Bilingual Language Supports in Online Science Inquiry Environments

Research over the past fifteen years has investigated and developed online science inquiry environments to support students engaging in authentic scientific inquiry practices. This research has focused on developing activity structures and tools to scaffold students in engaging in different aspects of these practices. Relatively little research, however, has focused on incorporating linguistic supports for English language learners (or other second language learners) studying science in their non-native language. These students are therefore learning both science and the academic language in their second language. This study investigates the potential value to 8th grade Spanish-speaking English language learners of an environment that provides them access to the content and supports in both English and Spanish as opposed to an English-only format. Student learning outcomes on an immediate post-test in English, a delayed post-test in English, a delayed post-test in Spanish, and a written essay in English in the form of a letter to the governor are compared between the two conditions. The outcomes suggest significant benefits for the Spanish-speaking English language learners on all of the post-tests. The findings of this study carry important policy implications in light of the growing English-only political movements in the United States.

Douglas Clark, Arizona State University
Stephanie Touchman, Arizona State University
Tina Skjerping, Salt River Project

Introduction

In recent years, the population of the United States has undergone a significant change in demographics, language, and culture. In 1990, 14% of the U.S. population spoke a native language other than English. By 2000, this number grew to 18%, which means that 47 million people were learning English as a second language (U.S. Census Bureau, 2002). This change is reflected in the elementary and secondary school population where the percentage of students enrolled as English language learners (ELLs) grew 58.5% from 1994 to 2004 (NCES, 2004). However, the increase in ELLs is not distributed evenly across the country. Of the total population of ELLs enrolled in public schools, 10.0% are located in the Northeast, 9.1% in the

Midwest, 23.8% in the South, and 57.2% in the West (NCES, 2004). In the state of Arizona (where the current study was conducted), nearly one-third of all the children were either foreign born or the child of an immigrant in 2000 (U.S. Census Bureau, 2002).

The growth of ELLs in U.S. schools has precipitated changes to local, state, and national education policy. Congress passed the Bilingual Education Act (Title VII) in 1968, for example, that requires schools to provide equal educational opportunities for language-minority students. Similarly, Lau vs. Nichols (1974) was a civil rights case under Title VII that expanded on the rights of limited English proficient students allowing them access to bilingual education when necessary (Stewner-Manzanares, 1988).

It is generally agreed upon that ELLs cannot afford to postpone learning subject content, such as science, while they learn English. However, policy makers have long debated over the type and duration of these programs (Hakuta, Butler, & Witt, 2000). Because these policies are determined at the state level, there is no national consensus on which is the most appropriate method for providing optimal educations for ELLs. Each state, in fact, enforces different programs. Some of the more common bilingual education programs include: English as a second language (ESL), dual-language immersion, and transitional bilingual education (Krashen, 1996).

Based on the research, it remains unclear which methods provide the best services to ELLs. To further compound the problem, our schools are generally failing at producing students who are scientifically literate (Lee & Luykx, 2007). This is usually a result of the way science is taught in schools, where curricula is often based on unconnected demonstrations and memorization of facts (Schmidt, McKnight, Cogan, Jakewerth, & Houang, 1999; Schmidt et al., 2001). This method of teaching prevents students from learning the nature of science or understanding how it is practiced by professional scientists because they are not learning the language of science (Lee & Luykx, 2007). ELLs are therefore being impeded doubly within the science classroom in terms of English language literacy as well as academic science literacy (Warren, Rosebury, & Conant, 1989). In the current study, we investigate a strategy for increasing science learning by providing ELLs with access to their linguistic resources in both Spanish and English as they learn about wolf ecology and population management in an online science inquiry environment.

Literature Review

This literature review first provides an overview of the research on language minority students in science education. The review then considers the affordances of online learning environments to support ELLs studying science Finally, the review looks at issues of bilingual and English-only education for ELLs regarding how best to provide supports for Spanish-speaking Ells studying science in online inquiry environments.

Language Minority Students and Science Education

For language minority students, there are complex interactions that exist between English proficiency, science learning, and literacy development. Overall, the research suggests that "students' limited proficiency in English constrains their science achievement when instruction and assessment are undertaken exclusively or predominantly in English" (Lee & Luykx, 2007). To make matters worse, teachers often lack the knowledge to address the complex educational needs of ELLs (Lee & Luykx, 2007).

Increasing the challenge, both monolingual English students and ELLs need to develop their academic language proficiency in science. Science is based on a specialized language with specific terminology (Sutton, 1996). It is rich with a vocabulary that reduces complex processes into singular words, for example ‘photosynthesis’, which denotes the conversion of sunlight into biological energy, or ‘diffusion’, which describes the natural movement of particles (Halliday & Martin, 1993). Science education focuses on this specific language. How this language is taught and used in the classroom affects ELLs’ progress as they learn science. Thus, the ability for a student to access science is couched in their development of scientific academic language. In *Talking Science; Language, Learning and Values*, Lemke states that “learning science means learning how to *talk* science- in other words, observing, describing, comparing, classifying, discussing, questioning, challenging, generalizing and reports, among other ways of talking science” (Lemke, 1990). As a result, science discourse, or the interactions between the participants involved, is essentially the gateway into the science community.

“Science learning can be conceptualized as students coming to know how to use specialized language, given the constraints of particular social configurations and cultural practices.” (Kelly, 2007). Knowing these cultural processes and how to participate in them is the key to accessing opportunities in science. However, differences between the cultures and languages of school and home can be problematic for students learning science (Au & Mason, 1983). Even among English speakers, problems can arise if the home language or cultures do not match with the academic language or cultures traditionally associated with western science. Western scientific practices like questioning and skepticism, for example, may clash with some cultural norms in the science classroom (Lee & Fradd, 1996).

A study done in Arizona found that Hispanic/Latino students were less likely to have access to western scientific discourse. Hence, they were less likely to participate in classroom interactions (Barba, 1993). In another study, Lee and Fradd (1996) distinguished differences in the discourse patterns of three categories of students (bilingual Spanish, bilingual Haitian Creole, and monolingual English speakers). The differences involved turn taking, the unit of discourse and nonverbal communication. This study highlights that “students may have difficulty deciding when to talk, how to present their ideas, and how to demonstrate their understandings” (p. 292) in alignment with the values and processes associated with western science.

Affordances of Online Science Inquiry Environments

Much research over the past fifteen years has focused on the development of tools and activity structures in online science inquiry environments to support students engaging in inquiry and discourse. We will henceforth refer to these online science inquiry environments as "environments" for brevity. Much less research has focused specifically on the potential of these environments to provide language supports for ELLs. This section first provides an overview of these environments for supporting students more generally in scientific inquiry and discourse. More specifically, we discuss these general supports for all students in terms of (a) scripting collaboration and activity structures, (b) providing access to data, (c) making sense of data, (d) supporting communication, (e) optimizing group composition, (f) facilitating the co-creation and sharing of artifacts, and (g) providing awareness tools. Subsequent sections will consider specific potential affordances for ELLs studying science within these environments.

Scripting collaboration and activity structures.

