Cases on Communication Technology for Second Language Acquisition and Cultural Learning

Joan E. Aitken
Park University, USA

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Chapter 17
English Language Learners' Online Science Learning:
A Case Study

Fatima E. Terrazas-Arellanes
University of Oregon, USA

Carmen Rivas
University of Oregon, USA

Carolyn Knox
University of Oregon, USA

Emily Walden
University of Oregon, USA

EXECUTIVE SUMMARY

English Learners may struggle when learning science if their cultural and linguistic needs are unmet. The Collaborative Online Projects for English Language Learners in Science project was created to assist English learners' construction of science knowledge, facilitate academic English acquisition, and improve science learning. The project is a freely available, online project-based, bilingual instructional website designed for English learners of Hispanic origin. The project website contains two units: Let's Help Our Environment and What Your Body Needs. To create these collaborative online projects, two constructivist approaches were combined: The Cognitive-Affective Theory of Learning with Media and Project-Based Learning. These approaches to science education were used as the basis for culturally and linguistically relevant science instruction, which was delivered within a collaborative, online instructional platform. Using a case study design, two teachers demon-

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strated implementation of the project with fidelity, and students showed statistically significant gains in science content assessments. The Collaborative Online Projects for English Language Learners in Science project provides educators with a strong model for creating instructional materials that support English learners' science learning by combining culturally-relevant, constructivist, collaborative projects using online, multimedia technology.

ORGANIZATION BACKGROUND

Collaborative Online Projects for English Language Learners in Science is a publically available, digital, Project-Based Learning and teaching platform for delivering bilingual science content to Spanish-speaking English learners. The Collaborative Online Projects for English Language Learners in Science project received funding from the National Science Foundation to design, translate, enhance, and evaluate culturally relevant and linguistically appropriate collaborative online projects in science for secondary level Spanish-speaking English learners. The project website (http://copells.uoregon.edu) houses two classroom-tested and supported collaborative online projects, the *What Your Body Needs* life science unit and the *Let's Help Our Environment* life science unit. Both units target 7th grade U.S. National Science and Engineering Curriculum Standards. Collaborative Online Projects for English Language Learners in Science was made possible through a strong partnership between the Center for Advanced Technology in Education at the University of Oregon, the Instituto Latinoamericano de la Comunicación Educativa in Mexico, and the Biological Sciences Curriculum Study group in the United States. Over the past three years, these organizations have been creating science units and studying their feasibility and usability, addressing both the cultural and linguistic needs of English learners in science education.

The Center for Advanced Technology in Education at the University of Oregon is a research and development group within the University of Oregon's College of Education, working in the area of technology-supported solutions to student challenges in reading, writing, and studying. The center has more than 20 years of research and development experience behind computer-based study strategies to support student learning in the general education curriculum, more than 10 years designing and evaluating online learning environments, and more than 10 years designing, developing, and evaluating supportive resources for learning in electronic environments. Currently funded projects include: The National Center for Supported eText; Mathematics eText Research Center; and Project SOAR: Strategies for Online Academic Reading.

The Instituto Latinoamericano de la Comunicación Educativa is a non-profit organization with 15 years of experience designing collaborative online projects. Over this time period, the Instituto has designed approximately 150 collaborative online project units in the areas of reading, math, science, social studies, and language arts covering 1st to 9th grade curriculum for schools in Mexico and Latin America. The Instituto's collaborative online projects have been designed using a constructivist theoretical approach, in which the teacher is a co-participant in the students' construction of knowledge. The Instituto's units were most recently aligned to the United Nations Educational, Scientific and Cultural Organization standards for Information and Communication Technologies. The Instituto's collaborative online project units have been implemented in 53,265 schools in Mexico and 180 schools from 14 countries throughout Latin America and the Caribbean, Spain, and the United States. The Instituto provided an online instructional model that the Collaborative Online Projects for English Language Learners in Science project further refined. The Instituto also provided an online platform for delivering instruction in a culturally and linguistically relevant multimedia rich environment. The Instituto has also supported this collaboration by offering the two science units developed through the Collaborative Online Projects for English Language Learners in Science project to students in Mexico at the same time as students in Oregon. Using their wide network of schools, students in Oregon and Mexico were able to take advantage of the project's asynchronous forums to communicate with each other across borders about what they were learning in science.

