner, 1998; Jones & Plass, 2002).

Research on computer-assisted word learning has been the focus of educators and educational researchers since the 1980's (Blok, 2001). Early studies by Miller and Gildea (1987), found that through the use of a video display, children significantly improved their understanding of unfamiliar words. They concluded that computers were able to make learning words easier for upper elementary grade students when definitions, sentences and pictures were utilized with a video display. It should be noted that in the study by Miller and Gildea, students learned words in their native language. Research by Beheydt (1990, 1994) in the field of second (L2) and foreign language vocabulary

learning also found evidence that computers can be effective for language and word learning. Goodfellow (1995), in reviewing examples of computer-assisted vocabulary learning programs also indicated the positive possibilities of 'second-generation courseware' yet gave no information regarding the efficacy of computer-assisted vocabulary learning compared with traditional vocabulary instruction (Blok, 2001). Though researchers advocate that computers do offer great potential for L2 and foreign language vocabulary learning, the majority of research is often exclusively done in secondary and postsecondary education (Blok, 2001).

Some of the major hurdles for second language learners are the mastering of grammar in their second language, along with word order, prepositions, nouns and verbs. For example, in acquiring knowledge and appropriate uses of verbs, one must gain an understanding of the many subcomponents and nuances, such as present tense, future tense, and two-level verbs. However, language teaching educators have recently shifted from a solely grammar-oriented approach to an integrated grammar and vocabulary acquisition approach which has been shown to be more effective in developing communicative competence (Groot, 2000).

Therefore in the designing and implementing of multimedia technology for second language learning, instructional methods should incorporate second language pedagogy in order to specifically target the skills intended for development, such as grammar and vocabulary. As a result, research in the field of multimedia learning has sought a theoretical framework of learning from technology in order to examine how technology can aid in second language learning. Working from Mayer's (1997, 2001)

Generative Theory of Multimedia Learning, which builds on Paivio's *Dual Coding Theory*, suggests that words dually-coded, both verbally and non-verbally along with pictures, can be more easily remembered as more paths for retrieval are solidified. Researchers have thus expanded these theories to examine the areas of listening comprehension, vocabulary acquisition, and visual and verbal learning preferences in second language acquisition (Plass, Chun, Mayer & Leutner, 1998; Jones & Plass, 2002).

This new theory of *multimedia second language learning* is derived from previous studies on memory and visual associations and dual coding of verbal and nonverbal pictures and information processing models. This research has indicated that second language learners, in the translation of words utilize a link between their two verbal systems in addition to an imagery system and the addition of the second verbal system, which aids in their learning (Plass et al. 1998). Therefore in aiding second language learners in the acquisition of vocabulary in L2, associating unfamiliar words with imagery of actual objects of these words may allow for well-connected mental representations and schemas, thus leading to easier learning. As Plass et al. (1998) states, "students learn new words when they can establish a direct connection between a word in their native language, the corresponding picture of an object or action, and its foreign equivalent. They thus build two types of retrieval cues in memory," (p. 26). Additionally, we know from research that vocabulary does not develop by exposure alone, requiring systematic and explicit instruction where students have repeated opportunities to hear and use the new words in various contexts along with strategies for their own independent

learning of new vocabulary, this being especially important for ELLs (Bailey & Heritage, 2008).

Multimedia may then be able to expand on and supplement traditional mediums for teaching a second language, (e.g., textbooks, lecturers, etc.) by the affordances that multimedia provides, such as allowing for additional information, additional aids/helps and allowing for multiple user/learner preferences for acquiring information. However, in order for multimedia to be effective in second language acquisition, one needs to specify the affordances that each medium provides, in terms of L2 development. One advantage of multimedia, primarily computers and software is the ability for learners to construct and create a learning environment of their own, attending to and choosing their desired learning modalities, and preferences. Modern learning theories such as the constructivist learning theory, suggest that allowing the learner to control the learning process through authentic creative experiences of their own creation, not only increases motivation and positive attitude towards the task, but also greater creative involvement on the task, all keys for successful learning (Nikolova, 2002).

It should also be noted that language is often taught and viewed merely as a set of linguistic structures (e.g., vocabulary, grammatical forms, discourse gambits, etc.), in essence words and sentences, neglecting to view language as discourse and interaction in context (Duranti & Goodwin, 1992). Through the use of multimedia as an educational tool, educators can address these issues in language learning of both grammar and discourse context by opening up immense possibilities that go beyond showing L2 in text and pictures, but also in video, which can show language learners the language in use by

native speakers. Providing a visual representation of new knowledge where students can link new vocabulary to new concepts is particularly helpful for ELLs (Bailey & Heritage, 2008). Such affordances of multimedia can allow for the understanding of cultural and social aspects of language, which research using multimedia has shown to be successful in teaching language through authentic cultural context (Kramsch & Andersen, 1999).

Summary

Researchers (August et al, 2005) agree there is a greater need for quasi-experimental and experimental studies that focus on English vocabulary development for elementary-school language-minority children, which utilize creative methods to expose English learners to more words that develop and reinforce word meaning, for example technology that is purposefully crafted to reinforce word meanings, given the importance of vocabulary to oral and written language comprehension (NICHD, 2000).

The review of literature in the research areas – bilingual education, second language acquisition, academic language, and technology and second language learning, served as the foundation for this study. As the primary objective of this study was to aid the academic English and Spanish vocabulary development of language minority and language majority students, on the topic of ecology, a supplement to the science curriculum was designed.

As a result, this study aimed to provide students in two-way immersion classroom with a web-based tool designed to aid in the acquisition of target vocabulary on the topic of ecology. The intervention coincided with the current science curriculum of the

classroom, thereby serving as a supplement to the unit of ecology. The target and non-target vocabulary chosen for the study were highlighted in the science textbook of the classroom and emphasized as essential vocabulary/concepts for third-grade life sciences according to the California science standards, thus not placing any unnecessary curriculum demands on students or teachers. As previously discussed, the intervention was based partly on the inquiry-oriented activities found in WebQuest's as defined by Bernie Dodge whereby learners explore essential questions by using information they gather from the Internet, and then synthesize this knowledge in order to demonstrate their understanding (Vidoni & Maddux, 2002).

One of the key features of WebQuest's is the use of hyperlinks as a departure from linear text, which can promote vocabulary learning by allowing children to tap prior knowledge by creating semantic webs, offering students rich opportunities to encounter new words in multiple contexts by allowing them quick assess to text and graphics, that can lead to acquiring greater depth in the area of content-specific vocabulary words (Wood, 2001). Therefore the CSVS web pages incorporated the use of hyperlinks in the presentation of information to students much like a WebQuest. Unlike a traditional WebQuest however, the intervention consisted of off-line web pages, created in collaboration with the teacher participating in the study, with the added focus being on developing content-specific vocabulary with embedded vocabulary strategies intended to aid students acquisition of English and Spanish target words. In addition to the web pages, was an Ecology WebQuest worksheet, which probed target word knowledge by

required students to answer questions regarding the target words, from information found on the intervention web pages (see Appendix A).

The CSVS web pages utilized a number of research-based vocabulary practices that have shown to be effective, that is strategies which included providing definitional and contextual information about each word's meaning; actively involving students in word learning through comparing, analyzing, and using the target words; and providing multiple exposures to meaningful information about each word (August, Carlo, Dressler, & Snow, 2005). Thus the CSVS web pages, with its focus on vocabulary development at the heart of its design, along with the combination of exposure and opportunity to use the target words, allowed for the investigation of the following research questions:

- Can a web-based vocabulary supplement aid the acquisition of academic science target words for multilingual students?

- To what extent did students utilization of the web pages contribute to their academic vocabulary growth?

- How did students demonstrate their comprehension of the academic vocabulary targeted in the intervention web pages?

CHAPTER III: METHODOLOGY

Participants and Setting

The participants for this study consisted of fourteen third-grade students enrolled in one elementary two-way immersion school in Southern California, where Spanish and English are the target languages. The age of the students in the third-grade classroom ranged from eight to ten years old. In terms of the linguistic characteristics of the participants, ten students were English learners and four students were native English speakers acquiring a second language (i.e., Spanish). The native languages of all students participating in the study were: Spanish (n=8), English (n=4), Norwegian (n=1), and Zapotec (n=1). For the ten English learners, performance levels on the California English Language Development Test (CELDT) were obtained.

According to the California Department of Education (2008), the CELDT serves three purposes, to 1) identify pupils as limited English proficient, 2) determine the level of English language proficiency (ELP) who are limited English proficient, and 3) assess the progress of limited English proficient students in acquiring the skills of listening, speaking, reading, and writing in English. Though a portion of CELDT test questions are intended to engage academic language functions, such as explaining, questioning, analyzing, and summarizing, the Framework for California Public Schools Kindergarten through Grade Twelve, (2007) states that the CELDT primarily assesses "*basic social conventions, rudimentary classroom vocabulary, and ways to express personal and safety needs*" to assess ELP (pp.273-274). There are five performance levels on the CEDLT: beginning, early intermediate, intermediate, early advanced, and advanced. Of the ten

students designated as English learners, there performance on the CELDT was as follows: Intermediate (n=3), Early Advanced (n=2), and Advanced (n=5). See Table 3 for detail.

Table 3. Student Demographic Information

Demographic Information	N	Percentage
Gender		
Male	7	50.0%
Female	7	50.0%
CELDT Level		
Beginning	0	0.0%
Early Intermediate	0	0.0%
Intermediate	3	21.0%
Early Advanced	2	14.0%
Advanced	5	36.0%
Age		
Eight years-old	4	29.0%
Nine years-old	9	64.0%
Ten years-old	1	7.0%
First Language		
Spanish	8	57.0%
English	4	29.0%
Norwegian	1	7.0%
Zapotec	1	7.0%

*Ten of the fourteen students were designated as English learners; therefore there are no CELDT scores for the four remaining students in the study.

School Setting

The elementary school that served as the research site for this study is a two-way immersion program located in a suburban school district in Southern California. The school had a 2007 Growth Academic Performance Index (API) of 815. The school served approximately 412 students that make up an ethnically and linguistically diverse student population. There were 207 (52.5%) students classified as English learners. In terms of instruction, Math, Science, and Social Studies are taught in Spanish, with other classes (i.e., physical education, language arts, etc.) taught in English.

Research Design

This study utilized a cross-sectional mixed method approach for data collection and analysis. This entailed a sequential explanatory design, in which quantitative data collection (i.e., academic vocabulary assessments) and analysis preceded qualitative data collection and analysis (e.g., student discourse). Both types of data were used in the interpretation of the entire analysis (Creswell, 2003). This design allowed for the investigation of the effects of the Computer-Supported Vocabulary Supplement (CSVS) on students' acquisition of academic science vocabulary. Specifically, this permitted the experimental manipulation of the science vocabulary into target and non-target words in order to examine within student change as a result of the embedded vocabulary strategies in the intervention web pages. Therefore, participants were initially tested on standardized vocabulary measures, for both general receptive and target and non-target academic vocabulary in English and Spanish, prior to the intervention and again at the conclusion of the study. Table 4 presents a timeline of the data collection sequence.

Table 4. Data Collection Sequence of Study

Date	Testing / Intervention Activities
10/22/07 – 10/24/07	Word Matching in English - (pre-test)
10/22/07 – 10/24/07	Word Matching in Spanish - (pre-test)
11/2/07 – 11/27/07	Intervention – Web Pages / Ecology WebQuest
12/3/08 – 12/10/08	Podcast Reports
12/12/07 – 12/13/07	Word Matching in English - (post-test)
12/12/07 – 12/13/07	Word Matching in Spanish - (post-test)

Procedures

Web Page Utilization. Students explored the intervention offline web pages, that is web pages not connected to the Internet and specifically designed for this study. This was key for several reasons. It allowed students to explore web pages created and approved by both their teacher and the primary researcher. Students used the computers in the school computer lab as well as the computer in their classroom. Content of the web pages contained information obtained from the Internet and was chosen and developed in collaboration with the teacher participating in the study and the primary researcher. The web pages included specific content corresponding to the related science topic of the classroom curriculum, that being the subject of ecology. The primary focus of these web pages served as a supplement to the curriculum designed to aid in the development of academic vocabulary. All content on the web pages was a continuation of the current science curriculum. The web pages built on content students received in class through

traditional information sources (e.g., textbooks, handouts, etc.), and provided additional examples and definitions in explaining concepts with the focus of highlighting specific vocabulary terms. Research has continually indicated that words are best learned from rich semantics contexts, such as brief, engaging reading passages, along with instruction which teaches students to infer meanings from context, and the use of cognates, roots, affixes, morphological relationships, and comprehension monitoring (Carlo et al, 2004; August et al., 2005).

In addition, the web pages were hyperlinked to each other, giving students the illusion of using the Internet, yet having them remain in a contained space where they were only exposed to content approved by their teacher and the primary researcher. Students interaction with the system was recorded and logged, which included their entry and exit time to measure how much time each individual learners spent on each web page and to determine which web pages students visited as well as what features of the web pages students utilized, in order to develop an understanding of how students navigated and made use of the intervention web pages.

The CSVS was designed for students to openly explore the web pages in any order they so desired. As previously mentioned, the content of each web page served to further explain the concepts related with each target word. The CSVS program also contained a WebQuest activity in which students answered questions regarding the target vocabulary. The answers to each question could be found on the web pages, thus the activity served to both assess students knowledge regarding the science vocabulary and to guide them through the intervention web pages. Students were not instructed as to which

intervention web pages to explore or in what order to explore the web pages. Nevertheless, having the WebQuest activity accompany the web pages served to ensure the probability that students would navigate to the target web pages and thus increase exposure to the target vocabulary (see Appendix A).

The content of the web pages centered on the academic vocabulary associated with the science topic. The science terms targeted for the intervention and presented on the Word-Matching assessment was determined in combination of examining the national and state standards for third grade and consulting the teacher of the classroom. As the setting for this study was in a two-way immersion program, vocabulary assessments and content of the web pages were provided in both English and Spanish.

After the introduction to the science topic, the intervention began. Students worked on computers individually, but were allowed to speak with their fellow peers while exploring the web pages. Prior to exploring the web pages, students were instructed on the process of the intervention, which included a demonstration of the features found on the web pages, such as clicking on target words and opening pop-up windows linked to target words.

Each web page served to introduce academic vocabulary and their related concepts. Target vocabulary words were presented in the context of the science topic, along with the explanation of the abstract concepts associated with the science term. Target words were hyperlinked to a pop-up window where students were able to obtain both a formal dictionary definition and additional explanations and descriptions in English and Spanish. Images of, or associated with, the target vocabulary were also

present on each web page along with audio files which students could click to hear the pronunciation of the target words in English and Spanish. Visual aids have been shown to be effective in providing a scaffold to support children's understanding of science-related concepts and eliciting children's understandings of them (Ogborn et al., 1996; Best, 2003; Best et al., 2006).

Academic Vocabulary Protocols

As previously mentioned, the intervention consisted of web pages that incorporated word learning strategies known to be effective for acquiring academic vocabulary for both native speakers of English and English-language learners. Web pages were designed for this study to allow students to be presented with multiple strategies simultaneously in the context of the science topic of ecology and supplement the science curriculum in English and Spanish, by further explaining the meaning and concepts associated with the target vocabulary. The following word selection protocols were used to select the academic vocabulary implemented in the intervention web pages.

Word Selection. Prior to the design of the intervention web pages, word selection of the academic vocabulary, targeted for acquisition, had to be determined as each web page would be designed around each individual target-word. Each target word had a dedicated web page focusing on the concepts related to that word. Non-target words were also included throughout the web pages but were not the focus, nor were they linked to additional resources, as were target words. Non-target words were identical to target words in order to allow for within student comparisons of computer-supported and

unsupported academic vocabulary acquisition. This allowed for investigation into the efficacy of the treatment in the absence of a control group, as each student served as their own control at the level of vocabulary learning.

Target and Non-target words (referred to as Keywords) were selected based on a three-tier system:

1) The keywords were first selected by consulting the California Department of Education Science Standards for Third Grade – Life Science. The science topic was then narrowed to the topic of ecology. The keywords were either directly mentioned in the science standards or were referred to as science concepts students were expected to understand by the third grade, (see Table 5).