The design of many of these environments can be thought of in terms of “scripts” that orchestrate and control students’ interactions with each other and the environments (e.g., Hesse, 2007; King, 2007; Carmien, Kollar, Fischer, & Fischer, 2007; Stahl, 2007; Stegmann, Weinberger, Fischer, 2007). As Weinberger and colleagues explain, "collaboration scripts provide more or less explicit and detailed instructions for small groups of learners on what activities need to be executed, when they need to be executed, and by whom they need to be executed in order to foster individual knowledge acquisition" (Weinberger, Stegmann, Fischer, & Mandl, 2007, p.195). These scripting and activity structures help students learn new tasks, technologies, and procedures in technology-enhanced learning environments.

Providing access to data.

Science education places strong emphasis on "data." Many phenomena, however, prove inaccessible, inappropriate, or impractical for investigation in a traditional classroom context. Technology-enhanced learning environments can provide access to data to facilitate students' investigations.

One approach involves embedding resources in knowledge bases without pre-defined access order or sequence. These knowledge bases can be generated by the students themselves as in *CSILE* (Scardamalia & Bereiter, 1994) or by curriculum developers or teachers as in *WISE* (Linn, Clark, & Slotta, 2003) or Learning by Design (Kolodner, Schwarz, Barkai, Levy-Neumand, Tcherni & Turbovsk, 1997). These knowledge bases may range from glossaries or reports of experiments to recordings of experiments or simulations. With the help of index pages or search engines, students can search and use these resources to support their claims or critique the arguments of others.

Enriched representations can also provide significant interrelated information to students (Fisher & Larkin, 1986). Online learning environments can, for example, incorporate media-rich representations of the learning task, materials that enhance the authenticity of the learning task, and contextual anchors to facilitate student learning (Bransford, Brown, & Cocking, 2000; Cognition and Technology Group at Vanderbilt, 1997). These environments can challenge students to identify the relevant problem information within complex problem cases and then create an appropriate solution strategy using these materials. Students can also collect evidence by observing rich representations. Visualizations and simulations may allow students to explore aspects of the subject matter to support a specific claim, thereby potentially increasing the persuasiveness of their arguments (Oestermeier & Hesse, 2000).

Making sense of data.

Environments can provide specific functionality to help students analyze the data in terms of its meaning and its relevance to their arguments. Early work of this type was conducted with the SenseMaker tool within the *KIE* and *WISE* environments (Bell, 1997, 2004; Bell & Linn, 2000). Related to this work, the *BGuILE* environment helps students design and practice scientific inquiry through investigation, refine their own explanations and reasoning, and critique other students' explanations (Reiser, Tabak, Sandoval, Smith, Steinmuller, & Leone, 2001; Sandoval & Reiser, 2004). The *BGuILE* environment integrates dynamic visualizations and outlining environments to help students learn, understand, and integrate new and complex knowledge and concepts that students might not otherwise address (Reiser, 2002).

Supporting communication.

Online science inquiry environments can incorporate both asynchronous and synchronous collaborative communication interfaces as modes of communication to promote and support interactions between students. Asynchronous and synchronous modes offer different affordances. Asynchronous modes of communication allow learners to participate more equitably and to spend more time on constructing well-conceived and elaborate arguments (e.g., de Vries, Lund & Baker, 2002; Joiner & Jones, 2003; Kuhn & Goh, 2005; Marttunen, 1992; Marttunen & Laurinen, 2001; Pea, 1994; Schellens & Valcke, 2006;), whereas synchronous modes of communication can deliver a higher degree of joint elaboration and construction of arguments but place higher demands on learners' ability to interpret challenging conceptual material (e.g., Barron, 2003; Munneke, Andriessen, Kirschner, & Kanselaar, 2007; Pfister, 2005; Rogoff, 1998). This type of communication support can also help students learn how select key pieces of a complex idea to express in words, sounds, and images, in order to build shared understanding. It can also help students learn how to negotiate positive outcomes with subordinates and superiors through social perceptiveness, persuasion, negotiation, and instruction.

Optimizing group composition.

Online environments also can support strategic composition and organization of groups to maximize the likelihood of successful interactions (e.g., Clark, 2004; Clark & Sampson, 2005, 2007, 2008; Cuthbert, Clark, & Linn, 2002; Dillenbourg & Jermann, 2007; Jermann & Dillenbourg, 2003). Organization of heterogeneous groups based on a variety of learner characteristics (e.g., prior knowledge, gender, opinions) can expose learners to a broad bandwidth of perspectives and resources. Technology can distribute these resources, analyze student characteristics, and compose groups of students accordingly. These types of tools can also help students learn how to adapt to people different personalities, communication styles, and cultures.

Facilitating the co-creation and sharing of artifacts.

Some online science inquiry environments encourage collaboration through the co-creation and sharing of intellectual artifacts that present or visualize arguments (e.g., Kirschner, Buckingham, Shum, & Carr, 2003). Students in these environments therefore create, modify, and share permanent external representations of their ideas and arguments with one another. Producing these external representations engages students in proposing, supporting, evaluating, and refining their ideas (e.g., Fischer, Bruhn, Gräsel, & Mandl, 2002; Suthers & Hundhausen, 2001). This approach includes tools that enable collaborative writing as well as tools that support the collaborative creation of argumentation maps. These external representations can help students think about how an entire system works, how an action, change, or malfunction in one part of the system affects the rest of the system and adopt a “big picture” perspective on work.

Providing awareness tools.

Online environments can also provide awareness tools to increase group members’ awareness of the nature and quality of contributions and participation within the group (e.g., Dillenbourg, 2002; Erkens & Janssen, 2006). These tools support the self-regulating capacities of collaborative learners. Students are made aware of possible strengths and deficits regarding the group’s collaborative activities and of possible gaps in the group’s argumentation. Based on this feedback, students can self-correct their collaboration accordingly (e.g., Hesse, 2007; Jermann, Soller, & Muehlenbrock, 2001). These tools also help students develop the skills they will need to process and interpret both verbal and non-verbal information in order to respond to other people in an appropriate manner.

Potential Affordances ELLs Studying Science and Language Supports

All of the affordances of the environments discussed above are useful for ELLs as well as monolingual students. These environments also offer, or could offer, affordances of particular value to ELLs in particular. For example, these environments not only provide rich visualizations and contexts but also provide powerful opportunities for social supports and discourse that sheltered instruction researchers consider critical in scaffolding academic language development (Chamot & O'Malley, 1986, 1994; Johnson, Johnson, Holubec, & Roy, 1984; Kagan, 1986). Thus, rather than being a challenge for the students to overcome, the text is in fact an excellent opportunity in and of itself (i.e., the text is an important medium through which literacy and understanding is developed). Academic text is at the heart of literacy, and researchers are calling precisely for this type of writing within the curriculum to support literacy development. Furthermore, text-based asynchronous interactions allow learners time to compose their responses and decode the other students' contributions and so learners with varying levels of proficiency in the language of instruction can all participate with one another.

In addition to these potential affordances for ELLs, environments could also potentially provide direct language supports for students. While teachers cannot reasonably be expected to provide native language supports for all of their students given the multiple languages often present in the diverse classrooms of the United States and other countries, online environments could very realistically be programmed to provide native language supports for multiple different languages simultaneously within the classroom. The purpose of the current study is to study the efficacy of one approach for providing these supports in Spanish. This study thus lays the groundwork for an approach that could provide language supports for ELLs of multiple languages as well as English-dominant students with diverse levels of literacy studying science within the same online environment in the same classroom. A core question that needs to be answered early along this path, however, involves the form of language supports that will best serve ELLs in these environments. The following sections of this literature review examine the research regarding language supports for ELLs.