The Biological Sciences Curriculum Study group in the U.S. is a 501(c)3 non-profit organization that has over 50 years of experience using and generating research for the development of materials and services that promote teaching and learning. The long-standing goal of this group has been to educate U.S. students in biology so that the general public will be better able to understand the science of life. With a particular focus on the science education community, their aims are to assist students in learning science by examining the following areas: (1) the nature of curriculum, (2) teacher learning and practice, and (3) leadership and policy. In their research, this group has produced several products that help science teachers and students, including handbooks, online video modules, symposiums, Compact Disc Read Only Memory (CD-ROM), and digital instructional resources. In addition, this group contributes to the science community by providing professional development opportunities, which assist Kindergarten through 12th grade science teachers all over the world in developing their knowledge of science and how best to implement science in their classrooms. The Biological Sciences Curriculum Study staff contributed to this project with their expertise in science curriculum development, teacher professional development, educational technology, and educational research for the design, content creation, and evaluation of the two units created by the Collaborative Online Projects for English Language Learners in Science project.

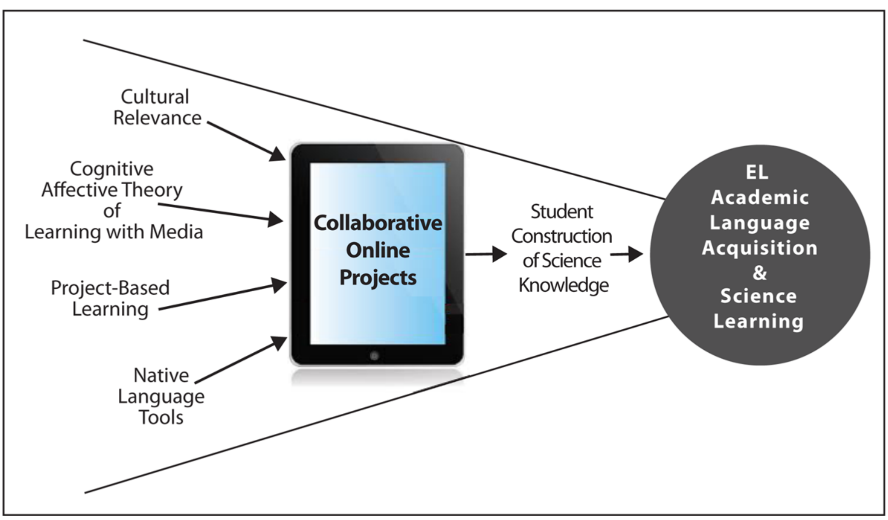
SETTING THE STAGE

Theoretical Foundations of the Collaborative Online Projects for English Language Learners in Science Project

The Collaborative Online Projects for English Language Learners in Science Theory of Learning (illustrated in Figure 1) combines the constructivist approaches of Cognitive-Affective Theory of Learning with Media with Project-Based Learning for the teaching of science embedded in culturally and linguistically relevant instruction in the form of collaborative online projects. This learning theory assists English learners' construction of science knowledge, facilitates academic English acquisition, and improves science learning.

McPherson (2009) believes "all children can learn if instruction is designed to trigger the neurological networks that control the learning process" (p. 230). Constructivist approaches such as the Cognitive-Affective Theory of Learning with Media and Project-Based Learning have been found effective for achieving this goal. Constructivism emphasizes that learning occurs in a context in which learners

Figure 1. COPELLS' Theory of Learning



are active constructors of knowledge. This learning theory views knowledge construction as a process of engaging students in higher order thinking through dialectic conversations. Within this philosophy, Project-Based Learning involves students in self-directed investigations of worthy issues (Grant, 2002).