Table 5. Science words found in CA Third Grade Science Textbooks & Standards

Keywords (Harcourt Science Textbook)		Keywords (CA Dept. of ED – Science)	
English	Spanish	English	Spanish
Adaptation	Adaptación	Adaptation	Adaptación
Climate	Clima	Climate	Clima
Drought	Sequía	N/A	N/A
Environment	Ambiente	Environment	Ambiente
Equilibrium	Equilibrio	N/A	N/A
Extinct	Extinto	Extinct	Extinto
Fossil	Fósil	N/A	N/A
Habitat	Hábitat	Habitat	Hábitat
Hibernate	Hibernar	N/A	N/A
Migrate	Émigré	Migrate	Émigré
N/A	N/A	Organism	Organismo
Pollution	Contaminación	Pollution	Contaminación
Reproduce	Reproducir	Reproduce	Reproducir
Survive	Sobrevivir	Survive	Sobrevivir
Characteristic	Característica	Characteristic	Característica

2) The science keywords were also selected based on their linguistic complexity. Lexical complexity was determined by whether words were derived, consisted of three or more syllables, and were low frequency words (i.e., had an SFI of less the 50). Keywords were checked for frequency of occurrence in third grade textbooks as determined in *The Educator's Word Frequency Guide* (Zeno et al., 1995). Target words selected had an SFI[1] ranging from 44 – 53; Non-target words had and SFI range of 44 – 57. This allowed for selecting comparable academic words for testing the effectiveness of the intervention (see Table 6).

Table 6. Standard Frequency Index of Keywords

Target Words	SFI	Non-Target Words	SFI
Adaptation	**48.6**	Atmosphere	**57.0**
Extinct	**49.1**	Biosphere	**44.4**
Habitat	**47.4**	Climate	**57.9**
Migrate	**44.4**	Ecosystem	**46.8**
Organism	**53.0**	Fossil	**51.5**
Reproduce	**51.5**	Pollution	**55.9**
Trait	**50.5**	Survive	**55.2**

3) The teacher participating in the research study was also consulted as to the key concepts, which in their experience have found to be challenging for students and necessary for conceptual understanding in the topic of ecology and as indicated in the

[1] SFI = the Standard Frequency Index based on the total Corpus (e.g., a word with an SFI of 55.0 has a frequency per million that is 10 times higher that the frequency per million of a word with an SFI of 45.0).

science textbook of the classroom for the unit of Ecology. The textbook in this case was "California Ciencias – Grade 3 Harcourt Science in Spanish" published by Harcourt School Publishers, 2008.

Assessment Procedures & Measures

Vocabulary Measures

The Word-Matching assessments were administered at the beginning of the study, prior to the introduction of the content area of instruction, and at the conclusion of the intervention. The word matching assessments were used to determine students' specialized English and Spanish vocabulary knowledge on the topic of ecology (see Appendixes C & D). The assessments consisted of word matching of vocabulary terms specific to the content of instruction (i.e., ecology). The assessments were created in collaboration with the teacher participating in this study. The Word-Matching assessments were intended to determine student gains of target and non-target vocabulary from the use of the intervention web pages. All participating students were individually tested on each of the vocabulary measures, with each testing session lasting approximately thirty minutes. The testing occurred in the students' classroom, with the primary teacher present at all times. The English and Spanish versions of the Word-Matching assessments were administered on consecutive days, with the English version administered first each time.

In determining the specific academic vocabulary gains students achieved, several additional measures were extracted from the Word-Matching assessment in English (WME) and Word-Matching assessment in Spanish (WMS) in order to examine any

correlational relationships between academic vocabulary gains and t-test analyses of pre- and post-tests. This resulted in following four measures: Target Words in English (TWE), Target Words in Spanish (TWS), Non-Target Words in English (NTWE), and Non-Target Words in Spanish (NTWS).

In the beginning and at the end of the study students in the intervention were also administered the following tests: the *Peabody Picture Vocabulary Test, Fourth Edition* (Dunn & Dunn, 2007) as a test of their general receptive vocabulary knowledge in English; and the *Test de Vocabulario en Imagenes Peabody* (Dunn, Padilla, Lugo, & Dunn, 1986) as a test of their general Spanish receptive vocabulary knowledge. Students viewed four pictures for each item on the tests and were asked to identify which picture best illustrated the target word in the item. Each test took 30 minutes to administer. Due to time constraints, the PPVT and TVIP were not administered to all students prior to the intervention. Therefore the PPVT and TVIP could not be used as pre- and post-test measures of vocabulary growth attributed to the intervention. However the PPVT and TVIP were eventually administered to all students during both the early phases of the intervention and after the intervention was concluded. Thus the PPVT and TVIP served as descriptive variables indicating student receptive vocabulary development, during the period in which the study was implemented.

English Language Proficiency Measures

The California English Language Development Test (CELDT) for ELLs in the study served as a measure of students' English language proficiency. This assessment

was used to inform student performance, in terms of academic vocabulary attainment. CELDT scores were examined in order to explain the variability between students in the *High* and *Low* performance groups. Student's placement in the high or low performance group was determined by their attainment of target words in English and/or Spanish.

Web Page Utilization Measures

The WebQuest worksheet (WEBQ), which accompanied the intervention web pages, was also utilized as a measure to identify students ability to obtain the correct information from the web pages in order to answer the questions on the WebQuest worksheet. The WEBQ contained eight questions pertaining to the target vocabulary (see Appendix A for detail), and served to examine students' word and conceptual knowledge. Though answers for each question could be found on the web pages, questions answered correctly by students based on information not found on the intervention web pages were also considered correct. As the questions on the WEBQ were open-ended, if students had prior knowledge of the target vocabulary they may have been able to answer the questions in lieu of viewing the web pages. Thus, the WEBQ allowed for examining students understanding of the target vocabulary aside from the traditional dictionary definitions.

To measure students' interaction with the intervention web pages, each students computer desktop was video recorded through screen capture software, which enabled me to determine the average amount of time the students spent viewing a web page, in addition to the number of features students utilized on the web pages, such as clicking on pop-up windows for additional information on target words, and listening to audio files of

the target words. The average time per page, referred to in the analysis as "ToP" (i.e., Time on Page) was calculated by dividing the number of web pages students visited by the total amount time students spent on the intervention web pages.

Treatment

The treatment, *Computer-Supported Vocabulary Supplement* (CSVS), was a set of research-based strategies and instructional materials embedded into web pages designed to facilitate the acquisition of academic vocabulary by elementary bilingual students. The intervention emphasized rich vocabulary instruction involving exploration of target words in multiple contexts, word learning in Spanish and English, and question and answer activities of word meanings, though the use of research designed web pages. The duration of the CSVS intervention was three sessions, with each lesson lasting approximately 45 minutes. The instructional context consisted of students working independently on computers in the schools computer lab. The researcher and the teacher were always present to assist students as they navigated the intervention web pages. Prior to students using the web pages, each computer had desktop screen capture software installed (i.e., *Snapz Pro X 2.1.2 © Ambrosia Software, Inc.*) and activated so that students web page activity would be recorded. In addition to the web pages students were also given an Ecology WebQuest worksheet to complete while exploring the web pages, which tapped their science knowledge (see appendix A for complete worksheet). The questions on the worksheet were related to the target vocabulary and science concepts of ecology, based on California science standards for third grade. As answers

for each question could be found throughout the web pages, the worksheet served to direct students to various web pages.

Intervention Design

The goal of the intervention was to build students' academic word knowledge by providing opportunities to actively process word meanings in both English and Spanish with exposures to multiple contexts for target words. Defining and explaining the academic vocabulary by creating individual web pages for each target word gave students the opportunity to read the word in the context of the science topic and associate the word with images and audio of the target word. Previous research has found that it is often most beneficial for students to be provided with learning opportunities that enable them to develop both a deep understanding of word meanings and background knowledge simultaneously in their instruction. Researchers agree this is particularly true in such subject domains as science, where a great deal of the science content and vocabulary are restricted to topic-specific discussions. Even literal, abstract and frequently used words can be difficult for students to achieve a deep understanding of these word meanings as they are closely tied to students' background knowledge and experiences, which often vary widely between students (Baker, Simmons, & Kameenui, 1995).

Thus, the intervention web pages were designed with research-based vocabulary strategies embedded in both the context of the text and through the available features found on the web pages. In determining the effectiveness of the web pages for the intended goal of attainment of target science vocabulary, a design map was created to illustrate the learning processes and predicted outcomes of the study. Figure 1 illustrates

the design processes of the intervention by detailing the mechanisms behind the design of the web pages, which led to students' acquisition of the target words. The mapping of the design features of the learning environment to the expected outcomes helps to define the design conjecture, which researchers have utilized to evaluate optimal design in order to achieve intended outcomes and test the underlying theoretical conjecture (Sandoval, 2004).

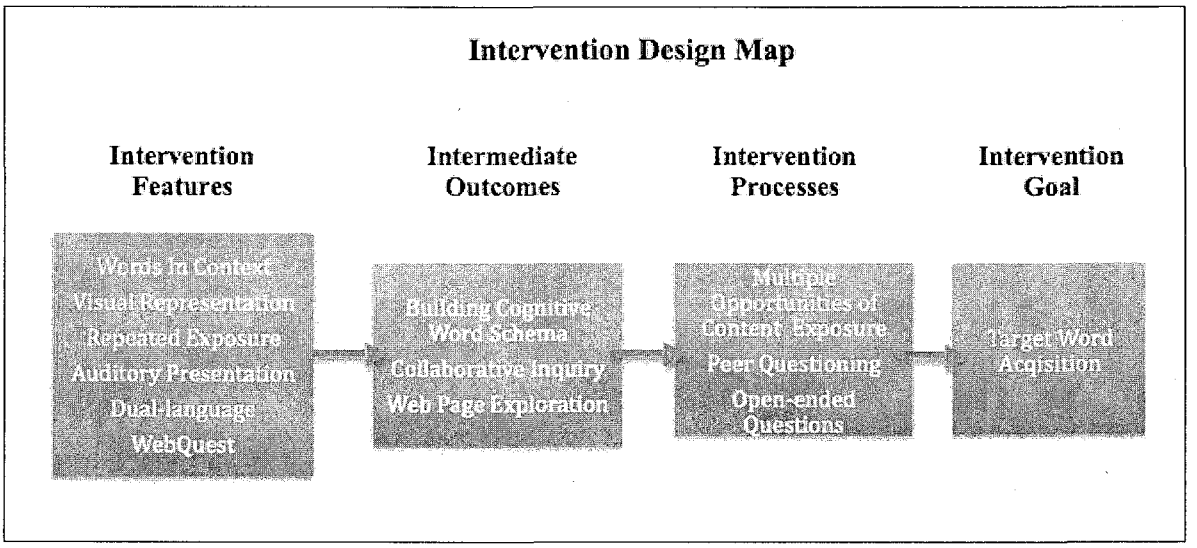

Figure 1. Intervention Design Map

Design graphic relating the intervention features and the mechanisms that account for student learning of target words.

Intervention Design Features & Strategies

Words In Context *(The ability to inferring meaning from the surrounding text)*

The web pages serve as a creative method of exposing ELLs to words in the context of science that develop and reinforce word meaning outside of whole group instruction, by presenting students with roots and cognates associated with the target

vocabulary. Knowledge of the cognate relationship that exists between Spanish and English can be a powerful example of positive transfer that facilitates reading comprehension (August, Carlo, Dressler, & Snow, 2005). All target words were presented multiple times throughout the web pages so that students had multiple opportunities to be exposed to these words and see these words used in various contexts.

Visual Representation

Providing a visual representation of new knowledge where students can link new vocabulary to new concepts is particularly helpful for ELLs (Bailey & Heritage, 2008). Thus, one of the key features of the intervention was the use of hyperlinks as a departure from linear text, which can promote vocabulary learning by allowing children to tap prior knowledge by creating cognitive semantic webs. Therefore, offering students rich opportunities to encounter new words in multiple contexts, along with representative images allows them quick access to text and graphics, which can lead to acquiring greater depth in the area of content-specific vocabulary words (Wood, 2001).

Repeated Exposure

While research indicates that students need several opportunities to meet and respond to words, we have yet to determine the optimal number of such opportunities (Nagy & Scott, 2000). Research has also shown that students require multiple opportunities to act on the words, such as judging the correct usage, change forms of words, classifying words, creative completion of sentences, using multiple target words

in a sentence and answering reading comprehension exercises (Beck & McKeown, 1991; Blachowicz & Fisher, 2000; Stahl & Fairbanks, 1986). As each web page served to introduce various topics of the science unit, students encountered target and non-target science terms repeatedly throughout the web pages.

Auditory Presentation

Audio files containing the pronunciation of the target words were provided along with text of synonyms and antonyms. We know from research that vocabulary does not develop by exposure alone, requiring systematic and explicit instruction where students have repeated opportunities to hear and use the new words in various contexts along with strategies for their own independent learning of new vocabulary, this being especially important for ELLs (Bailey & Heritage, 2008).

Dual-language

In aiding L2 learners in the acquisition of vocabulary in L2, associating unfamiliar words with imagery of actual objects of these words allowed for opportunities for students to form well-connected mental representations and schemas, thus leading to more effective learning. As Plass et al. (1998) states, "students learn new words when they can establish a direct connection between a word in their native language, the corresponding picture of an object or action, and its foreign equivalent. They thus build two types of retrieval cues in memory," (p. 26). As a result the target web pages contained both English and Spanish text allowing for linking the target vocabulary in

both languages, along with the use images to assist in both word meaning and understanding of the concepts the words represent.

WebQuest

The CSVS intervention included both web pages with embedded research-based vocabulary strategies and a WebQuest activity (see Appendix A). Each web page contained several target words in the context of scientific explanations and each target word was hyperlinked to additional information. For example, clicking on a target word activated a pop-up window providing students with additional definitions (in English and Spanish), and image(s) in order to provide the student with additional references for understanding the meaning or concept the target word represents.

The WebQuest worksheet consisted of open-ended questions regarding the target vocabulary, whereby students described and explained their conceptual ideas associated with the target academic words. Thus the intervention served as both an opportunity for students to use the words they had been learning and to demonstrate their word knowledge. Table 7 summarizes the previously mentioned vocabulary strategies and features as illustrated in the intervention design map, which informed both the design and inclusion of features found on the intervention web pages, in order to achieve the desired invention outcomes: acquisition of target words and the building of students' background knowledge of the science terms.

Table 7. Intervention Strategies, Features, and Goals

Vocabulary Strategies	Intervention Design/Features	Intervention Outcomes/Goals
Words in Context	Each target word presented in the context of its associated concept along with its formal definition	Definition acquisition and conceptual understanding of the target words.
Visual Representation	Target words presented along with images depicting the word or the concept associated with the word.	Knowledge and understanding of the of target words.
Repeated Exposure	All target words were found on various web pages outside its own dedicated web page, in addition to the glossary page.	Building students cognitive schema of word knowledge through multiple opportunities of content exposure and development of well-connected mental representations.
Auditory Presentation	For each target word a web page included a pop-up window were students could hear the word pronounced.	Understanding of the pronunciation of the word in English and Spanish, aiding reading.
Dual-Language Presentation	Web pages presented content in both English and Spanish; this included audio files and text.	Aiding word knowledge & conceptual understanding utilizing students' knowledge of both languages.

Building Cognitive Word Schema

Word meaning (*The ability to use context to derive the meaning of unknown words*)

It has been advocated that words are more effectively taught when they are grouped around a central concept than if randomly grouped, in that themes aid students to connect words, thereby fostering higher-level thinking and facilitating the learning process, in terms of word meaning and content knowledge (Beck, Perfetti, & McKeown,

1982; Durso & Coggins, 1991). As such, target words and non-target words were grouped into two themes, with target words describing and relating to organisms physical and behavioral attributes and non-target words centered around components of ecosystems (see Table 8).

Table 8. Intervention Science Words (English & Spanish)

Target Words		Non-target Words	
English	Spanish	English	Spanish
Adaptation	Adaptación	Atmosphere	Atmósfera
Extinct	Extinto	Biosphere	Biosfera
Habitat	Hábitat	Climate	Clima
Migrate	Émigré	Ecosystem	Ecosistema
Organism	Organismo	Fossil	Fósil
Reproduce	Reproducir	Pollution	Contaminación
Characteristic	Característica	Survive	Sobrevivir

Research has demonstrated that word learning is enhanced if definitions of words are combined with contextual information (Stahl, 1983; Kolich, 1991). In addition, including sample sentences in the introduction of words has been shown to be effective in fostering word learning (Scott & Nagy, 1997). This can be accomplished by having each target word be introduced with its definition, along with a sample sentence as part of the reading passage. Allowing for multiple and repeated exposures of information about the

target words facilitates vocabulary learning (Blachowicz & Fisher, 2000; National Reading Panel, 2000).