Bilingual versus English-Only Monolingual Instruction for ELLs

The focal issue of this study with regard to improving science education for ELLs involves providing them with access to linguistic supports in English as well as their native language as they study science in an online science inquiry environment. We now therefore outline some of the research regarding the debate over bilingual and English-monolingual instruction for ELLs.

Bilingual Education vs. English-only Education

Traditionally, ELL programs have often used bilingual education methods, where the student's native language is used to help guide them towards an all-English education. However, the English-only movement has gained momentum and is causing some conflict among policy makers, teachers, parents and students. This movement promotes policies that require ELLs to be totally immersed in an English-only classroom without the help of their native language as an aid (Krashen & Terrell, 1983). Legislation in California (1998) and Arizona (2000) requires public schools to use English-only immersion as the main method for teaching ELLs. This method allows the students to be in a "sheltered" class that uses their native language for only one year. Following the first year, ELLs continue on in a mainstream classroom immersed in an English-only environment. This is in contrast to bilingual programs that have no time limits (ECS, 2000).

It is still debated whether or not using native language in an ELL program can offer the best education. Advocates of bilingual education propose that providing students access to their native languages facilitates the transition to an English education. But advocates of English-only education propose that the bilingual programs hinder ELLs' ability to learn content by keeping them in the comfort zone of their native language too long. Part of the reason for this lingering debate is that research has shown conflicting results from both sides of the argument, which leaves educators and policy-makers unclear as to the most effective method. To make matters worse, the quality of methodology in the majority of studies done in this area is suspect due to a lack of peer-reviewed research; most of the data comes from federal evaluation reports required and funded by federal Title VII funds (McQuillan, 2005).

Research that supports Bilingual Education

‘Bilingual education’ refers to educational methods where instruction is given in two languages. Here in the U.S., it involves school programs for students whose first language is not English and have limited language skills in English. Bilingual education provides programs that are focused on English language development and subject area instruction using the student’s native language as an aid. These programs vary in their length of time and the extent that their native language is used.

There are many different variations of programs used across the United States. The majority of bilingual programs are grounded in one of the three following approaches: English as a Second Language (ESL), Dual-language Immersion, and Transitional Bilingual Education(Krashen, 1996). ESL programs are focused on teaching the students English. They are sometimes designed as a pull-out program where students spend a portion of the day separate from mainstream classes to receive instruction in the English language (McKeon, 1987).

Secondly, dual-language immersion programs, or two-way immersion, typically involve teaching students literacy and content in two languages. The most important characteristic of these bilingual programs is that students preserve their native language and are taught subject content in both languages. Effective dual-language programs strive to achieve proficiency in both English as well as the student’s native language. (Calderon & Minaya-Rowe, 2003; Howard, Sugarman, & Christian, 2003).

Lastly, Transitional Bilingual Education programs strive to transition students out of their native language and into English as quickly as possible. This is sometimes referred to as “subtractive bilingualism” since students lose their first language as they acquire English (Sohn, 2005). Although there is arguably adequate amount of services available to English-language learner (ELL) students in these programs, it is still widely debated whether these bilingual programs benefit these students or hinder them from learning English. Given the steadily increasing enrollment of ELLs in schools across the country, the importance of addressing this question scientifically has taken on new urgency.

Several groups of researchers have performed comparison studies measuring the outcomes of different teaching strategies. In a meta-analysis by Baker and de Kanter (1981), 28 studies examining four different programs were compared (ESL, transitional bilingual education, submersion, and structured immersion) and the results were mixed as to which program benefit ELLs most. They concluded their analysis with mixed results and recommended that schools be flexible with which bilingual education methods is used because it is difficult to determine which program would succeed in a particular school.

Slavin and Cheung (2003) did another comparison analysis that included 16 studies. Their focus was on teaching reading skills to ELLs. They compared a bilingual education method where students were taught first to read in their native language against an all-English method where students were taught to read only in English. From this comparison study, they reported that the majority of the studies analyzed favored bilingual approaches, although some of the studies found no difference between the two methods. In another meta-analysis done by Rolstad, Mahoney and Glass (2005), 17 studies were compared. In this analysis they report that developmental bilingual education programs (such as ESL) are superior to transitional bilingual education programs. Furthermore, they conclude that bilingual education is superior to all-English methods. Lastly, Jay P. Greene (2005) performed a meta-analysis taking 11 studies (from 75 total studies) that met minimal statistical standards for the quality of their research design to estimate the benefit of using native languages in bilingual education programs. From this investigation, the evidence suggests that native language instruction has a significant and positive impact on ELLs.

Despite the evidence in favor of bilingual education methods, it is difficult to validate comparison studies for three reasons. First, not all of the studies included in the comparisons have the same native language. As pointed out by [cite], some languages are more similar to English than others and this plays a large part in how easily a person can acquire English. For instance, French is closer to English than Chinese and therefore will be easier to learn. Also, students come into a bilingual program at different stages within a spectrum of English language literacy. This was not always taken into account in the studies used in these comparisons, and this detail will influence the success of a particular bilingual education program. Lastly, pointed out by August and Hakuta (1997), the level of the teacher's fluency in the native language of the ELLs is not taken into account. It is very common for teachers in bilingual education programs to be unfamiliar with the native language and this could also have an impact on the outcome. Comparison studies are useful to get a generalization of bilingual education practices, but clearly a complex mixture of variables influence learning outcomes.

In the literature, bilingual programs using native language as a support have a higher success rate when teaching ELLs English and subject content, compared to English-only education programs (Baker & Kanter, 1981; Calderon & Minaya-Rowe, 2003; V.P. Collier, 1990; Virginia P. Collier, 1995; Garcia, 2001; Genesee, 1987; Hakuta et al., 2000; Howard et al., 2003; Krashen, 1996; Krashen & Terrell, 1983; McKeon, 1987; McQuillan, 2005; Rolstad, Mahoney, & Glass, 2005; R.E. Slavin & Cheung, 2003; Robert E. Slavin & Cheung, 2005; Sohn, 2005; Stewner-Manzanares, 1988; W. P. Thomas & Collier, 1997; W.P. Thomas & Collier, 2002; Tse, 2001). Although these have been contested, several explanations are present in the literature that attempts to account for these findings. First, having native language support seems to be a benefit because academic skills that ELLs learn in their first language transfer to their second language (Virginia P. Collier, 1995; Garcia, 2001; Genesee, 1987; Krashen, 1996). In other words, literacy transfers. For example, once you have learned how to read, you can read more easily in other languages (Smith, 1994). In contrast to this, Porter (1990) in her book, Forked Tongue, states that there is a lack of evidence that literacy transfers. She claims that knowing how to read in one language does not necessarily mean that you can read in another, especially if that language does not use the Roman alphabet.