Cognitive-Affective Theory of Learning with Media

Moreno and Mayer's (2007) Cognitive-Affective Theory of Learning with Media was based on Moreno and Mayer's (2000) Cognitive Theory of Multimedia Learning, which described learning from instructional media with consideration of the potential cognitive overload that may characterize those settings. This theory was designed to provide researchers with specific design principles for multimedia instruction. The new theory was expanded to include new types of media such as virtual reality and other agent- and case-based learning environments not included in the original theory and to undergo updates based on the most current literature. Moreno and Mayer's (2007) theory is based on the following assumptions:

1. Working memory includes independent channels (i.e., auditory, visual, olfactory, tactile, and gustatory) (Baddeley, 1992), meaning that humans are able to actively process information simultaneously as long as all pieces of information are presented in different constructions.
2. Each working memory store has a limited capacity, consistent with Sweller's (1999) cognitive load theory. Learners are more likely to perform better on tasks if any channel of their working memory is not being over stimulated. Therefore, the learner will be more likely to learn from technology if provided with some guided instruction when using technology for learning.
3. Meaningful learning may be facilitated if a learner is engaged in the process of gaining new information and integrating the new information with previously gained knowledge (Mayer & Moreno, 2003). The learner may actively engage with the new information through selection, where a learner must select material, for example, by selecting written words after hearing them to show that the learner is attending to the material. In addition, learners engage by organizing new information, which allows them to represent new information (e.g., organizing pictures of vocabulary words into a cohesive framework), showing that the learner is processing the information. The learner also must integrate information (e.g., combining vocabulary words with pictures of the words learned separately) in order to achieve a higher level of knowledge about the new information.

4. Memories held in long-term storage consist of both previous experiences as well as general knowledge (Tulving, 1977). Thus, learners will have their own episodic memories of events that occurred in their lives where they gained new information as well as semantic memories in which general knowledge about the world will have been acquired without them remembering specific instances where that new knowledge was gained. Therefore, two distinct types of memories are stored in long-term storage.
5. Motivation for learning is influenced by how engaging tasks are for learners (Pintrich, 2003). If students are more engaged in a task, students may believe they will be more likely to complete that task successfully. The higher level of self-confidence that results from students' perceived likelihood to succeed then increases motivation for completing that task. Tasks that are more engaging for students are likely to increase students' levels of motivation.
6. Humans may regulate their own thought processes according to various metacognitive factors which ultimately affect how information is processed cognitively (McGuinness, 1990).
7. How much knowledge is gained may be determined depending on previously gained knowledge or experiences of the learners (Kalyuga, Ayres, Chandler, & Sweller, 2003; Moreno, 2004; Moreno & Durán, 2004). Kalyuga and colleagues (2003) found an "expertise reversal effect" where reducing the cognitive load for working memory may have no effect or a negative effect on learners who have previous knowledge of subject matter. However, reducing the cognitive load for working memory for novice learners does not appear to have negative consequences. It is better to reduce the cognitive load for working memory for novice learners, as novice learners cannot process a heavy cognitive load like expert learners can. This finding was demonstrated by Moreno (2004) when examining students' assessment scores in determining how the guided feedback hypothesis reduces the strain on working memory when giving students explanatory as opposed to corrective feedback. Moreno and Durán (2004) further showed that elementary school students with higher levels of computer experience often do better on multimedia games than students with less computer experience, which shows that previous experience, especially with technology, may promote better outcomes.

The Cognitive-Affective Theory of Learning with Media was particularly relevant to the design of the two collaborative online projects because it states that active learning occurs when information is presented in different constructions (so students can activate their memory channels) and when there is not cognitive overload. During the material design phase of each collaborative online project, techniques for presentation of auditory and visual information that minimize working memory load and promote meaningful learning were used. Multiple opportunities for background knowledge stimulation through the use of warm-up activities and highly motivating interactive activities are characteristic of both collaborative online project units.

Additional components of Cognitive-Affective Theory of Learning with Media include the instructional design principles for interactive multimodal learning environments, which we believe are tied with constructivist approaches and can be taken advantage of during Project-Based Learning. Interactive multimodal environments are those in which the actions and learning that happens depends on the actions of the learner. Moreno and Mayer (2007) describe five types of interactivities in multimodal learning environments.