The challenge of creating a direct one-to-one connection of word to picture when discussing academic vocabulary is that it is often the case that the target vocabulary represents actions or scientific concepts such as *adaptation* or *extinction*. For example, merely showing the student a picture of an extinct animal does not fully covey the meaning of what it means to be extinct, as extinction is a process not simply an object. Therefore teaching the word extinct requires using the word in context and requires an understanding of the life cycle of organisms and environmental factors on survival of a species. As a result the intervention web pages allowed students to further explore the meaning and concepts of the target vocabulary with content that supplemented their textbook, and provided this information in both English and Spanish to aid their reading and understanding of the academic vocabulary.

Word reference (*the ability to interpret dictionary definitions*)

Research has revealed that children have great difficulty deriving meaning from dictionary definitions (Miller & Gildea, 1987; Scott & Nagy, 1997). In response to these findings, Nist and Olejnik (1995) found evidence that definitions incorporated into sentences were more comprehensible. Students frequently misunderstand definitions found in dictionaries, as well as in children's dictionaries (McKeown, 1993; Richek, 2005). As a result, word learning often requires teacher's hands-on coaching in locating and interpreting definitions, and allowing students to choose the word meaning that

matches the words use in a sentence (Richek, 2005). Thus, instruction of conceptually challenging words should combine direct instruction in vocabulary and dictionary skills with contextual learning in reading. By presenting multiple target words in the context of the science topic and linking these words together, students can begin to form conceptual connections between words. Therefore, when students can see how words are used in various contexts can allow for a synthesizing of knowledge whereby they gain an understanding of the relationships between words that represent important concepts (Richek, 2005).

Web Page Design

The design of the intervention web pages and the inclusion of the WebQuest worksheet were explicitly related to the principles of vocabulary instruction advocated by Blachowicz and Fisher (2000), and the research-based recommendations of Stahl (1983), Scott & Nagy (1997), Beck, McKeown, and Kucan (2002), Corson (1997), Scarcella (2003), August, Carlo, Dressler, and Snow (2005), and Jimenez, Garcia, and Pearson (1996), reiterate these recommendations with the goal of the intervention being student attainment of target words. In order to aid students' acquisition of the target science words the intervention web pages allowed for the presentation of the target vocabulary in a language-rich environment.

Target and non-target web pages were designed in order to present students with supplemental information regarding fourteen specific science terms relating to the topic of ecology. Differentiating target and non-target web pages was the inclusion of

vocabulary strategies embedded into the target web pages. As detailed in Table 7, the target web page features included presenting the target words in the context of descriptive explanations regarding the concepts and/or processes associated with the target words. Research has shown that digital reading environments can be designed to present important information in both a consistent and systematic manner to ensure comparable access for all students, including linguistically diverse students, by creating a rich linguistic environment in order to build lexical and metacognitive skills needed for text comprehension for both native English speakers and English learners (Proctor, Dalton, & Grisham, 2007). Therefore, each web page presented students with two identical paragraphs, one in English and one in Spanish. Though all target and non-target words presented on the web pages were hyperlinked to a glossary page where students could find the definition of the words in either language, target web pages also included pop-up windows for target words, were students were presented with additional information about the target words. For instance a pop-up window would present images associated with the target word, audio files of the pronunciation of the target words in English and Spanish, along with synonyms and additional information and examples of the target words.

In contrast, non-target web pages contained no additional embedded vocabulary strategies. Students were presented with text relating to the non-target words, though not necessarily presenting the non-target words in the context of the explanation. Non-target words though not hyperlinked to pop-up windows, were linked to a glossary page were student could receive a dictionary style definition of the word. Non-target web pages also

did include some pictures regarding the non-target words, but to a much less extent than for target words, which had multiple pictures presented with target words. Thus, unlike web pages for target words in which the content was divided into three separate web pages for each target word, therefore minimizing the amount of reading on any one page, non-target word web pages presented students with all the information regarding the non-target word on one web page. Also, non-target web pages were only presented in English, with no additional Spanish support, aside from the dictionary definition for each non-target word.

Therefore, the intervention web pages along with the WebQuest activity sheet, which probed students to further explain the concepts of each target word, provided students with multiple exposures to the target academic words in multiple contexts, along with background knowledge of the science words and the concepts associated with these words. The hyper-linking of target words to additional word meaning resources and web pages provided students the opportunity to observe the relationship of each target word and their associated concepts to the study of ecology.

As shown in Figure 2, the web page provides the reader with target words, not in isolation, but in a narrative context in which the target vocabulary is presented in the explanation of the process that each target word represents. Each target word is also highlighted and hyperlinked to a dictionary definition presented in a pop-up window, where students have the opportunity to read and hear the word pronounced in English and Spanish.

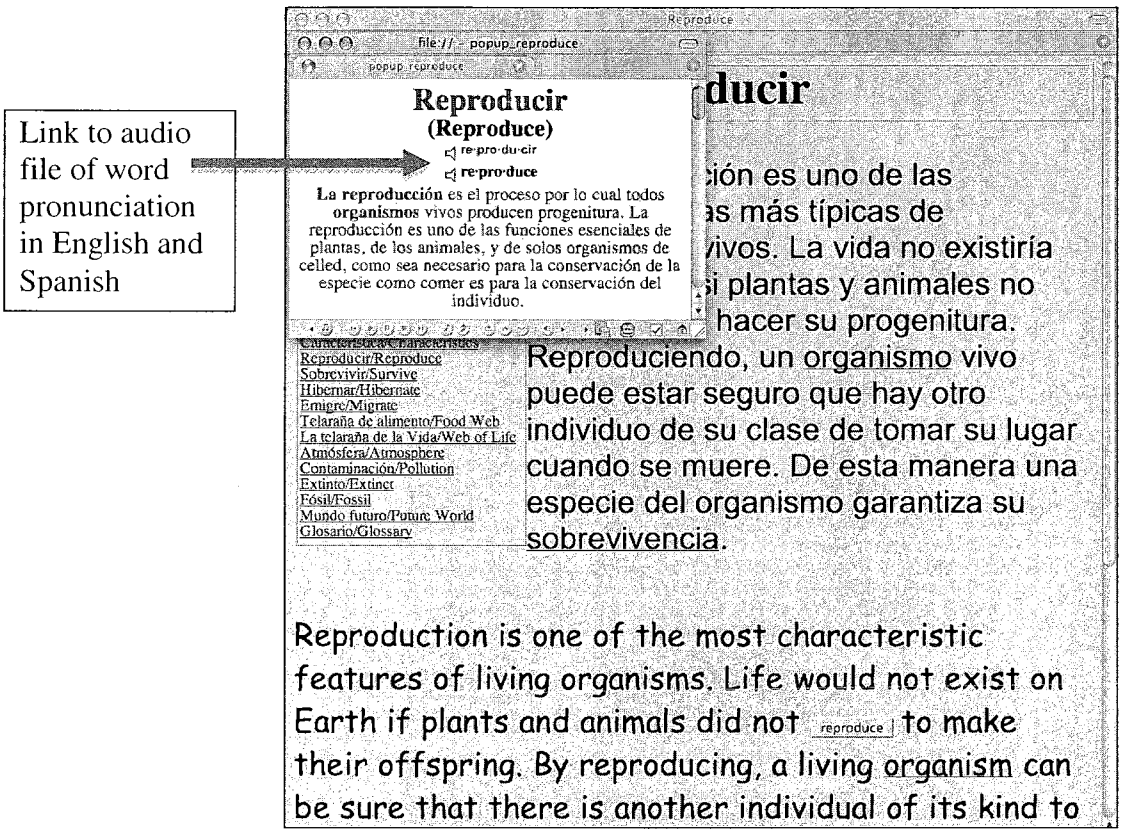

Figure 2. Intervention Target-Word Web Page Example

Web page example of pop-up window providing additional information (e.g., audio files of the pronunciation of the target word in English and Spanish)

As Scott & Nagy (2004), have stated: "definitions, context and word parts can each supply important information about the meaning of a word, but each of these sources has significant limitations," (p. 204). Therefore, by incorporating multiple research-based vocabulary strategies, including alternative definitions in both languages, audio of word pronunciation and images relating to target words and their associated concepts, and additional content regarding the target words through expository text, in the context of a web page gives students the advantage of having multiple modalities to aid acquisition of the target words. For instance, presenting words and their meanings in a verbal and pictorial format (e.g., pictures, animations, video), as shown in Figure 3, can

aid students in lower grades or who are not yet proficient in reading so long as the mode chosen is suitable to the age of the students concerned (Blok, 2001).

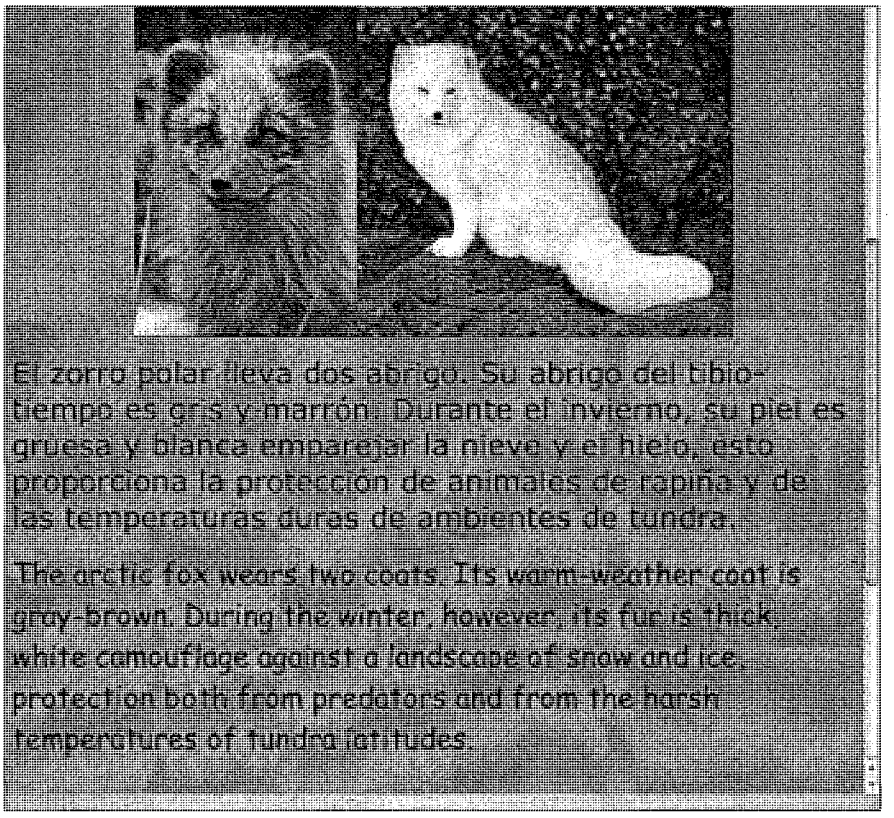

Figure 3. Visual Representation of Target Word – "Adaptation"

Web page example of the target word 'adaptation' being presented and explained through images & text, in both languages, to aid students understanding of the concept of how animals adapt to their environments.

Evidence exits that students are aided in word learning when they have words read to them, as knowing how a word is pronounced helps to establish a clear label for meaning of a word (Hebert & Murdock, 1994; Higgins & Cocks, 1999), and helps the attribution of meaning (Harmon, 1998). Also, knowing the correct pronunciation of a word can aid the understanding of the morphological structure of the word (Blok, 2001),

thus as shown in Figure 4, students had access to information, including text and audio, in both English and Spanish for each target word.

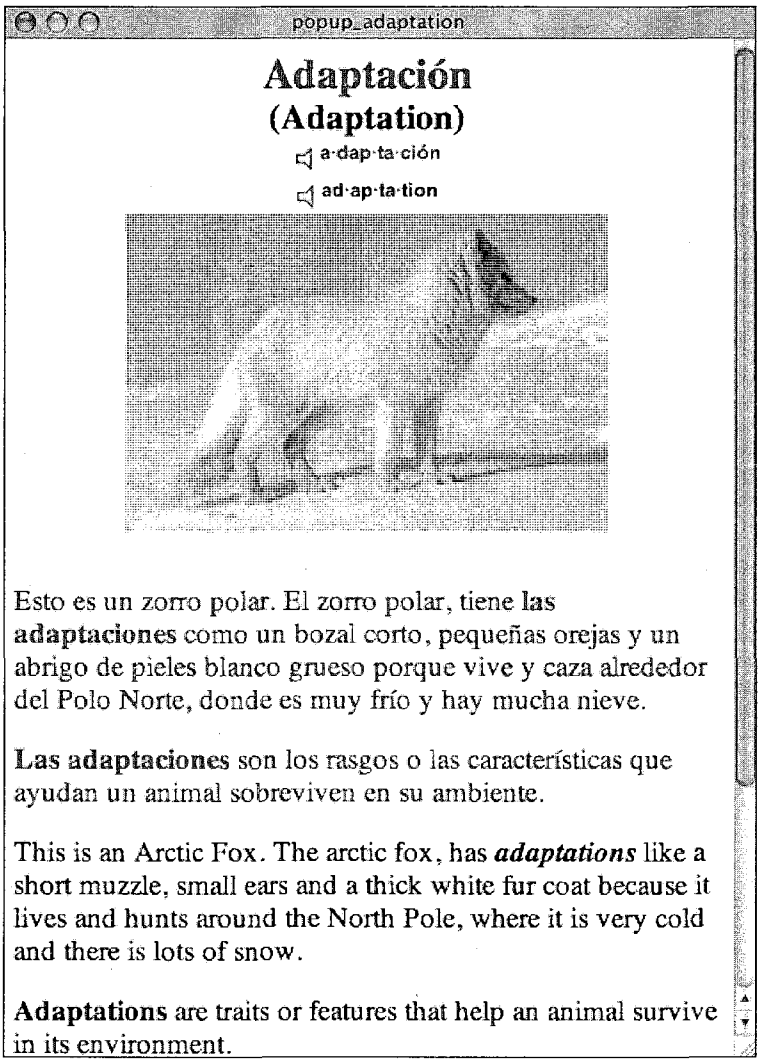

Figure 4. Pop-up window example of word knowledge strategies.

A pop-up window of various word knowledge strategies being presented to students simultaneously (i.e., text in two languages, definitions and explanations of target word, along with an associated image of the target word and audio files of word pronunciation in English and Spanish)

Data Collection

Data was obtained for all fourteen students for each vocabulary measure (i.e., Word –Matching Assessments (English & Spanish); PPVT and TVIP). The WebQuest worksheets, which accompanied the intervention web pages, were also obtained for each student. As previously mentioned, student utilization of the intervention web pages was obtained through screen-capture software which recorded students computer desktop screen-activity along with audio of student conversation. Due to technical difficulties with the screen-capture software, only ten of the fourteen students sessions were recorded. Each screen-capture video was logged and transcribed. Student's computer desktop videos were examined in order to identify which web pages students explored, the features utilized, and time-on-page. This analysis allowed for examining the specific target and non-target words students were exploring throughout the web pages. Along with the desktop video, audio files of student conversation, which were also captured through the computer, were transcribed in order to identify any academic vocabulary students were discussing with their peers while completing the WebQuest worksheet.

The transcripts recorded from the screen-capture software were also examined for peer discourse exchanges relating to the target vocabulary and for examples of student conceptual understanding when discussing the target vocabulary. Examples of student understanding of the target vocabulary were identified through student explanations to their peers regarding their answers to the questions on the WebQuest worksheet. Due to the fact that the majority of students chose to work independently while completing the WebQuest worksheet, only two of the seven transcripts consisted of students discussing

the web pages and the WebQuest worksheet. As a result only seven pages of student discourse, consisting of two students working together (Student 8 and Student 9), were available for examination.

At the conclusion of the study, the teacher of the classroom had students create a marine animal podcast report to conclude the ecology unit. As part of the activity students selected a marine animal to research, then created a written report, which described their marine animals habitat, physical features, known prey and predators of their marine animal, along with any additional information students deemed interesting and informative. The podcast written reports, which consisted of one to two pages of student writing, were examined for use of target and non-target vocabulary as introduced in the intervention web pages. In addition, all students were videotaped for their marine animal podcast reports. The examination of the students marine animal reports allowed for investigation of students retention of the vocabulary post-intervention, along with their ability to generalize the target words to an authentic task, outside of the intervention web pages, the Ecology WebQuest worksheet, and Word-Matching assessments.