Second, Krashen (1996) claims that knowledge gained in the native language makes English input more comprehensible and this can greatly assist in English language acquisition (pg. 4). Third, it has been established that students with a well-developed native language are able to learn English more successfully. This is due to the idea that learning another language enhances children's understanding of their native language and its structure (Nahari, Lopex, & Esquivel, 2007). So in fact there appears to be a reciprocal beneficial effect on learning. According to Diaz (1983), a "metalinguistic awareness serves as a critical component in the development of intelligence" and this contributes towards the learning of a new language. Lastly, for ELLs, development of their native culture and language identity has been shown to enhance their psychological health, which contributes positively to learning a new language. Children with high self-esteem work harder and learn more (Nahari et al., 2007). In contrast, Rossell and Baker (1996) claim that "it is impossible to say why native language development will help second language development" and that "there is no underlying psychological mechanism that accounts for the facilitation effect". There are experts that have reported significant findings on both sides of this debate. This just illuminates how difficult it is to determine the best solution for such a complex problem.

Research that supports English-only Education

In English-only education, sometimes referred to as "immersion," ELLs are expected to learn English with minimal scaffolding in their native language. Support, formal or informal, can include language development strategies used by the teacher, such as a total physical response (acting out words) and realia (using concrete objects to represent words). In addition, the teachers can simplify their language and teach specific vocabulary words. These strategies are designed to help ELLs internalize new vocabulary (Calderon 2001; Carlo et al. 2004).

In practice, the most common form of English-only education is "structured English immersion." This method allows for the smallest amount of native-language instruction necessary to supplement English-only curricula. The goal of a structured English immersion program is to use English as much as possible so that ELLs can move into mainstream classes in approximately one year. However, an English-only program can also involve placing ELLs immediately in classes containing English monolingual children. Educators often refer to this method as "submersion", or "sink or swim", in which no special provision is made for the needs of ELLs. The different variations certainly affect the outcome of immersion strategies, but their key common feature is the exclusive use of English texts, with instruction and assessment overwhelmingly or entirely in English (Brisk, 2006).

In 2001, the Bilingual Education Act was effectively terminated by the U.S. Congress with the implementation of No Child Left Behind. No Child Left Behind emphasizes accountability in English by mandating that all students (including ELLs) be tested every year in

English (Tinajero, 2005). Due to this change in legislation, all schools are forced to implement some form of English-only instruction.

Advocates of English-only programs propose that using native language instruction can interfere with English language development. There are several explanations that support this. First, using native language as an aid for understanding content can be viewed as a crutch for language learners. For example, when school content is translated for language minority students it leaves little incentive to learn English (Krashen, 1996; Krashen & Terrell, 1983). Secondly, researchers use a cognitive overload theory to explicate how using native language while learning a second language can impede learning. It has been shown that when language learners attempt to fit a new language into internalized grammar, cognitive overload can occur (Cummins, 1994). Furthermore, from a cultural perspective (which will be expanded upon in the next section), ELLs who receive native language instruction are delegated to a second-class status within the school and, ultimately, within society (R.E. Slavin & Cheung, 2003).

Research Questions

Online inquiry environments offer the opportunity to simultaneously provide language supports to ELLs studying science in multiple languages simultaneously. The question becomes then, how valuable are these linguistic supports to ELLs studying science. Will ELLs with access to linguistic supports in their native language demonstrate higher learning of science content on assessments in English than ELLs without the native language supports? The present study addresses this debate by exploring a possible means of incorporating students' native language while presenting the core curriculum in English. The goal was to increase students understanding of the science content and their ability to express their understanding of that content in English by allowing them to harness their textual and audio linguistic resources in both English and Spanish. We thus investigated the impact of a specific curricular design that allows students to switch between Spanish and English to support scientific conceptual development and academic language proficiency.

Method

Participants

This study analyzes data collected from 87eighth grade students in three classes taught by the same teacher in an urban public middle school with high numbers of ELLs located in the southwestern United States. The classes were considered normal classes, neither honors nor remedial. Students were randomly assigned to experimental condition within each class. The school [school district] reports a demographic distribution students by ethnicity of approximately 85% Hispanic, 6% Non-Hispanic White, 5% African American, 3% Native American, and 1% Asian. Approximately 75% of the students speak Spanish at home. Approximately 90% of the students are categorized as economically disadvantaged.

Of the 87 students, 16 were excluded from the data analysis due to absences, not completing one of the tests, or not completing the letter to the governor. Furthermore, 25 of these students are monolingual English speakers or bilingual students who speak other than Spanish and 47 are Spanish speakers, either bilingual in English and Spanish or ELL. In the analysis reported in this study we focus on the 47 Spanish-speaking students.

Online Learning Environment

We conducted the study using the Web-based Inquiry Science Environment (WISE), which is an inquiry-based environment that engages students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments about science (see http://wise.berkeley.edu).

More specifically, we developed a new version of a project focusing on wolf ecology and population management (henceforth referred to as “the Wolves project” or simply as “Wolves”). Wolves is a 5-6 hour web-based project designed to facilitate deeper inquiry regarding wolf population management (see Figure 1). The project comprises four activities focusing ecology and management of wolf populations. In addition to standard WISE functionality, we developed custom software to provide linguistic supports using audio and text.

The students worked with laptop and desktop computers provided by the school to access the WISE web site. The researchers provided head sets to all students for the audio tool provided in the project.

During that week the students worked individually on four major activities included in the project: a) the first activity of the project presents the perspectives of various participants in the wolf management controversy. Students focus particularly on the perspectives of farmers and environmentalists regarding the problem of wolf attacks on domestic animals; b) the second activity introduces students to the basic biology of wolves, food chains, and predator-prey relationships; c) the third activity investigates wolf management options and strategies that have been implemented by different states; d) the fourth and final activity focuses on a culminating project that engages students in writing a letter to the governor outlining a management plan that they believe best serves the needs of wolves, humans, and the environment.

Language supports and conditions

The linguistic support software allows users to switch content presented in the form of text and audio back and forth between English and Spanish. The language supports available in the wolves' project are:

a) Paragraph text: Allows the user to select the language of the content represented as text in the project (English-Spanish)

b) Support Language: Provides users with the option to choose the language of both, the audio support and the "word definition" function. The "word definition" function is activated by clicking on any word within the text of the content of the project.

c) Audio Support: Activates or turns off the audio support, which allows users to listen to the content of the project.

For programming reasons, the language support software only functions for the content of the lessons and not in the general interface or in the original WISE software tools.

Figure 1. The Wolves project from the Web-based Inquiry Science Environment (WISE)

Experimental Conditions

Students were randomly assigned within each classroom to one of the two conditions. Forty six students were assigned to the English-Spanish condition, whereas fourty one students were assigned to the English-only condition.

a) The English-only version (English/Text/Audio) provided the content of the project for both text and audio, only in English. This version allowed the participants only the option of activating or turning off the audio support in English. The Spanish language was not included in this condition at all.

b) The English-Spanish version of the project (English-Spanish/Text/Audio) allowed students to freely switch the paragraph text language and support language between English and Spanish. It also allowed the students to freely turn on/off the audio support.

It is important to note that both versions of the project included identical content (pictures, practice items, lesson structure, etc.) with the only variation occurring in terms of the availability of the language supports.

Data Sources

Pre-Test: The goal of the pre-test assessment was to evaluate the participants' prior knowledge of the science content in English. The test consisted of 20 multiple choice items drawn from the concepts covered in the four lessons of the project. All the participants received the same pre-test independent of experimental condition.