1. **Dialoguing:** Learners are allowed to ask questions and receive answers or feedback. For example, students may be reading an online text and are able to receive answers to their questions by using a hyperlink or other forms of online resources, such as forums and chats. Reflection is another example of dialoguing that occurs. Teachers can engage reflection through face-to-face interactions in the classroom, or interactive aspects of the technology itself can prompt students to reflect on answers to questions or discussion prompts within a forum environment. Reflective dialogue enriches students' answers and brings more and deeper educational value to the students.

Dialoguing also includes feedback where students receive both corrective and explanatory feedback. Corrective feedback occurs when students are told which answer is correct or incorrect, while explanatory feedback provides an account for why an answer is correct or incorrect. The importance of explanatory feedback was exemplified in four studies (Moreno & Mayer, 1999b; Moreno & Durán, 2004; Moreno, 2004; Moreno & Mayer, 2005) with children who received either corrective, or both corrective and explanatory feedback when solving math or science problems. From their findings, these studies indicate that children were able to solve more difficult problems when they had been provided with both corrective and explanatory feedback, as opposed to corrective feedback alone.

2. **Controlling:** Learners determine the pace and/or order of presentations. For example, if a student is watching a video, the student is able to press play/pause to determine when to move forward in the video. Pacing is part of controlling in that pacing allows students to determine at what speed they want material to be presented to them. Mayer and Chandler (2001) found that students who were able to control the pacing of material presented to them did better when tested on the material than students who had no control over the pacing. In addition, when students were allowed to choose whether they could click on

questions and receive independent answers versus watching a continuous presentation that included all of those answers at once, students who chose to receive the independent answers performed better on posttests (Mayer et al., 2003). Additionally, students who controlled the pace of presentations also reported that the material was less difficult than students who did not control the pace of presentations (Moreno, 2006c).

3. **Manipulating:** Learners set parameters for simulation, zooming in and out, and moving objects around the screen. For example, a student may play a simulation game, and it will be up to the student to set the parameters of the simulation, and then run that simulation to see the results. Students who engage in manipulating when learning tend to perform better when solving problems and tend to report having had a more interesting learning experience compared to students who were not allowed to engage in manipulating (Moreno et al., 2001). As in the Moreno, Mayer, Spires & Lester (2001) study, manipulating may occur when students, during a science activity, are allowed to design their own plants when learning about them. Students are able to manipulate the images of the plants on screen. This manipulation allows students to set their own parameters for the plants' physical appearances, zoom in and out when creating the plants, and move parts of the plants around on screen.
4. **Searching:** Learners engage in information seeking, selecting options, and finding new material. For example, a student may gain information by using a search engine to find information. By using the search engine, the student selects which words to type in the search box, makes decisions about which results are most relevant, and chooses which results to view and ultimately use. Thus, the process of searching allows students to participate more in the process of finding information. However, some environments, such as digital libraries, which incorporate searching in the task of locating information electronically, often require students to receive guidance by their teachers (Dillon & Jobst, 2005; Rouet, 2006).
5. **Navigating:** Learners move to different content areas by selecting from various available information sources. For example, if a student wants to go to a new Web browser page, the student must go to a certain menu in order to make the transition from one page to another. Navigating allows students to make their own choices about where to go to in a learning environment, as well as allowing students to decide where to go and what to view. To be interactive, navigating must allow students to gain information or learn while navigating (Puntambekar et al., 2003; Rouet, 2006; Rouet & Potelle, 2005). As seen in searching, navigating also may be used when searching electronic environments, such as digital libraries, which often require that students receive guidance by their teachers (Dillon & Jobst, 2005; Rouet, 2006).

Thus, each of the five interactivities involves students being actively involved in the learning process through the use of technology. The collaborative online projects' instructional activities were designed with those principles in mind. Students engage in meaningful conversations with the use of forums and they also receive both corrective and explanatory feedback within the interactive assessments. Students determine their own pace of learning. They have the opportunity to fast-forward, rewind, pause and replay videos as well as to ask questions of teachers. Various simulation games are integrated throughout the lessons as well as opportunities for navigating and searching on the Web.