Video Analysis Procedures

As the current study set out to examine students acquisition of target vocabulary, through their ability to define the target words and demonstrate their understanding of the target words from a web-based intervention, the video analysis consisted of examining transcriptions for any instances of student discourse, with the focus being on students' use of target vocabulary and/or explanation of science concepts associated with the target words. The unit of analysis was at the student utterance level, in order to determine the

specific target vocabulary students may have been discussing with their peers. Thus, videos were transcribed and analyzed for instances of target word use and/or discussion regarding the meanings of the target words. This allowed for indexing when students used any academic science terms while completing the WebQuest worksheet. Video analysis therefore concentrated on video files of students' desktop computer use of the intervention web pages while completing the WebQuest worksheet.

Analysis of the students' computer desktop video entailed methods by Hall (2001) and the methods of grounded theory (Glaser & Strauss, 1967) as described by Danish & Enyedy (2006). Thus, the video files were first logged to outline any major events, in this case, student discussion of the target words and/or use of the features found on the intervention web pages. Video files with segments determined to be of analytic interest were transcribed, including instances of student discourse exchanges with their peers, including the use of target words and explanations of their answers on the WebQuest worksheet. In addition, students' utilization of the embedded features on the web pages, such as the playing of audio files of the target words and the use of pop-up windows for additional information on the target words was also examined. The analysis progressed iteratively, by examining the video files directly to examine students exploration of the web pages in real-time, and through examination of the transcripts to match student discussion with their activity on the web page. This led to the creation of codes to identify instances of student discourse relating to the target vocabulary and/or any relevant discussion and exchanges between students regarding the scientific concepts associated with the target words. After reviewing the transcripts, two codes emerged

which were used to indentify instances of students demonstrating their understanding of the target vocabulary. These two codes were labeled as "Challenge," for instances in which a student would question the answers of another student when completing the WebQuest worksheet (see Appendix A). The second code, "Rationale" served to identify student responses to "Challenges" in which they defended their answers to questions on the WebQuest worksheet, by providing a reason or justification for their answers.

Due to the limited amount of discussion between students during the intervention, the resulting method of analysis yielded a minimal amount of examples of student discourse pertaining to the target vocabulary or discussion of scientific concepts. This led to examining transcriptions in order to identify, understand and explain what factors contributed to students' discussion of the target vocabulary while utilizing the intervention web pages. While the analysis cannot possibly capture all factors influencing students discussion for target word use or discussion of the science terms, for the purposes of this study the transcript segments selected for analysis were identified to be the most likely determining factors of student discussion of the information they obtained from the intervention web pages based upon transcripts from the video files of students completing the WebQuest worksheet as they explored the intervention web pages.

CHAPTER IV: RESULTS

To examine how students' academic science vocabulary development could be aided in a two-way immersion classroom, a web-based tool was designed to support the science curriculum. Specifically designed web pages were created to allow students the opportunity to acquire key vocabulary words in the context of the science topic of ecology. This permitted the target vocabulary to be presented through explanatory text describing the abstract processes associated with these terms. Research has suggested that providing definitional and contextual information about each word's meaning; actively involving students in word learning of target words; and providing multiple exposures to meaningful information about each word promotes vocabulary development (August, Carlo, Dressler, & Snow, 2005). Offering children rich opportunities to encounter new words in multiple contexts by allowing them quick assess to text and graphics, through the use of hypertext and hyperlinks can lead to acquiring greater depth in the area of content-specific vocabulary words (Wood, 2001). Therefore, by introducing students to target words in the context of web pages were these science terms were defined and explained along with the scientific concepts connected with these words, and presented with links to additional information may aid in the acquisition of these target words.

To test this hypothesis, several measures were administered and analyzed in this study to investigate students' academic vocabulary development through the use of the intervention web pages. Table 9 summarizes the results of students' performance on pre-

and post-test vocabulary measures of academic and general receptive vocabulary in English and Spanish.

Academic Vocabulary Development

Table 9. Student Vocabulary Development

Growth During Treatment Period				
Measures	**Pre-Test**	**Post-Test**	**Gain**	**T-test**
WME*	M = 5.69 SD = 2.72	M = 7.38 SD = 2.90	M = 1.57 SD = 1.70	t(12)=3.59, p=.004
Target Words	M = 2.62 SD = 1.50	M = 3.54 SD = 1.81	M = .857 SD = 1.23	t(12)=2.65, p=.021
Non-Target Words	M= 3.08 SD = 1.61	M = 3.85 SD = 1.35	M = .714 SD = 1.49	t(12)=-1.81, p=.096
WMS**	M = 6.15 SD = 2.88	M = 6.46 SD = 3.45	M = .286 SD = 3.17	t(12)=-.336, p=.743
Target Words	M = 3.00 SD = 2.20	M = 3.31 SD = 1.84	M = .286 SD = 2.37	t(12)=-.451, p=.660
Non-Target Words	M = 3.15 SD = 1.28	M = 3.15 SD = 1.95	M = .000 SD = 1.66	t(12)=.000, p=1.00
PPVT***	M = 140.00 SD = 16.93	M = 145.71 SD = 20.82	M = 5.71 SD = 7.99	t(13)=2.67, p=.019
TVIP***	M = 66.07 SD = 15.25	M = 74.00 SD = 17.25	M = 7.93 SD = 9.27	t(13)=3.20, p=.007

*WME = Word-Matching English assessment
**WMS = Word-Matching Spanish assessment
***PPVT – Results cannot be attributed to intervention
***TVIP – Results cannot be attributed to intervention

Target Word Development

As careful consideration was used in selecting the target and non-target science vocabulary for this study it was imperative to explore in depth the specific target and no-target words that students obtained and the language in which those words were more successfully acquired. Therefore to answer the following research question, "*Can a web-based vocabulary supplement aid the acquisition of academic science target words for multilingual students?*" a word matching assessment was administered to participants in order to examine their academic science vocabulary development in English and Spanish, of target and non-target vocabulary found on the intervention web pages.

To measure participants science vocabulary knowledge development, students were administered the academic Word Matching assessment in English (WME) and Spanish (WMS) on separate occasions. The WME and WMS consisted of both target and non-target words found on the intervention web pages. On the WME (English) post-test, nine (64%) students improved on their pre-test scores. A paired-samples t-test analysis indicated that the mean score on the post-test (M=7.38) was significantly greater at the $p<.01$ level (note: $p=.004$) than the mean score on the WME pre-test (M=5.69). A significant correlation also existed between pre- and post-test scores ($r=.819$, $p<.001$) indicating that those who scored high on the pre-test also tended to score high on the post-test.

Results from the Word Matching assessment in Spanish (WMS) post-test, showed five (36%) students improved on their pre-test scores. A paired-samples t-test analysis indicated that the mean score on the post-test (M=6.46) was not significant ($t(12)=-.336$,

p<.743) than the mean score on the WMS pre-test (M=6.15). These results also indicated a significant correlation did not exist between the pre- and post-test on the WMS (r=.469, p>.05), as seen in Table 9.

As previously mentioned, the Word Matching Assessment is comprised of both target and non-target academic science words. Results indicated that students varied on their acquisition of target and non-target words in English and Spanish.

Target words – English

In terms of English target words, students as a whole improved from a total of 35 target-words on the pre-test, to a total of 46 target-words on the post-test. A paired-samples t-test analysis was used to determine if this improvement of English target-words was significant. Results revealed that the mean score of English target-words post-test (M=3.54) was significantly greater at the p<.05 level (note: p=.021) than the mean score of English target-words pre-test (M=2.62). These results also indicated a significant correlation exists between these two variables (r=.727, p=.005) indicating that those who scored high on the pre-test also tended to scored high on the post-test.

Non-Target words – English

While students increased the number of correct non-target words on the word-matching assessment, though to a lesser degree, from 41 correct non-target words prior to the study to 52 correct non-target words at the end of the study, further analysis revealed that this improvement was not significant, t(12)=-1.81,p>.096. This result was expected as the focus of the intervention web pages was dedicated to the target words.

As hypothesized, after utilizing the intervention web pages, students improved on their knowledge of target words, as target-word web pages were specifically designed to aid students vocabulary acquisition. As non-target word web pages did not contain additional vocabulary support (e.g., additional explanatory text, definitions, images, audio, synonyms, etc.) students were not expected to increase their knowledge of non-target words to the degree of target words. While target-word web pages were designed to include information in both English and Spanish to support students' first language word knowledge, it was expected that students' would also improve on their knowledge of target words in Spanish to a greater degree than non-target words in Spanish, as was the case for English target and non-target vocabulary.

Target words – Spanish

From the results of the Word matching Assessment in Spanish, students also improved on their knowledge of Spanish target-words, from an initial total of 39 Spanish target-words on the pre-test to 50 Spanish target-words on the post-test. Nevertheless, a paired-samples t-test analysis indicated that students improvement of Spanish target words was not significant, $t(12)=-.451$, $p>.05$.

Non-Target words – Spanish

Interestingly, as was the case with non-target words in English, students as a whole improved on the word matching assessment post-test by collectively gaining 7 non-target words in Spanish. Students correctly identified a greater number of non-target Spanish words on the post-test (48 non-target words correctly identified) than on the pre-test (41 non-target words correctly identified). However, further analysis demonstrated

that the mean on the pretest (M=3.15, SD=1.28) and the mean on the post-test (M=3.15, SD=1.95) were identical, suggesting no significant change in students' knowledge of non-target words in Spanish, t(12)=.000,p>.05. These results were as expected, as the intervention web pages were designed to aid students' acquisition of target vocabulary in English and Spanish.

In reviewing the results of students academic vocabulary development of science terms relating to the topic of ecology, as expected students significantly improved on their knowledge of target words in English as opposed to non-target words. Unfortunately, students did not significantly improve their knowledge of Spanish target words. However, in reviewing the results from the Word Matching assessments, as can bee seen in the total scores in Tables 10 & 11, it was promising that collectively students did show gains in word knowledge for target words in both English and Spanish. To further understand students' academic vocabulary development, requires closer examination of individual student results from the Word Matching assessments.

Academic Word Analysis (Individual Student Results)

In terms of individual participant performance on academic keywords, eight (57%) students improved in terms of their English target vocabulary knowledge, and nine (64%) students improved in terms of their English non-target vocabulary knowledge (as seen in Table 10). From examining the results of students performance on the word-matching assessment of English academic vocabulary, four students (i.e., Students: 2, 8, and 3, 9) stand out as being closely matched on several factors: all four are English

learners, have similar scores on the pre-tests, and show similar results of their academic vocabulary on the post-test measures. Interestingly, Student's 2 and 8 both increased their knowledge of target vocabulary by three words though Student 8 also increased non-target vocabulary by two words. In contrast, Student's 3 and 9, who also had similar pre-test knowledge of target vocabulary, showed no gains after the intervention of target words, however both students increased their knowledge non-target vocabulary by three words.

Table 10. Individual Student Word-Matching Results (academic English)

	Target Words*			Non-Target Words*		
	Pre-Test	**Post-Test**	**Gain**	**Pre-Test**	**Post-Test**	**Gain**
Student 1	5	6	1	7	6	-1
Student 2	2	5	3	3	3	0
Student 3	4	4	0	2	5	3
Student 4	4	5	1	4	5	1
Student 5	0	1	1	2	2	0
Student 6	1	2	1	2	3	1
Student 7	1	0	-1	1	2	1
Student 8	2	5	3	2	4	2
Student 9	4	4	0	2	5	3
Student 10	4	6	2	5	4	-1
Student 11	2	3	1	3	5	2
Student 12	2	1	-1	1	2	1
Student 13	1	2	1	4	2	-2
Student 14	3	2	-1	3	4	1

* 7 target and 7 non-target words (14) in total

When examining students academic Spanish vocabulary, before and after the intervention, students as a group did acquire more target and non-target Spanish

academic vocabulary (see Table 11), however this improvement was not significant $t(12)=.000$, $p<1.00$.

Yet when looking at individual student performance, three students (Students 3, 5, & 8) improved on Spanish target words and five students (Students 2, 3, 8, 10 & 14) improved on Spanish non-target words, as seen in Table 11. Surprisingly, two students (Students 3 & 8) made gains on both Spanish target words and Spanish non-target words and one student (Student 8) made gains on English target and non-target words, as well as on Spanish target and non-target words. In order to understand the complexity in students' attainment of target and non-target vocabulary, it was necessary to determine the specific academic words in English and Spanish that students acquired.

Table 11. Individual Student Word-Matching Results (academic Spanish)

	Target Words*			**Non-Target Words***		
	Pre-Test	**Post-Test**	**Gain**	**Pre-Test**	**Post-Test**	**Gain**
Student 1	N/A	7	N/A	N/A	7	N/A
Student 2	4	4	0	2	3	1
Student 3	3	6	3	2	4	2
Student 4	7	4	-3	5	5	0
Student 5	2	3	1	5	1	-4
Student 6	3	3	0	3	2	-1
Student 7	2	1	-1	2	1	-1
Student 8	1	7	6	5	7	2
Student 9	6	4	-2	3	3	0
Student 10	6	4	-2	4	5	1
Student 11	1	1	0	3	3	0
Student 12	0	3	3	1	1	0
Student 13	1	1	0	3	1	-2
Student 14	3	2	-1	3	5	2

* 7 target and 7 non-target words (14) in total

Academic Word Analysis (Whole Group Results)

In terms of participant performance on individual Keywords (Target and Non-target science vocabulary), students as a whole acquired eleven English Keywords (*Adaptation, Biosphere, Characteristic, Climate, Ecosystem, Fossil, Habitat, Migrate, Organism, Reproduce, Survive*) and eight Spanish Keywords (*Atmosfera, Biosfera, Ecosistema, Emigrar, Extinto, Hábitat, Reproducir, Sobrevivir*), from pre- to post-test, see Table 12 below.

Table 12. Academic vocabulary results post-intervention

Target Words (English)	**No. Correct**	**Non-Target Words (English)**	**No. Correct**
Adaptation	6 (43%)	Biosphere	5 (36%)
Characteristic	3 (21%)	Climate	13 (93%)
Habitat	5 (36%)	Ecosystem	4 (29%)
Migrate	9 (64%)	Fossil	12 (86%)
Organism	3 (21%)	Survive	11 (76%)
Reproduce	9 (64%)		
Target Words (Spanish)	**No. Correct**	**Non-Target Words (Spanish)**	**No. Correct**
Emigrar	12 (86%)	Atmósfera	4 (29%)
Extinto	9 (64%)	Biosfera	5 (36%)
Hábitat	7 (50%)	Ecosistema	4 (29%)
Reproducir	9 (64%)	Sobrevivir	12 (86%)

As displayed in the Table 12, more than half the students acquired the English target words '*Migrate*' (64%) and '*Reproduce*' (64%), and the English non-target words '*Climate*' (93%), '*Fossil*' (86%), and '*Survive*' (86%). In terms of Spanish academic vocabulary, more than half the students acquired the Spanish target words '*Emigrar*'

(86%), *'Extinto'* (64%), *'Reproducir'* (64%) and the Spanish non-target word *'Sobrevivir'* (86%).

Web Page utilization on vocabulary growth

To examine how web page utilization may have contributed to students' vocabulary development during the study, a Pearson product moment correlations was performed using gain scores for each vocabulary measure as well as student scores on the WebQuest worksheet, taking into account the average amount of time each student spent on the web pages (i.e., Time on Page = ToP). Table 13 presents these results.

Table 13. Pearson Product Moment Correlations for Gain Scores

	PPVT	WME	WMS	TWE	TWS	NTWE	NTWS	WEBQ	ToP
PPVT									
WME	.580*								
WMS	.298	.510							
TWE	.621*	.521	.169						
TWS	.269	.378	.859**	.173					
NTWE	.148	.709**	.442	-.234	.287				
NTWS	.185	.436	.685**	.075	.215	.434			
WEBQ	.591*	.183	.367	.041	.375	.174	.166		
ToP	-.198	-.116	-.505	-.010	-.409	-.127	-.366	-.084	

PPVT = PPVT raw scores; WME = Word Matching English raw scores; WMS = Word Matching Spanish raw scores; TWE = Target Words in English raw scores; TWS = Target Words in Spanish raw scores; NTWE = Non-Target Words in English raw scores; NTWS = Non-Target Words in Spanish raw scores; WEBQ – WebQuest scores; ToP – Time on Page.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Several trends emerged from these correlations. The Peabody Picture Vocabulary Test (PPVT) tended to correlate positively with performance on three of the measures, such as the WME, $r=.580$, $p<.05$, the TWE, $r=.621$, $p<.05$, and on the WebQuest worksheet, $r=.591$, $p<.05$. This suggests that for students who significantly improved on the PPVT also improved their scores on the English academic vocabulary measures,

specifically acquiring English target words. In addition, students who had positive mean gains scores on the PPVT also performed better on the WebQuest worksheet, which probed students' understanding of the target vocabulary.