Posttest: The day after the students completed the Wolves project, a posttest was administered to the participants in an effort to measure learning and understanding of the science content in English. All the participants received the same posttest regardless of the language support condition that they were assigned.

Language Abilities: Students were categorized based on their language ability by the participating school. Students were categorized as either English Proficient (EP) or ELLs (ELL).

Procedure

The students completed the project in one week (5 class periods total) working one class period each day.

Day 1: Administration of pre-test and start of “the Wolves’ project”: Students first completed the pre-test in their classroom. The pre-test was administered by the teacher and two researchers of the research team. The same day that the students completed the pre-test they started to work on the Wolves’ project. Each student worked independently at his or her own computer. The researchers and the teacher instructed the students to complete one activity each day.

Days 2, 3 and 4: Students worked on activities 2, 3, and 4 at their own pace. However, all of the participants had completed the four activities of the project by the fourth day, except for 4 participants who had not completed the “Letter to the governor” (activity 4).

Day 5: A post-test was administered to the participants by the teacher and one member of the research team. The post-test was administered in the same classroom where the participants had been working all week.

Results

Pre-Test

We conducted an independent samples t-test on the pretest scores with home language and experimental condition as our variables to check for pre-treatment differences in our sample. The Spanish speaking students in the English-only condition ($M= 36.11$, $SD = 0.12$, $n=24$) performed the same as the Spanish-speaking students in the English-Spanish condition on the pretest ($M= 32.87$, $SD = 0.12$, $n=23$), $t(115) = 1.40$, $p = 0.165$. Thus, we found no significant difference in students’ prior knowledge of the science content pertaining to wolf ecology.

Post-Test

The post-test was in English and was given immediately after the lesson to measure what was learned in the wolf ecology lesson. For the statistical analysis, Spanish-speaking students were broken down into two categories, ranked by the teacher: bilingual in Spanish and English, and ELLs (ELL). The bilingual students in the English-Spanish condition had a mean score of 63.63% (n=5) compared to a mean score of 60.22% (n=7) in the English-only condition. The ELLs in the English-Spanish condition had a mean score of 54.54% (n=18) compared to a mean score of 45.45% (n=17) in the English-only condition. Conducting a t-test comparing the means of the post-test scores, the Spanish speaking students (bilingual students and ELLs) did better, although not significantly, in the English-Spanish condition compared to the English-only condition, t(32)=1.365, p=0.182 (Figure 2).

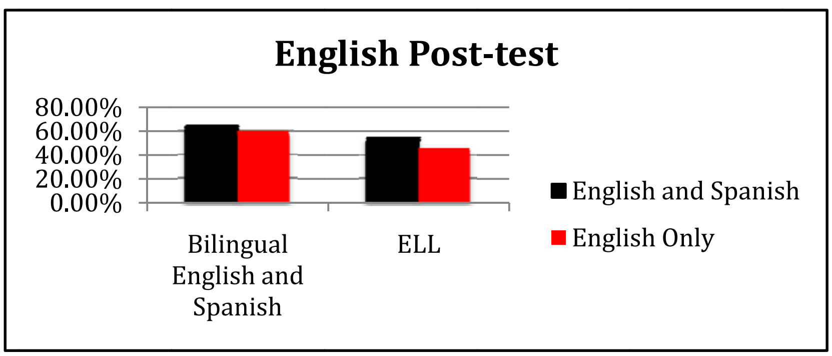

Figure 2. English post-test scores.

Two delayed post-tests were given, one in English and one in Spanish nine weeks after completing the project. Conducting a t-test by comparing the means of the English delayed-post-test scores, ELLs in the English-Spanish condition (M= 0.54, SD= 0.19, n= 18) did significantly better than ELLs in the English-only condition (M= 0.51, SD= 0.22, n=17), t(43) =4.569, p

=0.01. Bilingual students in the English-Spanish condition ($M= 0.62$, $SD= 0.19$, $n= 5$) did better, although not significantly in the English-only condition ($M= 0.61$, $SD= 0.06$, $n= 7$), $t(14)= 0.958$, $p= 0.35$. (Figure 3).

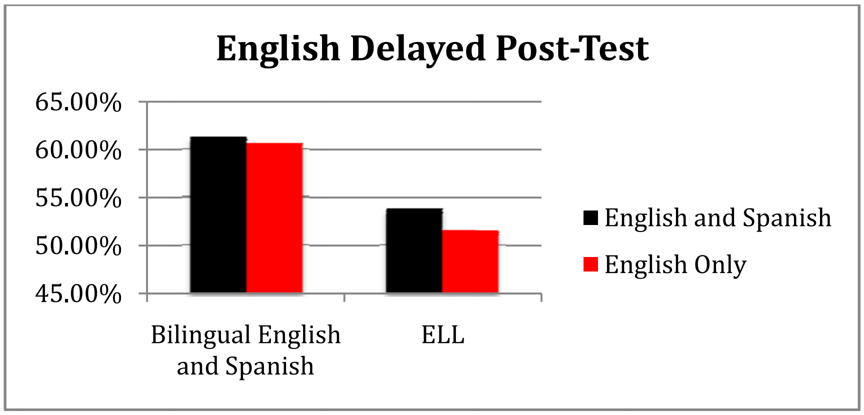

Figure 3. English delayed post-test scores for ELLs.

The trend of ELLs benefiting from having their native-language available for a learning aid was also seen on the Spanish version of the delayed post-test. This result implies that long-term retention is acquired in both languages (English and Spanish) for ELLs. Conducting a t-test by comparing the means of the Spanish delayed-post-test scores, ELLs in the English-Spanish condition ($M= 0.55$, $SD= 0.19$, $n= 18$) did significantly better than the ELLs in the English-only condition ($M= 0.38$, $SD= 0.13$, $n= 17$), $t(29) = 2.025$, $p = 0.007$. Bilingual students in the English-Spanish condition ($M= 0.64$, $SD= 0.22$, $n= 5$) did better, although not significantly, than in the English-only condition ($M= 0.57$, $SD= 0.20$, $n= 7$), $t(14)= 0.19$, $p= 0.85$. (Figure 4).

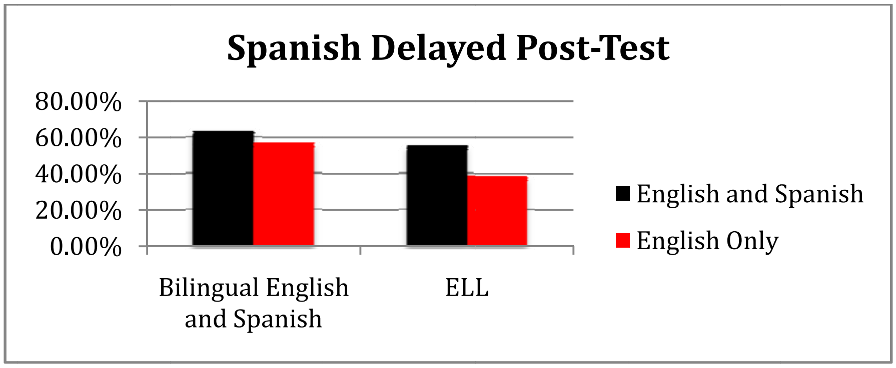

Figure 4. Spanish delayed post-test scores for ELLs.