Project-Based Learning

The rationale for designing collaborative Project-Based Learning curriculum materials for digital learning environments was straight forward. Project-Based Learning – powered by 21st century technologies – allows students to create their own learning experiences using technology to access and analyze information globally (Boss & Krauss, 2007). Project-Based Learning is a "dynamic approach to teaching in which students explore real-world problems and challenges, simultaneously developing cross-curriculum skills while working in small collaborative groups" (Edutopia, 2008).

Key features that facilitate Project-Based Learning in a collaborative online project environment include the following:

1. A driving question anchored in a real-world problem. The question may be generated by students, teachers, or curriculum developers. While questions may be created by teachers and curriculum developers, the questions must be open enough to allow students to achieve different results compared to each other as an outcome of being able to make their own decisions about how to find an answer to the question. In order for Project-Based Learning to be effective, the questions must allow for student exploration of the topic and not only for the result of specific fact-based answers teachers require.
2. Opportunities to make active investigations to learn concepts, apply information, and represent knowledge in a variety of ways. These opportunities include using inquiry, research, critical thinking and problem solving skills. In the process of investigating, students may be engaged in learning about the real world, which could potentially make the investigation more rewarding for students. The driving question then allows for students to more actively engage in an investigation, as opposed to teachers giving students questions to answer that lead to specific information and do not allow for the process of investigation and construction of knowledge;

3. Collaboration among students so learning can be shared within the "learning community." Collaboration may occur if teachers divide students into groups and give each group a driving question. The questions may complement each other in that they may be about the same broad topic, but specific enough so that each group has a different investigation to conduct. Students then must work together in order to investigate the problem and arrive at a conclusion. In these groups, students may collaborate in creating artifacts, such as videos, models, and reports, which allow students to directly engage with the information they are learning. Other students also may critique the artifacts, which will allow the students who created the artifacts to make revisions, thus acquiring further knowledge about the content. After students have discussed the problem within their groups, students will then be put into other groups, often referred to as "jigsaw groups," where a student from each original group will be placed together with students from other groups. These groups allow for each student to be the expert in their new groups as they explain the problem and conclusion to their new group members who have been working on other problems in their original groups. Students then are offered another level in which to collaborate on, as they must explain their problem and conclusion, receive and integrate feedback about that problem from their new group members, and then provide feedback about other problems their new group members pose.
4. The use of cognitive tools supports students in their representation of ideas (Blumenfeld et al., 1991). These cognitive tools include computer-based laboratories, hypermedia, graphic applications, and telecommunications. For example, students may create a report they will present to their class or post on a blog or forum, which also includes visual representations created by using technology such as slides or computer-generated models. Cognitive tools then allow for students to transmit their ideas as well as provide another way for students to collaborate with each other, both in creating artifacts and in obtaining feedback from their peers about the artifacts. Cognitive tools are thus important for collaboration, aiding in solving the problem of the driving question, and in facilitating students' communication.

Research on traditional, not computer mediated, Project-Based Learning has shown this method to be effective in increasing student motivation and improving students' problem solving and higher-order thinking skills (Stites, 1998). In Project-Based Learning, students work together to investigate open-ended questions and apply their own knowledge to produce authentic products. Project-Based Learning hones students' organizational and research skills, helps them develop better communication with their peers, and builds self-confidence. Results of project-based work are often more meaningful to students because of the active role they play in project design. In Project-Based Learning, the teacher's role has shifted; he or she is no longer the content expert. Instead the teacher plays the role of coach, mentor, or tutor, guiding students through the Project-Based Learning process.

Other studies have examined how Project-Based Learning may be applied in digital environments. Hung, Keppell, and Jong (2004) studied Project-Based Learning as it applies in the digital age with teacher education students in Hong Kong. Students were required to collaborate when conducting a project on a given topic (e.g., mobile phones, digital camcorders). Students created two digital videos; the first video introduced who the students were, while the second video discussed the students' topic. Feedback from students was overall positive, and Hung, Keppell, and Jong (2004) concluded that the study was ultimately successful due to the interplay between Project-Based Learning, technology, and meaningful nature of the learning. Project-Based Learning has also been applied to other types of digital projects.