It should be noted that the PPVT was not a true pre-test measure, as not all students were administered the PPVT prior to the start of the intervention, though all students were administered the PPVT by the end of the first week of the intervention. Thus students only received one session of the intervention prior to the completion of PPVT assessment. Also as the reader may recall, the PPVT is a measure of general receptive vocabulary and did not include the target vocabulary students encountered in the intervention web pages. Therefore improvement on the PPVT was not expected as a result of the intervention, also due to the short nature of the intervention, as the study lasted approximately five weeks.

Correlation results also indicated that for students with higher mean gains on the Spanish version of the academic vocabulary assessment (WMS) also improved on both Spanish target words (TWS), $r=.859$, $p<.01$ and Spanish non-target words (NTWS), $r=.685$, $p<.01$. Also, as seen in Table 13, students who made gains on the English version of the Word Matching assessment (WME), also positively correlated with gains on non-target words in English (NTWE), $r=.709$, $p<.01$. Results also revealed that the amount on time students spent on the intervention web pages (ToP) did not correlate with gains on the academic vocabulary assessments. Therefore any gains on target vocabulary that may be attributed to the intervention web pages required examination of each students utilization of the web pages including the use of features present on the web pages.

To examine the individual differences by students who made gains on target and non-target vocabulary required analysis of how students utilized the intervention web pages, which were designed to aid students' acquisition of both English and Spanish target vocabulary. Thus this led to following research question, exploring the utilization and potential effects of the intervention web pages on students' academic word knowledge.

To what extent did students utilization of the web pages contribute to their academic vocabulary growth?

It would seem that the intervention web pages along with the WebQuest worksheet did lead students to explore the target web pages, and read the target web pages, in order to answer the questions correctly on the activity worksheet. This may explain why students as a group acquired a significant amount of English target vocabulary ($t(12)=-2.65$, $p<.021$) from pre- to post-test on the academic word matching assessment. The screen-capture video of students exploration of the web pages confirms that target web pages were viewed in greater frequency (total of 122) than non-target web pages (total of 35) as seen in Table 14.

Table 14. Web Page Feature Analysis

Student	ToP	TWP	NTWP	Pop-Ups	Audio Files
1	2:19	13	0	4	4
2	4:15	15	3	6	0
3	2:20	11	0	7	0
4	1:22	15	5	1	1
5	1:15	10	5	2	0
6	1:06	20	14	11	0
7	1:32	14	8	9	0
8	2:46	9	0	6	0
9	2:47	9	0	9	0
10	4:24	6	0	3	0

ToP = Time on Page (minutes); TWP = Target Web Pages viewed; NTWP = Non-Target Web Pages viewed; Pop-Ups = Number of pop-up windows opened on target web pages; Audio Files = Number of times student listened to word pronunciations.

In examining students web page utilization, as detailed in Table 14, the average amount of time spent viewing a web page was calculated for each student (i.e., Time on Page = ToP). The number of target and non-target web pages viewed by students were also calculated, as well as number of times students made use of the features found on target web pages such as the pop-up windows which provided additional content for words learning, including audio files of target word pronunciation in English and Spanish. Students had an average time on page of two minutes and twenty-five seconds per web page. In terms of target and non-target web pages, students viewed on averaged twelve target word pages as opposed to four non-target web pages. Clearly students viewed a great number of target web pages than non-target web pages, therefore it was necessary to understand what features students made use of on the target web pages. As seen in Table 14, the majority of students did not utilize the audio features provided on the pop-up windows, despite the fact that on average students opened the pop-up

windows sixty-nine percent of the time they viewed a target web page. The lack of use of the audio files may be attributed to the design of the web pages. The fact that audio files for word pronunciations were hyper-linked to speaker icons and not clearly labeled may have attributed to the lack of use by students. Though students were instructed that clicking on the speaker icon found on the pop-up windows would play the audio file, they may have forgotten or simply were not interested in listening to the word being pronounced.

As previously stated, the intervention web pages were designed to aid students acquisition of academic science vocabulary through the context of supplementary material related to the ecology science unit. In addition, a WebQuest activity worksheet was presented to the students to complete as they navigated the web pages. The WebQuest activity sheet served to guide student's exploration through the web pages in order to ensure that students would visit the target word pages. From examining student performance on the WebQuest worksheet, 83% of student responses were correct, with 72 of the 92 correct student responses coming from information found on the web pages, as detailed in Table 15. Students also varied in the amount of time needed to complete the WebQuest worksheet. Nearly half the students completed the worksheet in one session while others took two sessions to complete the worksheet. This was not a surprise given the variability in student's exploration of the web pages.

Table 15. WebQuest Worksheet Results

Student	Score	Percent Correct	Sessions
1	8	100%	2
2	7	88%	2
3	5	63%	1
4	8	100%	2
5	7	88%	2
6	5	63%	2
7	7	88%	2
8	8	100%	2
9	7	88%	1
10	6	75%	2
11	7	88%	1
12	1	13%	1
13	8	100%	1
14	7	88%	1

WebQuest worksheet consisted of eight questions regarding target words. Session = Number of sessions student needed to complete the WebQuest worksheet.

In examining the screen-capture video, only half the students for which data was available went to non-target web pages. Given that non-target web pages contained content not referred to or needed to complete the WebQuest worksheet may have influenced the amount of time students needed to complete the worksheet. However, the WebQuest worksheet did appear to have to guided the student's navigation from web page to web page, specifically to target web pages. This would explain why the majority of the students viewed target word web pages and also acquired target words over non-target words. Thus as expected, the intervention web pages and WebQuest worksheet did work in tandem to guide students to target word web pages and probe students knowledge of target words and provided opportunities for target word acquisition.

Though student's explored target-word web pages to a greater degree than non-target word web pages, individually students varied in their acquisition of target and non-target vocabulary in English and Spanish. Examination of students' progression through the web pages revealed that students took a very linear path through the web pages, as dictated by the questions on the WebQuest worksheet. To understand how students' utilization and path through the web pages was related to their academic vocabulary acquisition, a matched pair of students in terms of language dominance and pre-test vocabulary scores were examined in detail to determine differences in target and non-target vocabulary acquisition in both languages. In the following example, Student's 2, 3, 8, and 9 are English learners, and had similar scores on the word-matching pre-tests (English and Spanish versions), and utilized the intervention web pages in similar but unique ways, as seen in Table 16.

Table 16. Web Page Utilization (Case Study Results)

*WP	**Student 2**	**Student 3**	**Student 8**	**Student 9**
WP1	Extinction	Extinction	Extinction	Extinction
WP2	Reproduction	Adaptation	Reproduction	Reproduction
WP3	Survive	Reproduction	Migrate	Migrate
WP4	Hibernate	Migrate	Characteristic	Characteristic
WP5	Migrate	Characteristic	Adaptation	Adaptation
WP6	Reproduction	Adaptation	Organism	Organism
WP7	Future World	–	–	Habitat
WP8	Migrate	–	–	–
WP9	Adaptation	–	–	–
WP10	Characteristic	–	–	–

*WP = Web Page

In examining Student 2's path through the web pages, he visited 10 different web pages (7 target pages, 3 non-target pages), returning to two target pages (Migrate, Reproduction). In the two target pages that the student viewed on multiple occasions, he explored deeper into those pages by linking to additional pages on the topic of *Migration* and *Reproduction*. For each of the target pages Student 2 also utilized the pop-up window feature providing additional information about the target words and the general science topic.

Unlike Student 2, Student 8 visited at total of 6 different pages (all target pages), in the order of questions asked on the WebQuest activity sheet, suggesting that unlike Student 2, Student 8 was much more concerned with completing the activity sheet. As seen in Table 16, Student 8 had a very linear path across the web pages, never going to non-target web pages or returning to previously visited target pages, as did Student 8. It should be noted that Student 8 did complete the WebQuest activity sheet, whereas Student 2 did not.

In terms of the academic vocabulary acquired by Student's 2 and 8, each student acquired three additional English target words on the English Word-Matching post-test. As seen in Table 17, both students only correctly identified two English target words on the Word-Matching pre-test. Student's 2 and 8 pre-test knowledge of Spanish target words differed as Student 2 correctly identified four Spanish target words, while Student 8 only correctly identified one Spanish target words. However, on the Spanish Word-Matching post-test Student 2 made no gains, whereas Student 8 acquired six additional target words. Interestingly, Student 8 made the most gains in academic science

vocabulary than any other student in the study. Between the pre-test and the post-test she gained an additional three target words and two non-target words in English, and six Spanish target words and two Spanish non-target words, as a result obtaining a perfect score on the Spanish academic vocabulary word-matching post-test assessment, identifying all seven target words in Spanish (see Table 17).

In summary, though both students roughly explored the same amount of target-word web pages, with Student 2 visiting five target-word web pages, and Student 8 viewing six target-word web pages, their progression through the web pages differed greatly, as did their acquisition on target words. Student 2 took a much more non-linear pathway through the web pages, taking a more random approach to navigating the web pages, often going back and fourth between target and non-target web pages, in addition to not completing the WebQuest activity, whereas the Student 8 allowed the activity sheet to determine the web pages she viewed, and thus only explored target-word web pages. This may explain the differences in target-word acquisition by both students, especially in Spanish target-words, as seen in Table 17.

Table 17. Academic Vocabulary Acquisition – (Pre and Post-Tests)

Student 2 – English Target Words		**Student 8 – English Target Words**	
Pre-test	Post-test	Pre-test	Post-test
Extinct	Extinct	Extinct	Extinct
Migrate	Migrate	Reproduce	Reproduce
–	Adaptation (+)	–	Adaptation (+)
–	Habitat (+)	–	Characteristic (+)
–	Organism (+)	–	Migrate (+)

Student 2 – Spanish Target Words		Student 8 – Spanish Target Words	
Pre-test	Post-test	Pre-test	Post-test
Emigrar	Emigrar	Emigrar	Emigrar
Extinto	Extinto	–	Extinto (+)
Organismo	Organismo	–	Organismo (+)
Reproducir	Reproducir	–	Reproducir (+)
–	–	–	Adaptación (+)
–	–	–	Característica (+)
–	–	–	Habitat (+)

(+) Denotes vocabulary student acquired at the end of the study.

Ideally there is no true correct way to navigate the web pages, as the intervention web pages were designed based on various topics of the ecology science unit. Therefore students would have the opportunity to explore the web pages in any order that would interest them. As previously stated the WebQuest activity sheet served to reinforce that students would explore web pages with target vocabulary, but in no means was intended to dictate how students utilized the web pages. However it appears from analyzing student's navigation through the web pages, the activity sheet did influence student's progression through the web pages. Analysis of students web page navigation (see Appendix B for further detail), revealed that 83% of viewed web pages were related to target words, as compared to 17% of non-target word web pages. This would imply that students were much more goal oriented in their approach of exploration, and may shed light on how they perceive the internet as a resource for answering questions and problem solving then simply as a tool to freely explore for information.

How did students demonstrate their comprehension of the academic vocabulary targeted in the intervention web pages?

In building students academic science vocabulary, the study aimed to aid students understanding of the target vocabulary at the definitional level and examine if students were able to use their newly acquired vocabulary outside of the vocabulary assessments. In order to understand how students conceptualized the academic vocabulary targeted in the intervention, transcripts were examined of students discourse while exploring the intervention web pages and answering the questions on the WebQuest activity sheet. In the following discourse exchange, Student 8 and Student 9 were working side by side on individual computers, exploring the intervention web pages, and each completing their WebQuest activity sheet. In the following example, the students are exploring the 'Reproduction' web pages, in order to answer question #2 on the worksheet: "Why do animals need to reproduce?" Student 8 begins by reading from the web page, and then soon discovers what she believes to be the answer to the question, and suggests to Student 9 to write what she has found. Interestingly when Student 9 challenges her assumption, she defends her answer by restating the answer and explains why animals and plants need to reproduce.

In following example Student 8 finds an answer to the question on the worksheet, by reading from the web page. This was a typical scenario for most students as the majority of answers to the worksheet were directly from the web pages. Specifically, 77% of all correct responses to questions on the worksheet came from content found on

the web pages. This suggests that students were reading from the web pages in order to answer each of the questions on the worksheet.

30. STU8: Um, let's see, reproduce is one of the most XXX (Reading from the web page, most likely having trouble with the word 'characteristic')
31. STU8: Life would not exist, oh! I know, um, life would not extinct on Earth if plants and animals did not reproduce.
32. STU9: Where are you at? [To Student 8]
33. STU8: ...to make their offspring.
34. STU8: Look right here, [To Student 9] life would not exist on Earth if plants and animals did not reproduce to make their offspring (Reading form web page)
35. STU8: Write that [To Student 9], I'm gonna write that, life...would...because...life would not, that's why, because life would not exist on Earth if plants and animals did not reproduce to make their offspring. (Reading aloud while writing on worksheet)
36. STU9: Are you sure? [To Student 8] – (**Challenge**)
37. STU8: Yup, cuz that's why they need to reproduce. [To Student 9] – **(Rationale)**
38. STU8: Animals and plants, need to reproduce because, uh, otherwise Earth, um, would not exist if plants and animals did not reproduce to make their offspring, so um, lets see.

The excerpt above illustrates how students, when working together on the WebQuest worksheet, can create a learning environment where '*challenging*' each others answers to questions on the worksheet, as seen on Line 36, provided the opportunity for students to demonstrate their knowledge of the target words, identified by the code '*rationale*' on Line 37. Beginning on Line 35, Student 8, having found the information on the intervention web pages, tells Student 9 what she believes to be the answer to the question on the worksheet, "Why do animals need to reproduce?" However, Student 9 does not accept Student 8 answer on face value, and thus challenges Student 8 to explain why she believes the answer to be correct. On Lines 37 and 38, Student 8 explains her rational for her reasoning by summarizing the information found on the web page. Though Student 8 answer in Line 35, is not precisely correct, as she states that *"Earth,*

um, would not exist if plants and animals did not reproduce to make their offspring", the fact the on Line 31 Student 8 paraphrasing the text form the 'reproduction' web page that *life* would not exist on Earth if plants and animals did not exist, demonstrates the correct rational for the answer she gives to Student 9. Accepting this interpretation, Student 8 does correctly demonstrate her understanding of the target word 'reproduce' beyond the literal definition. The discourse exchange between Student 8 and Student 9 as a result of utilizing and intervention web pages and completing the WebQuest worksheet, supports previous research indicating that technology when combined with science curriculum activities can lead to students science talk (Kafai & Ching, 2001), through emulating scientific discourse by examining and making arguments (Linn & Hsi, 2000), and/or facilitating and enriching discussion through peer interactions (Brown & Campione, 1994).

In answering questions from the worksheet students also used their knowledge of the target words based on information they had received in addition to the web pages, as illustrated below. In the following example, Student 8, is exploring the 'Habitat' web pages in order to answer the question #8 of the Ecology WebQuest activity, "What type of habitat do you think it lives in?" After navigating to the 'Habitat' web page, Student 8 recalls a field trip students took to a local area aquarium where they learned about marine animal habitats.

In following excerpt, Student 8 has previously learned about habitats, and how they differ for various animals, by recalling a fieldtrip occurring earlier in the school year, where students were introduced to a variety of marine life habitats at a local marine

aquarium and had the opportunity to explore the beach on guided tour by marine biologist.

154. STU8: ...what type habitat do you think it lives, habitat (Reading from worksheet)
155. STU8: Habitat is where they live, remember we learned about that in the aquarium at the beach [To Student 9]
156. STU8: Habitats are like, um, remember 'sandy bottom' that's habitat where people, not people, fish...so its where they live [To Student 9] (Referring to a fieldtrip student took to an aquarium earlier in the school year]
157. STU8: Isn't um habitat, is where like they live, like um a stingray, um they live in sandy bottom [To Researcher]
158. STU8: So could I write stingray live in sandy bottom [To Researcher]
159. STU9: Deer's live in the forest.

Interestingly, Student 8 misinterpreted question eight to mean 'name an animal and its habitat', not realizing that question #8 is a continuation of question seven, "Name an organism that is an herbivore," followed by "What type of habitat do you think it lives in?" as seen in Appendix A. Though Student 8 wrote "*deer's eat grass*" for question seven, for question eight, Student 8 answered: "*Stingrays live in sandy bottom.*" Though Student 8 response to question eight is correct, it would seem that question eight primed Student 8 recollection of the aquarium fieldtrip about marine habitats leading the student to tap prior knowledge of animals habitats in order to answer question eight.