Furthermore, when further differentiating ELLs further into "slightly ELL" and "heavily ELL" categories on the Spanish delayed post-test results, we observed that all three Spanish-speaking groups (i.e., bilingual, slightly ELL, and heavily ELL) scored higher if they were in the English-Spanish condition. However, the benefit of being in the English-Spanish condition was the most significant for slightly ELLs the most in their ability to express their new knowledge in English (Figure 5). When reviewing the data, all of the students categorized as heavily ELL were new to the United States and had resided here for less than 4 years. This result suggests that new immigrants learning English might need more intensive methods of native-language instruction for learning and expressing science in English.

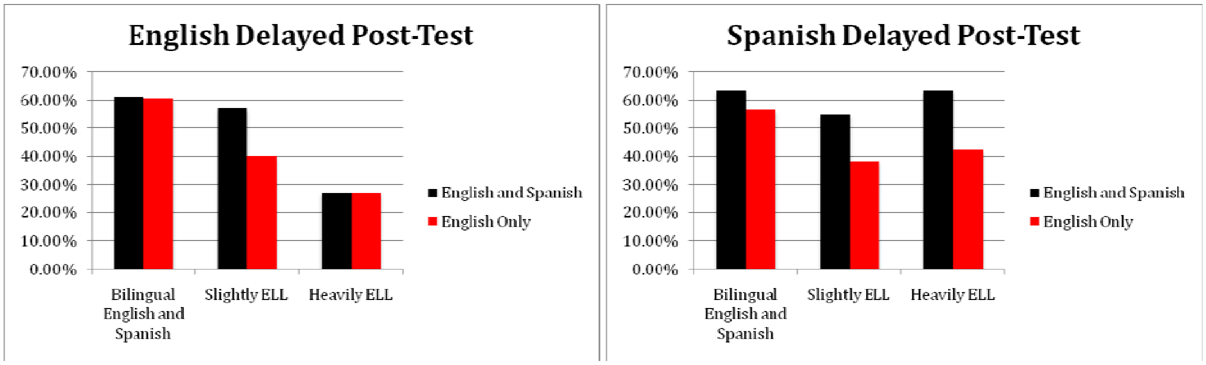

Figure 5. Comparison between English and Spanish delayed post-test scores for all Spanish-speakers.

Essay

Students were required in the final activity of the project to write a letter to the governor outlining a plan for the management of the wolf population. The letter was used to demonstrate their knowledge about wolf ecology. For the statistical analysis of the letter scores, students were categorized as either bilingual English-Spanish or ELLs (ELL) according to their English proficiency. Our results, based on a t-test, comparing the means of the essay scores show that ELLs in the English-Spanish condition ($M = 0.55$, $SD = 0.19$) do better, although not significantly, than ELLs not in English-only condition ($M = .47$, $SD = 0.19$), $t(32) = 1.22$, $p = 0.233$. Figure 6. This may be a function of the scoring rubric not be precise enough allow detection of differences between the groups, or it might be a function of the students having access to all of the project information as reference material when they wrote their letters whereas they had no reference materials available on the post-test.

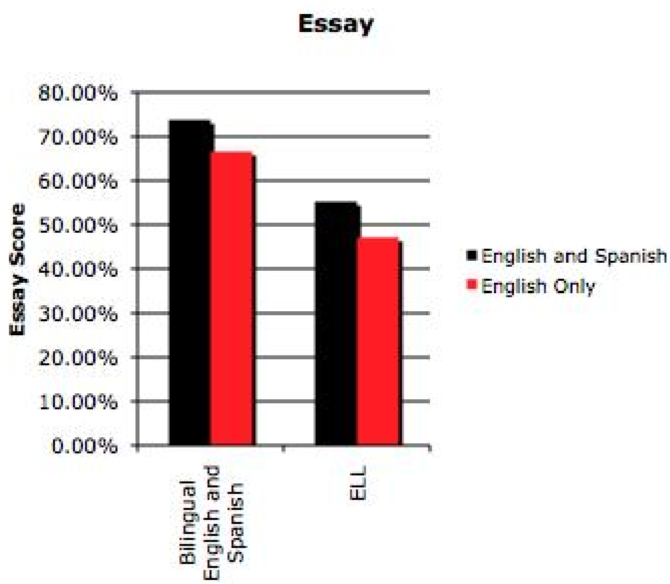

Figure 6. Essay scores.

Educational and Scientific Implications and Conclusions

Language learners cannot afford to postpone science learning while they learn English. Furthermore, with its multiple opportunities for hands-on and visual interaction with the academic concepts, science provides rich contexts supporting academic language development (Cohen, De Avila, & Intili, 1981; De Avila & Duncan, 1984; Chamot & O'Malley, 1986, 1994). This study suggests that ELLs learned and retained more understanding about wolf population management when they had access to language supports in both English and their native-language (Spanish in this case). This result was observed on the English post-test as well as the Spanish and English delayed post-tests nine weeks later. Counter to the claims of proponents for monolingual education, these results suggest that access to their native language not only enhanced their learning about the science concepts involves but also enhanced their ability to express their understanding in English.

The value and strength of an online science learning environment as a medium for this pedagogy focuses on the versatility of the technology. In theory, once a model is developed to incorporate metalinguistic supports for one group of diverse learners, the guidelines can be implemented for other groups into the same environment simultaneously so that all learners can access linguistically appropriate supports. Our initial work will focus on Spanish speaking students in Arizona, but our goal focuses on implementing these supports for multiple groups so that these online science learning environments can serve students in the highly diverse classrooms across the country.

These results further suggest the promise of online learning environments for facilitating the dissemination of these practices across the country. Offline implementation of similar language support practices is challenging because only a small percentage of teachers are trained to support ELLs (Arizona Department of Education, 2000) or support inquiry (Weiss, Banilower, McMahon, & Smith, 2001). Online environments have already been structured to scaffold inquiry practices involving higher order thinking skills for English-dominant students (Clark, Weinberger, Jucks, Spitulnik, & Wallace, 2003; Edelson, Gordin, & Pea, 1999; Simons & Clark, 2004; Scardamalia & Bereiter, 1996). The results of this study suggest that we can extend these opportunities to ELLs by integrating appropriate language supports to increase their access and understanding.

References

Au, K. H., & Mason, J. M. (1983). Cultural congruence in classroom participation structures: Achieving a balance of rights. *Discourse Processes*, *6*, 145-167.

Baker, K., & Kanter, A. A. d. (1981). *Effectiveness of bilingual education; A review of the literature*. Washington, DC: Department of Education, Office of Planning, Budge, and Evaluationo. Document Number)

Barba, R. H. (1993). A study of clturally syntonic variables in the bilingual/bicultural science classroom. *Journal of Research in Science Teaching, 30*, 1053-1071.

Barron, B. (2003). When smart groups fail. The Journal of the Learning Science, 12, 307-359.

Bell, P. (1997). Using argument representations to make thinking visible for individuals and groups. In R. Hall, N. Miyake & N. Enyedy (Eds.), *Proceedings of the Second International Conference on Computer Support for Collaborative Learning (CSCL 1997)* (pp. 10-19). Toronto: Toronto University Press.

Bell, P. (2004). Promoting students' argument construction and collaborative debate in the science classroom. In M. C. Linn, E. A. Davis & P. Bell (Eds.), *Internet environments for science education* (pp. 115-143). Mahwah, NJ: Erlbaum.