Hafner and Miller (2011) conducted a Project-Based Learning study with undergraduate students in Hong Kong who were taking a science course in English. Students worked on projects in a digital environment, which included accessing a course website, writing reflections on a weblog, using digital video cameras, working with video editing software, and sharing videos through a YouTube channel. Results from the study were positive in that students overall reported high motivation for doing the project, citing that what they were doing in the project was interesting because it differed from a typical learning environment. Students also believed that the skills they learned in the digital environment would transfer to future employment skills.

Henry and Semple (2011) conducted a study with middle school science teachers using a geographical information system that would aide teachers and students in exploring earth science. The geographical information system is a digital database where students can keep track of field observations. Teachers reported positive results when trained on this software, citing the perceived usability of the software in their classrooms.

Project-Based Learning has been implemented with elementary school students. Hung, Hwang, and Huang (2011) conducted a study with fifth grade students in Taiwan to compare the effects of Project-Based Learning within a digital environment versus traditional Project-Based Learning without the use of the digital environment. The digital environment allowed students to create stories on the computer by using digital photos and editing software. Students who completed the Project-Based Learning within the digital environment scored higher on posttests measuring motivation to learn science, problem-solving abilities, and learning achievement for science.

Erstad (2002) also conducted case studies with Norwegian elementary school students, finding that the influence of using a digital environment in Project-Based Learning was generally positive. Case studies of Project-Based Learning in digital environments included activities such as creating animated videos, speaking with others over satellite phone connections, and being trained to use digital tools such as iMovie, Apple Works, and digital video cameras. Students were engaged in the project and according to reports from parents and teachers, students at all performance levels did well when using Project-Based Learning in a digital environment.

Clearly, based on previous research in examining Project-Based Learning in digital environments, students appear to benefit greatly not only from Project-Based Learning, but also as it is applied in digital environments. Students have the opportunity to become more knowledgeable about the technology as well as about the information that the technology provides. When using Project-Based Learning within digital environments, students are able to collaborate with each other and bring the real world inside the classroom.

Culturally Relevant Instruction

The shared, learned, transmitted, and adaptive culture of people is reflected in their thinking and doing (Bodley, 1997). Charles Hutchison (2005) stated that knowledge-creation is influenced by cultural traditions and paradigms. The questions students ask, the way they respond to teachers' questions, and what is an acceptable scientific hypothesis are all influenced by cultural beliefs. According to Rakow and Bermudez (1993), culture even influences the way we perceive and frame what we believe about people. For example, these authors found studies in which European-American teachers tend to see boys as silent, steady, open, factual, rational, and independent while Mexican teachers rate boys as morose, dependent, talkative, shy, protective, emotional, and imaginative (Rakow & Bermudez, 1993). These stereotypic images influence how teachers view and approach their students and the learning outcomes they expect.

Okhee Lee's (2005) review of the literature on cultural and linguistic influences on science learning indicates that while cultural partners can affect science learning, the partners' expectations are often inconsistent with those of the school. Lee (2005) reported that little recognition has been given to the "linguistic and cultural resources that nonmainstream individuals and groups bring to the science classroom, and little thought has been given to how to articulate these resources with the norms and practices of science disciplines and school science to enhance student learning" (p. 491). Students may do better in science if these cultural considerations are made. Lee (2005) also makes the observation that English learners are just as able to perform well in science, but at times may have obstacles facing them within the educational system, which has not incorporated a cultural awareness.

To combat these obstacles, Lee (2005) recommends that educational systems follow these guidelines. First, students should be given instruction where they are allowed to ask questions about the material in a hands-on environment, as this is less involved with mastering the English language as compared to more traditional methods. Hands-on activities also allow English learners to communicate with others about science in different ways (e.g., verbal, written, graphic, gestural), which allows them to practice their English grammar and vocabulary skills while learning about science. Second, teachers need to have professional development not only in science but also in how to promote literacy in English learners. Literacy development should include not only basic language skills but also should include how to apply these language skills in advanced writing tasks, such as explaining or comparing two items. Teachers should have an understanding from a human development perspective when making expectations about English learners' ability to comprehend vocabulary. It is also important that teachers are able to promote literacy development both in a general sense and when teaching content-specific vocabulary. Lee (2005) concludes that with these recommendations, and by educators understanding the underlying factors that may inhibit English learners' understanding of science, educators will be better able to teach science to this population.