In reviewing students discourse as they interacted with their peers in the process of exploring the intervention web pages and completing the Ecology WebQuest, indicated the effectiveness of the CSVS intervention in aiding the acquisition of academic vocabulary and providing the opportunity for students to use their newly acquired academic language to express their ideas and describe in detail intricate processes

through the use of terms associated within the specific content domain of ecology. This type of interaction is very relevant to the classroom activities in two-way immersion programs, as students are participating through language in different contexts as they interact with their teacher, other language minority/majority students and work independently in the classroom. As students interact with each other they are seemly creating their own learning environments for each other thus leading to different role relationships with each new change of context (Erickson & Schultz, 1997). In this case, the CSVS intervention allowed students to quickly share their knowledge of newly acquired science terms with their peers, and taking on the role of teacher, as Student 8 explains to Student 9, "*Habitat is where they live, remember we learned about that in the aquarium at the beach...like um a stingray, um they live in sandy bottom.*"

Post-Intervention Data

After the conclusion of the study, students created podcast reports about the marine animals they had been studying over the course of the science unit. This included written reports as well as video presentations for the creation of podcasts. These projects provided the opportunity to observe and document student's use of the target vocabulary in their written reports on their marine animals. The written reports were also used to make collages of the marine animal used for the podcast presentations. Student's reports averaged in length of approximately 158 words, with an average of one target word per report, as seen in Table 18.

Table 18. Podcast Report Data

Student ID.	No. of Target Word Types	Length of Reports (in words)
1	2	176
2	0	71
3	2	160
4	1	115
5	2	61
6	1	276
7	2	86
8	2	220
9	3	236
10	2	224
11	0	198
12	0	91
13	2	199
14	2	102

As part of students marine animal reports, students were instructed that the reports include a description of their marine animal, the environment in which the animal lives, features of the animal that help it to survive in its environment, and any interesting facts about their marine animal. It should also be noted that all students' reports were written in Spanish, as science is taught in Spanish at this school. In the following examples, Student 4, Student 5 and Student 9 have incorporated target words in their science reports. It should be noted that spelling and grammar have been corrected in the English translation, though keeping in the spirit of students' word choice. Student 4, a native English speaker in the two-way immersion classroom, wrote a report on Orcas for the podcast presentation. In this excerpt, Student 4 uses the target word 'adaptation' in explaining how features of the Orcas help the to obtain food:

Las Orcas tienen un capa de gordura, si no tiene comida no se va a morir. Otro ***adaptacion*** *es su color. Si su comida esta abajo de la Orca no va a verla, porque es blanco como el cielo, también si la comida esta arriba de la Orca no la va a ver, porque es negro como el océano.*

The Orcas have a layer of fatness, so if they do not have food they will not die. Another adaptation is its color. If its food is below the Orca it is not going to see it, because it is white like the sky, also if the food is above the Orca it will not see it, because it is black like the ocean.

Student 5 is also a native in English speaker in the two-way immersion class. In the following example Student 5 included two target words, 'habitat' and 'reproduction' in describing their marine animal, the Bluebanded Goby:

Su ***hábitat*** *es aguas tropicales y sercas de roquenos arrecife.*

Its habitat is in tropical waters and near rocky reefs.

La ***reproducción*** *que Ellos desovan entre febrero y hembra de septiembre El coloca sus huevos en Esqueletos vacíos.*

The reproduction spawns between February and September. They place its eggs in empty shells.

It should be noted that Student 5 did not correctly identify the English target word 'habitat' on the Word-Matching assessment, yet was able to correctly use the word in a sentence in her podcast report.

Student 9, a native Spanish speaker in the two-way immersion classroom, reported on tiger sharks. In the following paragraph, Student 9 used the target word 'migrate' in discussing the migration of tiger sharks:

Cuando el tiburón tigre muerde a un pez u otros animales es peligroso porque tienen los dientes en los lados para matar más rápido. El tiburón tigre ***migra*** *al océano Pacífico hasta Hawai porque los pájaros apenas están aprendiendo a volar y los tiburónes tigre los coman.*

When the tiger shark bites into a fish or other animals its dangerous because they have the teeth in the sides to kill faster. The tiger shark migrates from the Pacific Ocean to Hawaii because the baby birds are barely learning to fly and the tiger sharks eat them.

In examining the podcast reports some students were able to generalize the science lexicon, in this case the target words introduced in the intervention, and apply these words to an authentic task, that is in writing their marine animal reports. As previously stated, students used their written reports to create a collage of the marine animals. In figure 4, Student 4 has created a collage about Orcas.

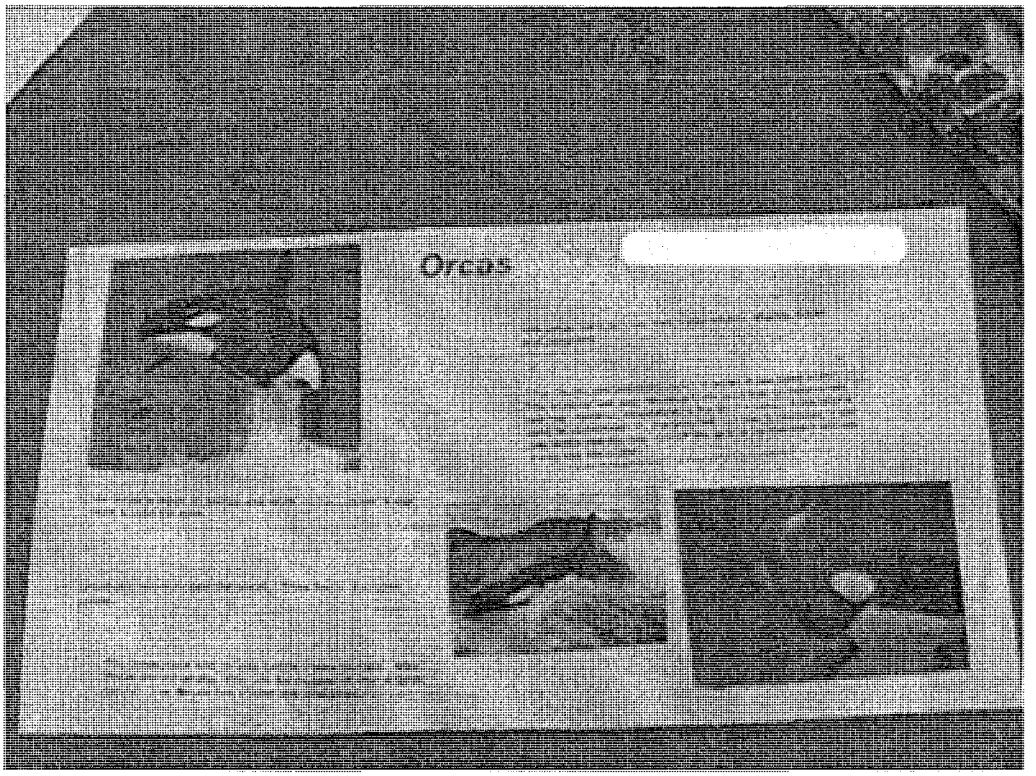

Figure 5. Podcast report collage.

Student marine animal reports with images, created for podcast presentations.

Variability in Student Word Knowledge

As previously stated, the majority of students did improve their knowledge of target words, yet there was still a great deal of variability in terms of student's attainment of academic vocabulary. In order to examine this variability between students, a high and low group was created based on students gain scores on the academic vocabulary assessments. As the reader will recall, there were two versions of the academic vocabulary assessments, a Word-Matching assessment composed of both target and non-target science terms found on the intervention web pages. The Word-Matching assessments administered to students were identical, though one version was in English and the other in Spanish, as students were enrolled in a two-way immersion class and given the fact that the information on the intervention web pages was presented in both languages. In creating the high and low group, students performance was examined on four aspects of academic vocabulary attainment, the improvement or lack thereof on the English and Spanish Word-Matching assessments, which tested students knowledge of both target and non-target words. In addition, as it would be possible to improve their scores on the Word-Matching assessment without improving their knowledge of target words, student's performance of target words in English and Spanish was also taken into account in determining their status in the high or low group.

First students were placed in one of four groups (i.e., Group A-D) as determined by their performance on (1) Word-Matching assessment in English, (2) Word-Matching assessment in Spanish, (3) their acquisition of target words in English and (4) their acquisition of target words in Spanish. Thus, student's post-test scores were examined

and were placed in one of the four following groups, Group A (improvement in 3 or 4 areas); Group B (improvement in 2 areas); Group C (improvement in 1 area) and Group D (no improvement in any area). As seen in Table 19, the majority of students were placed in Groups A & B.

Table 19. Student Variability in Academic Vocabulary Attainment

High Performance Group		Low Performance Group	
Group A	Group B	Group C	Group D
Student 2	Student 4	Student 1	Student 7
Student 3	Student 6	Student 9	–
Student 5	Student 10	Student 13	–
Student 8	Student 11	Student 14	–
–	Student 12	–	–

In determining the *High* and *Low* status groups, in terms of academic vocabulary development, Groups A & B were merged to create the high performance group and Groups C & D were merged to create the low performance group. The primary factor that determined student's placement in the high or low performance group was their attainment of target words in English and/or Spanish. As a result, Students 1 and Student 13 were placed in Group C, a low performance group, as they only improved in one area, yet the one area of improvement was their knowledge of target words in English. Therefore, the intervention was somewhat successful for Students 1 and 13 as they each

acquired one additional target word from their pre-test assessment. It should be noted that only three students, Student 7, Student 9 and Student 14, did not make gains on target words in English or Spanish. In terms of the student profiles of the low performance group, there was variability between each student. For instance, through each student in the low performance group is a native Spanish speaker they varied in their CELDT scores. Student 7 had a CELDT score of 3 (Intermediate); Student 9 had a CELDT score of 4 (Early Advanced); and Student 14 had a CELDT score of 5 (Advanced). There were also differences in students' general receptive vocabulary as measured by the PPVT. For example, Student 7 had a standard score on the PPVT of 71, which the PPVT identifies this score with an age equivalent of a five-to-six year old, and a grade equivalent of a kindergartner, though this student is a third-grader. Student 9 had a PPVT standard score of 97, which according to the PPVT is the age equivalent of an eight-year-old, and grade equivalent to a third-grader, which places this student right on target. Student 14, had a PPVT standard score of 124, placing this student in the 95 percentile, an age equivalent of an eleven-year-old, and a grade equivalent of a fifth grader.

CHAPTER V: DISCUSSION AND CONCLUSION

The main purpose of this study was to investigate the effects of a web-based tool infused with vocabulary learning strategies, that aimed to enrich the academic vocabulary knowledge of bilingual, native English speakers and EL students enrolled in a two-way immersion program. The instructional context for the intervention was a third-grade two-way immersion classroom and use of the school computer lab, which allowed for the examination of the efficacy of web pages embedded with research-based strategies for acquiring academic vocabulary. In this chapter, I discuss the results from the following research questions:

- Can a web-based vocabulary supplement aid the acquisition of academic science target words for multilingual students?

- To what extent did students utilization of the web pages contribute to their academic vocabulary growth?

- How did students demonstrate their comprehension of the academic vocabulary targeted in the intervention web pages?

These research questions enabled the testing of several theories regarding multilingual students' acquisition of content specific target words in English and Spanish. The first theory this study examined concerned the use of technology as a web-based delivery system designed to aid the attainment of target vocabulary in English and

Spanish on the topic of ecology. Second language acquisition research using technology have been successful in building students vocabulary, word translations, reading comprehension, and listening comprehension using multimedia to aid students learning (Plass, Chun, Mayer, Leutner, 1998; Jones & Plass, 2002).

The second theory this study examined concerned multilingual students academic vocabulary development, specifically their acquisition of target science terms. As elementary school curriculums are becoming increasingly complex and academic in nature (Baker, 2001; Gersten & Baker, 2000; Wong Fillmore & Snow, 2000; Merino & Hammond, 2001, 2002; Scarcella, 2003), academic language knowledge, specifically vocabulary development is becoming increasingly more important for academic success as such language skills are tied to higher order cognitive tasks, such as language for categorizing, reasoning and abstract thought (August & Shanahan, 2006).

The intervention, a Computer-Supported Vocabulary Supplement (CSVS), was designed specifically for this study. The CSVS consisted of bilingual web pages with embedded vocabulary strategies designed to enable students' attainment of specific science terms and to aid their comprehension of the scientific concepts introduced on the topic of ecology. The web page content was aligned with California science standards for third grade and involved providing students with multiple exposures to the target words in multiple contexts and provided students with word meanings in English and Spanish. The specific strategies that were used included: text-rich environment in English and Spanish, dictionary definitions, interactive learning activities, group work and group talk around word meanings, and visual and audio support for all target words. These strategies

have all been shown to be effective with various populations of students for vocabulary acquisition (Stahl, 1983; Scott & Nagy, 1997; Beck, McKeown, and Kucan, 2002; Corson, 1997; Scarcella, 2003; August, Carlo, Dressler, and Snow, 2005; and Jimenez, Garcia, and Pearson, 1996), but they had not, until thus study, been systematically examined in the context of web pages for science academic vocabulary learning in English and Spanish with students in a two-way immersion program.

Summary of Results

In reviewing the findings from the vocabulary measures and students use of the intervention web pages, students significantly improved on the Word-Matching assessment of target words in English. Collectively students made small yet significant gains in acquiring additional target words in English, as intended by the intervention. Students' attainment of target words ranged from 1-3 additional target words over the course of the four-week intervention. On average students acquired 3 target words in English (M= 3.54, SD=1.81). Though the word gains seem modest, they are consistent with similar vocabulary intervention studies. For instance, in a study teaching students both concrete words and abstract words using the keyword method and a traditional rehearsal method, Mastropieri, Scruggs, and Fulk (1990), taught 25 student's eight abstract words and eight concrete words. The rehearsal method consisted of experimenter-led drill and practice, rapid-paced questioning and corrective feedback. Mastropieri et al. (1990), found the keyword method to be equally effective in teaching the meaning of abstract (4.96 words) and concrete word meanings (5.71 words). Also, in

a study by Vaughn-Shavuo (1990), a 3 week intervention with first-grade ELLs, Spanish dominant students were randomly assigned to two groups with each group presented with 31 words. One group was instructed with learning words in individual sentence contexts, while the other group received words presented in meaningful narratives, picture cards of the word meanings and created their own sentences using the target words. At the conclusion of the study, the experimental group with elaborated instruction was better able to use target words than the control group, specifically 21 words learned vs. 9 words learned (August et al., 2005). Thus, as students in this study were able to improve their knowledge of target words, which were presented in various contexts along with vocabulary strategies throughout the web pages as opposed to non-target words, the results of this study support previous research indicating that vocabulary development requires repeated opportunities for students to see and hear novel target words in various contexts along with vocabulary strategies in order to aid acquisition (Bailey & Heritage, 2008).

Students were also able to successfully navigate the web pages, and utilize the features of the target-word web pages to complete the WebQuest worksheet and significantly improve their knowledge of English target words. Students made use of the features on the target-word pages, such as opening pop-windows to learn more information on the target words, listening to audio recordings of the target word pronunciation in English and Spanish, and clicking on links within the target-word web pages. For example, students opened the pop-up windows 58 times or 69% of the time students were on target word web pages. Students' increased web page activity when

presented with the opportunity for enhanced exploration of target words as compared to web pages with no features follows previous research, which have demonstrated students' preference for and use of additional computerized features for word learning. Using computer-assisted instruction, Reinking and Rickman (1990), provided students with immediate access to definitions of difficult words from passages presented on a computer screen. In two non-computer-assisted conditions, students had the use of a dictionary and glossary to look up the definitions of words. Reinking and Rickman (1990) found that students in the computer-group selected an average of 9.6 words, compared to the glossary group who looked up an average of 2.1 words (Baker, Simmons, & Kameenui, 1995).

The Ecology WebQuest activity was also successful in both directing students to target-word web pages, thus increasing students' exposure to target words and providing students with opportunities to further explore in depth each target word and the concepts associated with these science terms. Additionally, the Ecology WebQuest allowed for a limited amount of student discourse of target word meanings and content regarding target words found on the intervention web pages, thus providing students with the opportunity to discuss and explain the target words with their peers.

The student created podcast reports also served as delayed outcome data given that students wrote their reports after the intervention had concluded and WebQuest worksheet had been completed. In their descriptions of their marine animals as part of their podcast reports some students included target words as part of their written reports. Thus some students were able to generalize the target science vocabulary and apply their

newly acquired word knowledge to an authentic task, in this case their written podcast reports.