Bell, P., & Linn, M. C. (2000). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. *International Journal of Science Education, 22*(8), 797–817.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington: National Academic Press.

Brisk, M. (2006). *Bilingual Education. Second Edition*. Hillsdale, NJ: Erlbaum.

Calderon, M., & Minaya-Rowe, L. (2003). *Designing and implementing two-way bilingual programs*. Thousand Oaks, CA: Corwin.

Carmien, S., Kollar, C., Fischer, G., & Fischer, F., (2007). The interplay of internal and external scripts. In F. Fischer, H. Mandl, J. Haake & I. Kollar (Eds.), *Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives* (pp. 303-324). New York: Springer.

Chamot, A. U., & O'Malley, J. M. (1986). *A Cognitive Academic Language Learning Approach: An ESL Content-Based Curriculum*. Washington, DC: National Clearinghouse for Bilingual Education.

Chamot, A. U., & O'Malley, J. M. (1994). *The CALLA handbook*. Reading, MA: Addison-Wesley.

Clark, D. B. & Sampson, V. D. (2007). Personally-seeded Discussions to scaffold online argumentation. *International Journal of Science Education 29*(3), pp. 253-277.

Clark, D. B. (2004). Hands-on investigation in Internet environments: Teaching thermal equilibrium. In M. C. Linn, E. A. Davis., & P. Bell (Eds.), *Internet Environments for Science Education* (pp. 175-200). Mahwah, NJ: Lawrence Erlbaum Associates.

Clark, D. B., & Sampson, V. (2005, June). *Analyzing The Quality Of Argumentation Supported By Personally-Seeded Discussions*. Paper presented at the annual meeting of the Computer Supported Collaborative Learning (CSCL) Conference, Taipei, Taiwan.

Clark, D. B., & Sampson, V. (2006, July). *Evaluating argumentation in science: New assessment tools.* Paper presented at the International Conference of the Learning Sciences 2006. Bloomington, Indiana.

Clark, D. B., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. To appear in *Journal of Research in Science Teaching, 45*(3). 6.

Cognition and Technology Group at Vanderbilt. (1997). *The Jasper Project: Lessons in curriculum, instruction, assessment, and professional development*. Mahwah: Erlbaum.

Collier, V. P. (1990). How long? A synthesis of research on academic achievement in second language. *TESOL Quarterly*, *23*, 509-531.

Collier, V. P. (1995). Acquiring a Second Language for School. *Directions in Language and Education-National Clearinghouse for Bilingual Education, 1*(4).

Cuthbert, A. J., Clark, D. B., & Linn, M. C. (2002). WISE learning communities: Design considerations. In K.A. Renninger & W. Shumar (Eds.), *Building Virtual Communities: Learning and Change in Cyberspace* (pp. 215-246). Cambridge: Cambridge University Press.

de Vries, E., Lund, K., & Baker, M. (2002). Computer-mediated epistemic dialogue: explanation and argumentation as vehicles for understanding scientific notions. *The Journal of the Learning Sciences, 11*(1), 63-103.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL?* (pp. 61-91). Heerlen, NL: Open University of the Netherlands.

Dillenbourg, P., & Jermann, P. (2007). Designing integrative scripts. In F. Fischer, H. Mandl, J. Haake & I. Kollar (Eds.), Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives (pp. 275-301). New York: Springer.

ECS. (2000). from http://www.ecs.org/ecs/ecscat.nsf/WebTopicView?OpenView&count=-1&RestrictToCategory=Bilingual/ESL

Erkens, G., & Janssen, J. (2006). Automatic coding of communication in collaboration protocols. *Proceedings of the 7th International Conference of the Learning Sciences (ICLS 2006),* Bloomington, IN.

Fischer, F., Bruhn, J., Gräsel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. *Learning and Instruction, 12*, 213-232.

Fisher, C., & Larkin, J. H. (1986). *Diagrams as Working Memory for Scientific Problem Solving (Technical Report)*. Carnegie-Mellon University Department of Psychology.

Garcia, E. (2001). *Student cultural diversity: Understanding and meeting the challenge*. Boston, MA: Houghton Mifflino. Document Number)

Genesee, F. (1987). *Learning through two languages: Studies of immersion and bilingual education*. Boston, MA: Newburyo. Document Number)

Hakuta, K., Butler, Y. G., & Witt, D. (2000). How Long Does it take English Learners to Attain Proficiency? *The University of California Linguistic Minority Research Insititue Policy Report*.

Halliday, M. A. K., & Martin, J. R. (1993). *Writing science; Literacy and discursive power*. Pittsburgh: University of Pittsburgh Press.

Hesse, F. (2007). Being told to do something or just being aware of something? An alternative approach to scripting in CSCL. In F. Fischer, I. Kollar, H. Mandl, J., & Haake (Eds.), *Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives* (pp. 91-98). New York: Springer.

Howard, E. R., Sugarman, J., & Christian, D. (2003). *Two-way immersion edcuation; What we know and what we need to know.* , Baltimore, MD: Johns Hopkins University, Center for Research on the Education of Students Placed at Risk.

Jermann, P., & Dillenbourg, P. (2003). Elaborating new arguments through a CSCL script. In J. Andriessen, M. Baker & D. Suthers (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 205-226). Dordrecht, NL: Kluwer Academic Publishers.

Jermann, P., Soller, A., & Muehlenbrock, M. (2001). From mirroring to guiding: a review of state of art technology for supporting collaborative learning. Paper presented at the European Computer Supported Collaborative Learning Conference. (EU-CSCL'01), Maastricht, NL.

Johnson, D. W., Johnson, R. T., Holubec, E. J., & Roy, P. (1984). *Circles of Learning: Cooperation in the Classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Joiner, R., & Jones, S. (2003). The effects of communication medium on argumentation and the development of critical thinking. *International Journal of Educational Research, 39*(8), 861-971.

Kagan, S. (1986). Cooperative learning and sociocultural factors in schooling. In California Sate Department of Education, *Beyond Language, Social and Cultural Factors in Schooling Language Minority Students,* pp. 231-298. Los Angeles: Evaluation, Dissemination, and Assessment Center, California State University.

Kelly, G. J. (2007). Discourse in Science Classrooms. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc. Publishers.

King, A. (2007). Scripting collaborative learning processes: A cognitive perspective. In F. Fischer, H. Mandl, J. Haake & I. Kollar (Eds.), Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives (pp. 275-301). New York: Springer.

Kirschner, P. A., Buckingham Shum, S. J., & Carr, C. S. (Eds.). (2003). *Visualizing argumentation: software tools for collaborative and educational sense-making*. London: Springer.

Kolodner, J. L., Schwarz, B., Barkai, R. D., Levy-Neumand, E., Tcherni, A., & Turbovsk, A. (1997). Roles of a case library as a collaborative tool for fostering argumentation. In R. Hall, N. Miyake & N. Enyedy (Eds.), *Proceedings of the 1997 computer support for collaborative learning (CSCL 97)* (pp. 150-156). Hillsdale, NJ: Erlbaum.

Krashen, S. D. (1996). *Under Attack: The Case Against Bilingual Education*. Culver City, California: Language Education Associates.