In summary, the Collaborative Online Project for English Language Learners in Science Theory of Learning hypothesizes that science learning embedded in culturally relevant collaborative online projects, coupled with appropriate teacher professional development, will assist English learners' communication skills and teacher-student interactions with science content. The curriculum design and delivery approach for these collaborative online projects not only takes into account students' cultural backgrounds, but also builds upon that resource to further the learning gains.

Language Tools

English learners need to develop English language and literacy skills in the context of subject area instruction to reduce achievement gaps (Lee, 2005). Despite the substantive literature on the benefits of bilingual instruction and the use of native language, U.S. policies and practices do not consider native language as relevant to English language development and content area learning. During a five year study, Thomas and Collier (2002) collaborated with schools across the U.S. in order to determine what resources are in place for English learners and how these resources affect English learners' academic performance. Thomas and Collier (2002) found a great deal of evidence on the success of school programs using students' native languages to support content-area learning when compared to those in which students were immersed in the new language without linguistic support. English learners were less likely to perform well on reading and math achievement tests if their parents determined that their elementary school should not provide bilingual or English as a Second Language services to these students compared to English learners who did receive bilingual or English as a Second Language services. Thus, English learners who are given bilingual or English as a Second Language supports perform better academically than students who are not given supports when learning in their non-native languages. It is important then to provide language supports in English learners' native languages when teaching content. Thomas and Collier (2002) also found that native Spanish-speaking students, when tested in Spanish, performed better on math tests during grades 2 through 5 compared to English-speaking students, when tested in English, on math tests during grades 2 through 5. English learner students then are able to perform as well as or better than other students, but it is important that they are able to receive bilingual or English as a Second Language supports in order to perform well.

Lee's (2005) review suggests that English learners' limited proficiency in English constrains their science achievement when instruction and assessment are undertaken in their second language. Lee (2005) only found two studies in science instruction that took place in the U.S. However, those studies did not have a direct focus on native language instruction. The first study was conducted by Duran, Dugan, and Weffer (1998) with Spanish-speaking English learner high school students. In the study, students used semiotic tools such as diagrams when learning about biology. As students learned more of the tools, the students became more responsible about acquiring knowledge and using the semiotic tools to create meaningful diagrams of scientific concepts, instead of relying only on the teacher to provide information. The researchers concluded that English learners should be allowed access to semiotic tools, which assist them in using scientific language. The second study was conducted by Torres and Zeidler (2002) and examined outcomes on a science achievement test with both Spanish-speaking English learners and non-English learners. Results showed that students who were highly proficient in the English language and were able to reason about science were more likely to understand science knowledge when it was presented in English. Based on these results, it can be concluded that provisioning or prompting the use of language tools by English learners is advantageous to their understanding and ultimate success with science content.

Tobin and McRobbie (1996) worked with Chinese students learning English in an Australian high school who were enrolled in a chemistry class taught in English. These students showed high levels of effort, but ultimately struggled with learning the material, because they were forced to engage with the material in their second language, without being allowed to fully explore the material in their native language. By not employing their native language, the Chinese students learning English were not able to work fully with or engage in the material at their highest level of performance. The study highlights that learning chemistry can be facilitated when English learners are provided with opportunities to fully employ their native language. Kearsey and Turner (1999) conducted a study with middle school students from the United Kingdom to determine whether being bilingual would be helpful in students acquiring science vocabulary, due to previous exposure to two languages, or whether the cognitive load of knowing two languages would negatively impact students' abilities to gain science vocabulary. After examining a standard United Kingdom science textbook, researchers determined that being bilingual could ultimately be a resource for students when gaining science vocabulary. The study reported that English learners could benefit from curriculum materials that support linguistic tasks and the additive effects of bilingualism.

The Collaborative Online Projects for English Language Learners in Science Theory of Learning hypothesizes that having all instructional materials immediately available in both English and Spanish along with other native language supports facilitates English learners' access to scientific content and improves their science literacy in both languages. Examples of "supports" include pop-up vocabulary definitions and translations. In combination, cultural relevance, language tools, cognitive-affective processes, multimodal digital environments, and Project-Based Learning make the collaborative online projects suitable platforms for facilitating Spanish-speaking English Learners' acquisition of academic English and science learning.