Can a web-based vocabulary supplement aid the acquisition of academic science target words for multilingual students?

This study indicated that a research-based computer-supported vocabulary supplement could aid students' academic vocabulary development as part of the science curriculum. Indeed, participants showed greater growth in their knowledge of English academic science vocabulary targeted in the intervention, as measured by the Word-Matching Assessment, as opposed to the non-target words, which were not supported in the CSVS web pages.

Students as a group improved on their scores on both the English and Spanish version of the Word-Matching Assessments. Interestingly, students acquired more Spanish target words (50) than English target words (46), and more English non-target words (52) than Spanish non-target words (48). Considering the majority of the students in the study were English learners, this may explain the greater acquisition of Spanish target words over English target words. However, the difference between the number of Spanish and English keywords (target and non-target words) acquired was minimal, a difference of eight keywords in total between the English and Spanish word-matching assessments. As a result, while there was significant growth on English academic target words, there was not significant growth on Spanish academic target words. The lack of significant growth of Spanish target words may be attributed to two factors. First,

students did obtain higher scores on the pre-test Spanish version of the Word-Matching assessment for target words. Therefore students had greater knowledge of Spanish target then English target words prior to the study. Secondly, though the intervention web pages provided content regarding the target words in English and Spanish, the WebQuest worksheet was presented only in English. Thus, students may have focused on reading the information from the web pages primarily in English, in order to complete the worksheet.

It should be noted that though students as a whole did improve their knowledge of target words, individually students varied in their acquisition of both English and Spanish target words. Variability between students was examined through gain scores from the Word-Matching assessments. As mentioned, in order to account for the variability in students' performance between pre- and post-tests, students were placed in a 'high' or 'low' group as determined by their attainment of target words. The subsequent analysis identified nine of the fourteen students as *high performers*, as they improved on at least two of the four criteria for inclusion in the high performance group, which included acquisition of (1) academic English vocabulary, (2) academic Spanish vocabulary, (3) English target words, and (4) Spanish target words. As a result, Students 1, 7, 9, 13, 14 were placed in the low performance group. However it should be stated that though Student 1 and Student 13, only improved in one area of academic vocabulary acquisition, this improvement was in their knowledge of English target words. Therefore, one could argue that the intervention was successful for these students, as the primary goal of the intervention was to aid the acquisition of English target words. In examining some of the

characteristics of the students in both the low and high groups, we find that the high performance group was composed of six of the ten English learners and three of the four native English speakers who participated in the study, while the low performance group was comprised of four English learners and one native English speaker. Further analysis revealed that all seven females in the study, three of whom were English learners, improved on English target words, while only four of the seven males (all of which were English learners) improved on English target words. In addition, only three English learners (all males) did not improve on their knowledge of English or Spanish target words. Due to the small number of participants in the study (n=14), gender and native language differences should be interpreted with caution.

To better understand the variability in student attainment of target words, examination of students use of the intervention web pages was required. Thus, student's exploration of the web pages and the use of features on the web pages were examined to identify differences and similarities between students background characteristics, web page use and their performance on the academic vocabulary assessments. This led to the following research question.

To what extent did students utilization of the web pages contribute to their academic vocabulary growth?

In examining students exploration of the intervention web pages, students primarily spent the majority of their time viewing target-word web pages compared to non-target word web pages. In fact, students almost exclusively spent their time viewing

target-word web pages (97%) as opposed to non-target word web pages (3%). This disparity between target and non-target word web pages can most likely be attributed to the WebQuest worksheet, which accompanied the intervention web pages. The WebQuest worksheet, which probed students' knowledge regarding target words (e.g., Why do animals need to reproduce?), directed students to target-word web pages, as can been seen when examining students' paths through the web pages. As the reader may recall, though target words and non-target words appeared throughout the web pages, only target words were supported with additional vocabulary aids. In addition, target-word web pages (e.g., Habitat web page) provided content specific to an individual target word (i.e., habitat). Therefore exploration of target-word web pages provided greater content and strategies regarding target words, as opposed to non-target word web pages, which often contained fewer target words in the description and explanation of non-target words.

Students often visited the web pages in a similar sequential order as the questions asked by the WebQuest worksheet (see Appendix B). For instance, the order of questions on the WebQuest worksheet regarding target words begins with a question regarding extinction, and proceeds with a question on reproduction and so on. The target words are presented in the following order, in the form of questions, on the WebQuest worksheet: *extinct, reproduce, migrate, characteristic, adaptation, organism,* and *habitat*. When comparing the order of these questions with students' navigation of the web pages, a clear pattern is observed in the beginning of students' exploration. For example, the 'extinction' web page was the first web page chosen by each student to explore; that is, it

was not the home page or the first web page automatically opened when the browser was launched. The 'extinction' web page was the first web page link all students clicked on after viewing the Ecology home web page. This was proceeded by the 'reproduction' web page, which as viewed ninety percent of the time after the 'extinction' web page, and the 'migrate' web page which was viewed as the third web page seventy percent of the time. Following these three target-word web pages, students varied in their choice of web page viewing, linking to various target and non-target word web pages. The 'characteristic' web page was viewed as the fourth web page forty percent of the time, followed by the 'adaptation' web page, which was viewed as the fifth web page also forty percent of the time. See Appendix B for a graphic representation of students web page exploration.

Clearly students were influenced in their web page viewing by the WebQuest worksheet, as they proceeded to use the web pages to answer the questions. As expected this ensured that students would be exposed to target-word web pages, increasing the likelihood that students would acquire the target words by further exploring the links and additional features found on the target-word web pages.

Though students did vary in the pathways in which they explored the intervention web pages, the majority of students successfully completed the WebQuest worksheet. In addition, eighty-three percent of student responses on the WebQuest worksheet were correct, with seventy-eight percent of correct student responses coming from information found on the web pages. Therefore, though students explored non-target web pages, students frequently linked to target-word web pages in order to complete the WebQuest worksheet.

In order to understand the effect of target-word web pages on students' academic vocabulary acquisition, examination on how students made use of the target-word web pages was made. Analysis indicated that students did make use of the features found on the target-word web pages designed to aid students' acquisition of academic vocabulary. For example, each target-word web page included a link to a pop-up window where students were provided with additional information on the topic of the target word, including alternative definitions, synonyms, images relating to the target word and audio files containing the pronunciation of the target word. All additional information was presented in both English and Spanish. Students opened the pop-up windows on the target-word web pages sixty-nine percent of the time. In addition, each target-word web page consisted of three web pages with additional content for students to explore the target word meaning in more depth. Students made use of these embedded target-word wed pages forty-five percent of the time.

In examining the web page use of those students who did not make gains on target words, Student 7 and Student 9 did vary in both their exploration of the web pages and their completion of the WebQuest worksheet. Unfortunately, screen-capture data of Student 14 does not exist due to a malfunction with the computer Student 14 was using. However, in examining Student 14 WebQuest worksheet data reveals that he completed the worksheet, in one session, and answered seven of the eight questions regarding the target words correctly. In addition Student 14 answers on the worksheet are from information found on the intervention web pages suggesting that the student may have viewed at least some target web pages. As to why Student 14 did not gain any target

words is undetermined. Perhaps Student 14 was working with a partner when completing the WebQuest worksheet, which may explain why he correctly answered questions about the target words, yet could not identify the definitions on the Word-Matching assessments. Also, the Word-Matching assessments may have been more difficult, requiring students to identify specific definitions to target words as opposed to the more open-ended questions on the WebQuest worksheet. Student 7 and Student 9, who also did not improve their target word attainment, differed in their use of the web pages in the completion of the WebQuest worksheet. For instance, Student 7 viewed twenty-two web pages, with fourteen of those web pages specifically discussing the target words in detail and containing information regarding the WebQuest questions. Student 7 required two sessions to complete the WebQuest worksheet, and on the second attempt he correctly answered seven of the eight questions on the worksheet. Student 9, also was able to correctly answer seven of the eight questions on the WebQuest worksheet, yet he only required one session to complete the worksheet and he only viewed nine web pages, though each web page did directly address the questions asked on the worksheet. Clearly while Student 7 sporadically explored the web pages, Student 9 allowed the questions on the worksheet to guide his progress through the web pages. Though Student 7 and Student 9 both performed well on WebQuest worksheet, they each failed to improve their scores on the Word-Matching assessments, thus not acquiring additional target words. There are several possible explanations why this may be have been the case. First, Student 7, spent on average only one minute and thirty-two seconds per web pages, which likely is very little time to read and comprehend the information on each web page,

especially given that Student 7 scored below grade level on the PPVT, a measure of general receptive vocabulary. Unlike Student 7, Student 9 did spend almost three minutes per web page, with little to no clicking between web pages. However, even with more time on each web page Student 9 did not improve in target word acquisition. Therefore, the second and most likely explanation for Student 7 and Student 9 high performance on the WebQuest worksheet and low performance on the post-test Word-Matching assessments may be due to the fact that each of these students were working with partners who did improve their target word attainment and thus may have relied a great deal on their partner in completing the WebQuest worksheet.

To further understand the variability in which students performed on the WebQuest worksheet and on the academic vocabulary assessments, investigation into the opportunities students had to display their target word knowledge (i.e., discourse between students working on computers to complete the WebQuest worksheet and students podcast reports) were examined. As it may have been the case that students on some level acquired conceptual understanding of the target words from the intervention, yet were unable to identify specific definitions on the Word-matching assessments, this examination of student work was deemed necessary, as research as consistently found that students require multiple opportunities to encounter and act on new target words, through such exercises as creative completion of novel sentences with new words and answering reading comprehension questions which make use of the target words (Nagy & Scott, 2000; Beck & McKeown, 1991; Blachowicz & Fisher, 2000; Stahl & Fairbanks, 1986).

How did students demonstrate their comprehension of the academic vocabulary targeted in the intervention web pages?

As previously mentioned, as students explored the intervention web pages, they also were instructed to complete the Ecology WebQuest worksheet, which featured questions pertaining to the target words of the intervention. Though each student worked independently on each computer and on the Ecology WebQuest worksheet, students did often discuss their web page exploration and the information found on the web pages with their neighbors, as well as soliciting help from their peers in answering the questions from the WebQuest worksheet. In the following example, Student's 8 and 9, were sitting next to each other in the school computer lab, and progressing through the WebQuest worksheet. Student's 8 and 9 used the information from the pop-window to answer the fifth question on the worksheet regarding animal adaptations.

98. STU9: Number five; name an animal with an adaptation (Reading from the worksheet)

[Student 8 opens the 'Adaptation' web page]

99. STU8: Think of an adaptation

100. STU8: There's like a lot of…

[Student 9 opens the pop-up window on 'Adaptation' web page]

101. STU9: This is an Arctic Fox

102. STU9: The Arctic Fox has adaptations like a short muzzle, small ears. (Note: Student 9 is reading aloud the Spanish text in English from the pop-up window)

103. STU8: Hey! That's what I'm going to write.

104. STU9: Hey, they have a thick white coat.

105. STU8: The Arctic Fox, adaptation is short muzzle, short ears, and a thick white fur…because it lives and hunts around the North Pole, okay lets see.

108. STU9: What are you writing about? [To Student 8]

109. STU9: I was writing about the arctic, Arctic Fox has a thick white coat.

121. STU8: It has short muzzle, small ears, white fur, oh thick
122. STU9: Which are you writing for, are you writing the thick white coat?
123. STU8: Yup, white fur
124. STU8: Fur coat, you mean

From examination of the transcript, students were able to ascertain specific biological features that enable the Arctic Fox to survive in its habitat around the North Pole. In one instance Student 8 observed that the Arctic Fox has certain physical features due to its environment: "*The Arctic Fox, adaptation is short muzzle, short ears, and a thick white fur...because it lives and hunts around the North Pole.*" Primarily, the discourse exchanges between students regarded the content found on the web pages as they completed the WebQuest worksheet. As a result, the intervention web pages along with the Ecology WebQuest created the opportunity for students to discuss and explain the reasoning for their answers on the worksheet. In addition to the worksheet questions, the students themselves, when working together created opportunities to explain their thinking to each other. For example, Student 9 challenged Student 8 on two occasions regarding the rationale for each answer with phrases such as, "*Are you sure*" on Line 36 and "*How do you know*?" on Line 129, as seen in the following excerpts:

35. STU8: Write that [To Student 9], I'm gonna write that...life would not exist on Earth if plants and animals did not reproduce to make their offspring. (Reading aloud while writing on worksheet)
36. STU9: Are you sure? [To Student 8] – **(Challenge)**
37. STU8: Yup, cuz that's why they need to reproduce. [To Student 9] – **(Rationale)**

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125. STU8: Name an organism that is an herbivore (reading question from worksheet)
126. STU9: Which one is that?

128. STU8: Lets see, a deer is an organism
129. STU9: How do you know? [To Student 8] – **(Challenge)**

130. STU8: I don't know [laughs] because it [web page] has a picture of a deer. – **(Rationale)**

139. STU9: Oh, I know what that means, animals that eat grass.
140. STU8: Oh, eat plants, so that's what we can write.
141. STU8: Koala
142. STU9: I'm going to do deer.

Given the fact that students did significantly improve their knowledge of target words, which was not the case for non-target words, this may imply that exposure alone from the web pages was not sufficient for students to acquire a significant amount of academic vocabulary. Therefore, the combination of technology and embedded research-based vocabulary learning strategies, as found on the target-word web pages, supports previous research which has found similar success using multimedia in building students vocabulary, word translations, reading comprehension, and listening comprehension (Plass, Chun, Mayer, Leutner, 1998; Jones & Plass, 2002). The results from this study also support past research, which has shown that a combination of factors, including having multiple exposures to target words, activities and strategies for enabling students to further explore the meaning of words and having the opportunity to discuss and use these words, work in tandem to aid academic vocabulary acquisition (Baumann et al., 2003; Scarcella, 2003; Townsend, 2007).

In terms of the podcast reports, students were able to generalize the academic science target words introduced in the intervention web pages into their writings of their marine animals. Eleven of the fourteen students did include target words into their podcast reports. The is was notable as research has shown that students will low vocabulary are less likely to incorporate new vocabulary words into their active lexicons

without explicit instruction, and are also more likely to forget new word meanings than their high vocabulary peers (Fawcett & Nicolson, 1991; Baker, Simmons, & Kameenui, 1995). Only Student 2, Student 11 and Student 12 did not use target words in their podcast reports. Though Student 2 and Student 11 chose not to include target words in their reports, they both improved their scores on the Word-Matching assessments and acquired additional target words. It should be reiterated that students were not required or instructed to use target words in their marine animal reports, as they were unaware as to which science terms were target and non-target words. However, the fact that student's would be describing their marine animals features, environment, and activities for survival, provided students with the opportunity to use the target words if they so chose. Given that the target words were: *adaptation, reproduce, characteristic, extinct, habitat, migrate* and *organism*, there was a possibility that students could have used the target words in their descriptions.

Interestingly, Student 9 and Student 14 who did not improve their knowledge of target words as assessed by the Word-Matching assessments at the conclusion of the intervention, were able to correctly use target words in their written podcast reports. For example, Student 14 did not correctly identify the definition for the target word 'adaptation' in English or 'adaptación' in Spanish on the Word-Matching assessments, though he was able to correctly use the target word 'adaptación' in his written report:

> Las morena tienen una forma de serpiente. Es una **adaptación** para meter se en las grietas de rocas para esconder se y para comer su alimento.
>
> The Moray Eel have the form of a snake. It is an **adaptation** to put itself in the cracks of rocks to hide itself and eat its food.

Clearly, the podcast reports gave students the opportunity to use the science terms targeted in the intervention and allow them to demonstrate their understanding of these target words. Student ability to use the target words in the reports indicates that determining students target word knowledge based solely on the Word-Matching assessments may not truly capture students understanding of the target science terms.

Limitations

The current findings should be considered in light of several limitations. In regards to the study design, the lack of a control group hinders a complete understanding of the effect of the intervention web pages on students' academic vocabulary development. However, the intervention web pages did allow for the examination of within-student acquisition of target and non-target words in a varying context, with non-target words receiving no greater exposure than students would have received from viewing these words in their science textbook.

A second limitation was the duration of the intervention. Previous research on vocabulary instruction has recommended that such instruction be long term and embedded across content areas (Nagy, 2005). Yet, short-term vocabulary interventions have shown to increase vocabulary development in as little as six days (Beck & McKeown, 2007). As this study aimed to improve students' academic science vocabulary on the topic of Ecology, the intervention was restricted to the length of the science unit. Despite the short duration of the intervention students did significantly improve their word knowledge of target words. These results suggest that a long-term implementation

of the intervention web pages across various science units may prove beneficial for academic vocabulary development.