Krashen, S. D., & Terrell, T. (1983). *The Natural Approach: Language Acquisition in the Classroom*. New York: Prentice Hall.

Kuhn, D., & Goh, W. W. L. (2005). Arguing on the computer. In T. Koschmann, D. Suthers & T. W. Chan (Eds.), *Computer Supported Collaborative Learning 2005: The Next 10 Years* (pp. 125-134). Mahwah, NJ: Lawrence Erlbaum.

Lee, O., & Fradd, S. H. (1996). Interactional patterns of linguistically diverse students and teachers: Insights for promoting science learning. *Linguistics and Education, 8*, 269-297.

Lee, O., & Luykx, A. (2007). Science Education and Student Diversity: Race/Ethnicity, Language, Culture, and Socioeconimic Status. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education*. Mahway, New Jersey: Lawrence Erlbaum Associates, Inc.

Lemke, J. L. (1990). *Talking science: Language, Learning and Values*. Norwood, NJ: Ablex.

Marttunen, M. (1992). Commenting on written arguments as a part of argumentation skills: Comparison between students engaged in traditional vs on-line study. *Scandinavian Journal of Educational Research, 36*(4), 289-302.

Marttunen, M., & Laurinen, L. (2001). Learning of argumentation skills in networked and face-to-face environments. *Instructional Science, 29*, 127-153.

McKeon, D. (1987). Different Types of ESL Programs. *ERIC Digest*.

McQuillan, J. (2005). An Urban Myth. The "Poor Quality" of Bilingual Education Research *Langague Learner*, 13-14,30.

Munneke, L., Andriessen, J., Kirschner, P, & Kanselaar, G. (2007, July). Effects of synchronous and asynchronous CMC on interactive argumentation. Paper to be presented at the CSCL 2007 Conference, New Brunswick, NY.

Nahari, S. G., Lopex, E. C., & Esquivel, G. B. (2007). *Multicultural Handbook of School Psychology*. Hillsdale, NJ: Elbaum.

NCES (2004). English Language Learner Students in U.S. Public Schools: 1994 and 2000. National Center for Education Statistics. U.S. Department of Education.

Oestermeier, U., & Hesse, F. (2000). Verbal and visual causal arguments. *Cognition*, *75*, 65-104.

Pea, R. D. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communications. Special Issue: Computer support for collaborative learning. *Journal of the Learning Sciences, 3*(3), 285-299.

Pfister, H.-R. (2005). How to support synchronous net-based learning discourses: Principles and perspectives. In R. Bromme, F. Hesse & H. Spada (Eds.), *Barriers and biases in computer-mediated knowledge communication* (pp.39-57). New York: Springer.

Reiser, B. J. (2002). Why scaffolding should sometimes make tasks more difficult for learners. In G. Stahl (Ed.), *Computer Support for Collaborative Learning: Foundations for a CSCL community. Proceedings of CSCL 2002* (pp. 255-264). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Reiser, B. J., Tabak, I., Sandoval, W. A., Smith, B. K., Steinmuller, F., & Leone, A. J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms. In S. M. Carver & D. Klahr (Eds.), *Cognition and instruction: Twenty-five years of progress* (pp. 263-305). Mahwah, NJ: Erlbaum.

Rogoff, B. (1998). Cognition as a collaborative process. In D. S. Kuhn & R. W. Damon (Eds.), Cognition, perception and language 5th ed., Vol. 2, pp. 679-744). New York: Wiley.

Rolstad, K., Mahoney, K., & Glass, G. V. (2005). The Big Picture: A Meta-Analysis of Program Effectiveness Research on English Language Learners. *Educational Policy, 19*(4), 572-594.

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic supports for science inquiry. Science Education, 88, 345-372.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *Journal of the Learning Sciences, 3*(3), 265-283.

Schellens, T., & Valcke, M. (2006). Fostering knowledge construction in university students through asynchronous discussion groups. *Computers & Education, 46*(4), 349-370.

Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H., Wiley, D. E., Cogan, L. S., et al. (2001). *Why schools matter: A cross-national comparison of curriculum and learning.* San Francisco: Jossey-Bass.

Schmidt, W. H., McKnight, C., Cogan, L. S., Jakewerth, P. M., & Houang, R. T. (1999). *Facting the consequences: Using TIMSS for a closer look at U.S. mathematics and science education*. Boston: Kluwer.

Slavin, R. E., & Cheung, a. (2003). *Effective reading programs for English language learners: A best-evidence synthesis.* Baltimore: Johns Hopkins University Center for Research on the Eeucation of Students Placed At Risko. Document Number)

Slavin, R. E., & Cheung, A. (2005). A Synthesis of Research on Language of Reading Instruction for English Language Learners. *Review of Educational Research, 75*(2), 247-284.

Smith, F. (1994). *Understanding Reading. Fifth Edition*. Hillsdale, NJ: Erlbaum.

Sohn, J. (2005). The Effectiveness of Bilingual School Programs for Immigrant Children. *Program on Intercultural Conflicts and Societal Integration*.

Stahl, G., (2007). Scripting group cognition. In F. Fischer, H. Mandl, J. Haake & I. Kollar (Eds.), *Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives* (pp. 327-335). New York: Springer.

Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*, 2(4), 421-447.

Stewner-Manzanares. (1988). The Binlingual Education Act: Twenty Years Later. from http://www.ncela.gwu.edu/pubs/classics/focus/06bea.htm

Suthers, D. D., & Hundhausen, C. D. (2001). Learning by constructing collaborative representations: An empirical comparison of three alternatives. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *European perspectives on computer-supported collaborative learning* (pp. 577-592). Maastricht, NL: University of Maastricht.

Sutton, C. (1996). Beliefs about science and beliefs about language. . *International Journal of Science, 18*, 1-18.

Thomas, W. P., & Collier, V. (1997). *School effectiveness for language minority students.* . Washington, DC: National Clearinghouse for Bilingual Education.

Thomas, W. P., & Collier, V. (2002). *A national study of school effectiveness for language minority students' long-term academic achievement: final report*. Santa Cruz, CA and Washington, DC: Center for Research on Education, Diversity & Excellenceo. Document Number)

Tse, L. (2001). *"Why Don't They Learn English" Separating Fact from Fallacy in the U.S. Language Debate*. New York and London: Teacher's College Press.

U.S. Census Bureau (2002). American Fact Finder. from http://factfinder.census.gov/servlet/BasicFactsServlet?_lang=en

Warren, B., Rosebury, A. S., & Conant, F. R. (1989). *Cheche Konnen: Science and Literacy in Language Mintority Classrooms*. Cambridge, Mass.: Bolt, Beranek and Newmano. Document Number)

Weinberger, A., Stegmann, K., Fischer, F., & Mandl, H. (2007). Scripting argumentative knowledge construction in computer-supported learning environments. In F. Fischer, I.

Kollar, H. Mandl, & J. Haake (Eds.), *Scripting computer-supported communication of knowledge - cognitive, computational and educational perspectives* (pp. 191-211). New York: Springer.

Author Note

This study was supported by the National Science Foundation as part of the center for Technology Enhanced Learning in Science (TELS) CLT grant (0334199) and the Project Pathways MSP grant (0412537), Any opinions, findings, and conclusions or recommendations expressed in this study are those of the researchers and do not necessarily reflect the views of the National Science Foundation.