An additional limitation of the study may have been the Word-Matching Assessments. Given that the English and Spanish versions of the assessment were identical, it was possible that students when identifying a presumably correct answer on one language version simply selected the same answer on the other language version. It is unknown whether students were aware of the similarity. The fact the students often correctly identified a word in one language and incorrectly identified the word in the other language on both the pre- and post-measures indicated this may not have been a significant issue. It should also be noted that while students did significantly improve their scores on the English version of the Word-Matching assessment they did not significantly improve their scores on the Spanish version of the Word-Matching assessment. This would indicate that students were either not aware of the similarity between tests or could not remember the order of their answers on the previous test. As each test was administered on separate days the latter may have been the case, and thus were relying on their word knowledge in both languages. The Word-Matching assessments were designed for this study and had been piloted once before.

Implications

The results from this study demonstrate that research-based vocabulary strategies can work in tandem to effectively aid the academic vocabulary development of both English learners and native English speakers, through the use of a web-based tool. Previous research on vocabulary instruction has indicated that providing students with

both definitional and contextual information about each word's meaning; actively involving students in word learning through comparing, analyzing, and using the target words; in addition to providing multiple exposures to meaningful information about each word enables students to acquire academic vocabulary (August, Carlo, Dressler, & Snow, 2005). This study was successfully able to embed multiple research-based strategies into web pages allowing for students to be presented with various strategies simultaneously, thus avoiding superficial vocabulary learning and building students' background knowledge and conceptual understanding of the science terms. By introducing target vocabulary in the context of explanatory narratives regarding the concepts associated with these science terms, found throughout the web pages, led to gains in students' knowledge of academic English words on the topic of ecology.

Though explicit vocabulary instruction is often insufficient to produce substantial gains in overall vocabulary size or in reading comprehension (Nagy & Herman, 1987), incidental learning of a small set of key vocabulary may be ideal for science instruction, where the goal is often not breadth of vocabulary but depth of word knowledge, in relation to the scientific concept(s) associated with the target words. In regards to English learners, previous research has postulated that a considerable percentage of the L2 vocabulary of learners is acquired incidentally, i.e., as a 'by-product' of reading. However, the static written context usually supplies the reader with only a limited amount of information about the meaning of unfamiliar words and thus can sometimes be misleading for given definitions (Beck, McKeown, & McCaslin, 1983; Deighton, 1959; Nagy & Herman, 1987). In order to produce reliable gains in vocabulary acquisition and

reading comprehension, instruction must provide multiple encounters through various information sources regarding the target words (Nagy & Herman, 1987). An active digital context can provide the opportunity to supply multiple rich encounters for a small number of target words through explanation of science concepts along with embedded vocabulary strategies that allow students to self-scaffold through the features provided by hypertext (Proctor, Dalton, & Grisham, 2007).

As technology is becoming ever more present the lives of young children in the context of school learning, especially so in bilingual programs (Bishop, 2000) there continues to be an under utilization of technology in U.S. schools, despite the fact on average there is one computer for every 5 students, with 99 percent of U.S. schools having Internet access, according to the National Education Technology Plan (NETP) by the U.S. Department of Education (2004). The results of this study suggest that such technological resources can be effectively utilized to aid and supplement traditional aspects of teaching when research-based vocabulary strategies are incorporated into computer applications, thereby increasing the opportunities for students to acquire content-specific academic vocabulary and enriching the science curriculum. According to Bailey and Heritage (2008), linking new vocabulary to new concepts by providing students with a visual representation of new knowledge is especially helpful for young English learners. Content areas, such as science instruction offer the necessary opportunities for academic language acquisition by not equating word learning with memorizing synonyms or short definitions, but rather treating target words as labels for concepts that are embedded in larger schemata. Learning definitions alone does not

produce the level of word knowledge necessary for reading comprehension. Thus, instruction must establish the rich ties between new words and prior knowledge and present new words and concepts in the context of larger domains of knowledge (Nagy & Herman, 1987).

As a result this study demonstrated the effectiveness of using web pages to provide vocabulary support in a two-way immersion classroom by linking science target vocabulary with images and audio to assist in word meaning and defining target words through explanatory text regarding the abstract concepts and processes associated with each target word. As both English learners and native speakers of English improved their knowledge of target words, and not so for non-target words, emphasizes that technology alone regarding the presentation of science words was insufficient to significantly improve students acquisition of academic vocabulary. Clearly, the combination of web pages with embedded vocabulary strategies, the WebQuest worksheet and students' Podcast reports led to the result of students' attainment of target words and in building their background knowledge and conceptual understanding of the science terms.

Historically in the computer-assisted language learning literature, computer technology as a medium for learning has been viewed as either technology-driven or pedagogy-driven based projects (Levy, 1997; Colpaert, 2003). Yet, researchers advocate that computer technology and methodology (i.e., learning strategies) can be thoroughly integrated into the design to monitor and control user actions in order to guide language learning activities and foster high learning potential (Ma & Kelly, 2006). Though students as a whole acquired only a small number of target words (1-3 additional target

words in English and Spanish), during the four-week intervention, these results are on par with similar short-term vocabulary interventions (Mastropieri et al. 1990; Vaughn-Shavuo, 1990; Reinking & Rickman, 1990; Baker, Simmons & Kameenui, 1995; August et al., 2005). The results from this study may warrant a long-term computer-supported vocabulary supplement intervention, consisting of research-based instructional strategies to increase students' acquisition of target science vocabulary in a two-way immersion program. In addition, as students in the study significantly improved their knowledge of English target words and not so for Spanish target words from utilizing the bilingual web-pages, it may be the case that future interventions focus on one language per computer-session in order to maximize student's exposure and time with the application to promote vocabulary acquisition in multiple languages.

Future Research Directions

The results of this study allow for several possible avenues for future research. Given the fact that students were able to improve their knowledge of target science words, through minimal use or a web-based tool with embedded research-based vocabulary strategies, suggests that long-term use with the intervention web pages as a supplement to the science curriculum, will help students acquire specialized academic vocabulary. Results showed that with three sessions of the intervention web pages along with the Ecology WebQuest, students considerably increased their scores on the English academic Word-Matching assessment. Therefore, considering such gains in academic vocabulary attainment by utilizing technology along with research-based vocabulary strategies and activities may demonstrate the efficacy of further longitudinal investigation

of such a supplemental program to the science curriculum for students in a two-way immersion program. Researchers, such as Shanahan and Beck (2006), indicate the need for long term investigations of instruction and procedures leading to deeper processing of word meanings and use of word learning in different formats for the acquisition of more abstract words, including the identification of effective vocabulary instruction for English-language learners.

As proclaimed by Anderson & Nagy (1991), vocabulary development with the specific intention of aiding the needs of diverse learners should focus on teaching words that are strategic to academic success and are not typically acquired independently, especially due to the fact that of the approximately 3000 words students learn per year in the early primary grades, a large percentage are often more complex infrequently used words, and used primarily for specialized academic activities (Baker, Simmons, & Kameenui, 1995). Riches and Genesee (2006) assert that in order for ELLs' to achieve their full literacy potential, the development of proficiency in various genres of literacy is required. According to Watson & Olson (1987), even sixth grade children find it difficult to understand definitions of novel words, and this can apply to older students learning a second language as Fischer (1990, 1994) has found that high school foreign language students struggle to effectively utilize bilingual dictionaries, as they simply look for cross-language synonyms, thus displaying an overly simplistic concept of definition (Scott & Nagy, 2004). Thus, providing opportunities for students to explore target words across various content areas, through the affordances of multimedia may prove to be beneficial in academic vocabulary acquisition.

Future research may also explore Spanish academic language development, in addition to academic English acquisition, for students in dual-language programs. With expansion of the Computer-Supported Vocabulary Supplement, through the inclusion of Spanish and English WebQuest activities accompanying the target bilingual web pages, may aid student attainment of Spanish and English academic vocabulary. Second language learners often show increases in vocabulary development when instruction provides both definitional and contextual information about words to be learned as well as having multiple exposure and opportunities to use them (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006).

Additionally, further research is needed in the development of effective academic English assessments. As academic language is composed of multiple elements such as phonological, syntactic, sociolinguistic and discourse components (Scarcella, 2003), measures are needed to assess students' knowledge beyond general and content-specific academic vocabulary. Such assessments of academic language ought to encompass four language modalities: listening, speaking, reading and writing – in order to accurately identifying students' academic language knowledge across various content domains (Bailey, 2007).

In conclusion, the results of this study and associated literature underscore the importance of academic vocabulary development and building students' background knowledge to aid conceptual understanding of complex abstract concepts found in content areas such as science. The findings of this study may also warrant the need for further research regarding the merging of technology with research-based word-learning

strategies for the successful acquisition of academic vocabulary. As research has indicated that students, especially ELLs, often struggle with academic or cognitively demanding types of text, for example having greater difficulty reading and understanding reports as compared to stories (Jimenez et al., 1996; Langer et al., 1990), the ability to present target vocabulary in the context of scientific explanations through the use of multimedia (e.g., hypertext) with research-based vocabulary strategies at the heart of its design, may aid students with interpreting decontextualized text. Thus, it is critical in future research to include measures which detail students' use of supports in such learning environments, especially for struggling and English learning students for understanding student learning and in the designing of effective computer-assisted learning environments (Laufer, 2003; Proctor, Dalton, & Grisham, 2007).

It should be noted that providing children with access to various modalities for learning in digital environments can place greater demands on students' cognitive processing, necessitating the need for high level information processing skills as they synthesize information through text, images, video, audio, etc. and within nonlinear hypertext structures (Proctor, Dalton, & Grisham, 2007). However, research on embedded supports designed to aid word learning and text comprehension by overcoming cognitive processing demands through multimedia learning have consistently shown promising results and thus continue to be a recurring characteristic of many digital learning environments (Reinking, 1988; Plass et al., 1998; Mayer, 2003; Strangman & Dalton, 2005; Proctor, Dalton, & Grisham, 2007). As a result, numerous researchers continue to advocate for the use technology as one of the most important new avenues to

aid educators working with struggling readers and ELLs (see, e.g., Alvermann, 2002; Jiménez, 2003; Rose & Dalton, 2002; Strangman & Dalton, 2005; Proctor, Dalton, & Grisham, 2007) in the endeavor of improving literacy and learning outcomes for all students.

Appendix A

Ecology WebQuest

Name: _____ Date: _____

Answer the questions below
Explore the web pages to find the answers

1. Name an animal that went extinct:

_____

2. Why do animals need to reproduce?

_____

3. Name an animal that migrates:

_____

4. Name a characteristic that is inherited in animals:

_____

5. Name an animal with an adaptation:

_____

6. What type of adaptation does it have?

_____

7. Name an organism that is an herbivore:

_____

8. What type of habitat do you think it lives in?

_____

Appendix B*

Student Web Page Utilization Matrix

	STU1	STU2	STU3	STU4	STU5	STU6	STU7	STU8	STU9	STU10
WP1	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**
WP2	**R**	**R**	**A**	**E2**	**R**	**E2**	**E2**	**R**	**R**	**R**
WP3	**M**	**R2**	**R**	**R**	HB	**E3**	EC	**M**	**M**	**M**
WP4	**M2**	**R3**	**R**	**M**	**M**	EC	**E**	**C**	**C**	**C**
WP5	**M3**	SV	**M**	**M2**	**C**	**E**	EC	**C2**	**C2**	**C2**
WP6	**C**	HB	**C**	**M**	**A**	EC	**R**	**C**	**A**	**A**
WP7	**C2**	**M**	**C2**	HB	HB	**R**	**R2**	**A**	**O**	–
WP8	**C3**	**M2**	**C3**	**C**	**H**	**R2**	EC	**O**	**O3**	–
WP9	**C2**	**M**	**C2**	**C2**	EF	**R3**	**M**	**O3**	**H**	–
WP10	**C**	EC	**C**	**C3**	WL	EC	EC	–	–	–
WP11	**C2**	**R**	**A**	FW	AT	**R**	**R**	–	–	–
WP12	**C3**	**R**	–	**A**	**O**	EC	**M**	–	–	–
WP13	**A**	**R2**	–	**A2**	**O2**	**M**	**C**	–	–	–
WP14	–	**R**	–	**O**	**O3**	EC	EC	–	–	–
WP15	–	FT	–	**O2**	**H**	**R**	**M**	–	–	–
WP16	–	**M**	–	**O3**	–	EC	EC	–	–	–
WP17	–	**A**	–	**O3**	–	**H**	**C**	–	–	–
WP18	–	**C**	–	WL	–	EC	**A**	–	–	–
WP19	–	–	–	AT	–	**M**	EC	–	–	–
WP20	–	–	–	PL	–	EC	**A**	–	–	–
WP21	–	–	–	–	–	**C**	EC	–	–	–
WP22	–	–	–	–	–	**R**	**H**	–	–	–
WP23	–	–	–	–	–	EC	–	–	–	–
WP24	–	–	–	–	–	**M**	–	–	–	–
WP25	–	–	–	–	–	**M2**	–	–	–	–
WP26	–	–	–	–	–	**M3**	–	–	–	–
WP27	–	–	–	–	–	EC	–	–	–	–
WP28	–	–	–	–	–	**C**	–	–	–	–
WP29	–	–	–	–	–	EC	–	–	–	–
WP30	–	–	–	–	–	**A**	–	–	–	–
WP31	–	–	–	–	–	EC	–	–	–	–
WP32	–	–	–	–	–	**A**	–	–	–	–
WP33	–	–	–	–	–	**A2**	–	–	–	–
WP34	–	–	–	–	–	EC	–	–	–	–

* Web Page Codes: Target Web Pages: **E**=extinction; **R**=reproduction; **M**=migrate; **C**=characteristic; **A**=adaptation; **O**=organism; **H**=habitat – Non-Target Web Pages: HB=hibernate; SV=survive; FT=future world; FW=food web; GL-glossary; WL=web of life; AT=atmosphere; PL=pollution; EF=ecology facts; EC = Ecology web page.

Appendix C

Ecology Vocabulary Word Matching

Name: _____ Date: _____

Match the following vocabulary words to their definitions
Draw a line from the word to its definition

1. Ecology	Change in an organism or its parts that improves its ability to live in a specific environment
2. Climate	The science that studies the relationships between living things and their environment
3. Adaptation	The most common weather of an area
4. Biosphere	Contamination of soil, water, or the atmosphere by harmful substances
5. Reproduce	Ecosystem of the entire planet
6. Pollution	To produce new individuals of the same kind
7. Survive	Community of living things interacting with their environment
8. Ecosystem	To remain alive; continue to exist
9. Characteristic	The whole mass of air surrounding the earth
10. Extinct	An inherited feature or trait
11. Atmosphere	No longer existing or living
12. Habitat	A living person, plant, or animal
13. Migrate	Remains of a plant or animal preserved in earth or rock from long ago
14. Organism	The natural environment of an organism
15. Fossil	To move from one place to another for feeding or breeding

Appendix D

El Emparejar De la Palabra Del Vocabulario De la Ecología

Nombre: _____ Fecha: _____

Empareja las palabras siguientes del vocabulario a sus definiciones
Dibuja una línea de la palabra a su definición

1. Ecología	Cambio en un organismo o sus partes que mejora las condiciones que exista en un ambiente especifico
2. Clima	La ciencia que estudia las relaciones entre seres vivos y su ambiente
3. Adaptación	El tiempo típico de un lugar
4. Biosfera	Una sustancia o la cosa que tiene los efectos negativos o tóxicos en el ambiente
5. Reproducir	El ecosistema del planeta entero
6. Contaminación	Para producir nuevos individuos de la misma clase
7. Sobrevivir	La comunidad de seres vivos que interactúan con su ambiente
8. Ecosistema	Para quedarse vivo
9. Característica	El aire y los gases que rodean la tierra
10. Extinto	Un rasgo o la calidad que pertenecen típicamente a una persona, al lugar, o a la cosa y sirven para identificarlo
11. Atmósfera	Para tener ningún miembro de una familia que vive ni la especie
12. Hábitat	Una persona viva, la planta, o el animal
13. Emigrar	Lo que se queda de una planta o un animal preservada en la tierra o la piedra hace mucho tiempo
14. Organismo	El ambiente natural de un organismo
15. Fósil	Mover de un lugar a otro para alimentar o criar

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