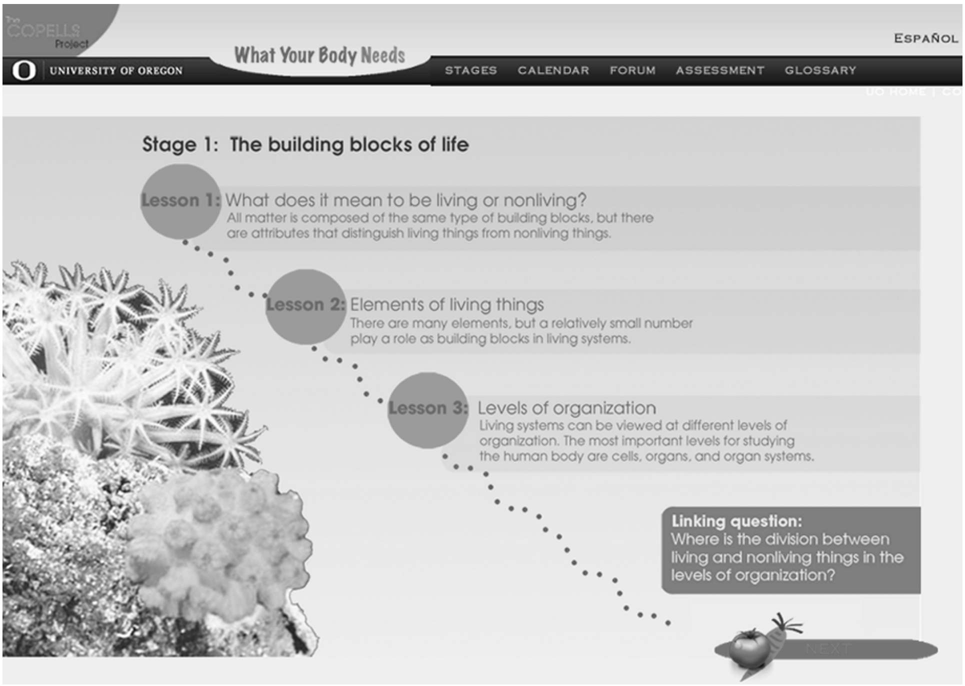
CASE DESCRIPTION

Technology Components

A collaborative online project is a complete thematic unit that provides Project-Based Learning experiences within an interactive multimedia environment for students to engage in real-world activities and work collaboratively to solve authentic problems. Each collaborative online project unit contains five to seven stages, or chapters, of learning that present all the content to be learned in an 8 to 10 week period of daily instruction. Stages are organized by lessons, and the lessons are divided into strategically planned activities that delineate key features of Cognitive-Affective Theory of Learning with Media and Project-Based Learning. To establish a conceptual connection between stages of learning there is a "linking question" to prompt students to reflect about what they already know and what they are about to learn in the subsequent lessons. Figure 2 shows the organizational structure of the first stage, or chapter, for the *What Your Body Needs* unit. This graphical structure is intended to be used by teachers to introduce students to the lesson, establish the driving question, and allow students first explorations of topics.

In each lesson, content learning is multimodal, allowing for the presentation of content in different formats for multiple purposes:

Figure 2. Collaborative online projects' organizational structure



1. Activate students' background knowledge with the use of warm-up activities. Warm-up activities are critical components of instruction in a constructivist approach because student input is fundamental for the construction of knowledge. Warm-up activities may have the form of a question accompanied by images and specific instructions to help students generate discussion. Figure 3 shows an example of a warm-up used in Stage 2 of *What Your Body Needs*, in which students are asked to consider the characteristics that help determine if an object is a living organism.
2. Allow for the construction of knowledge, using activities such as reading content combined with comprehension questions or summaries, enhanced vocabulary definitions and translations, teacher guided discussions, and video tutorials. These activities are documented in a student notebook available both in printed or electronic form.
3. Allow students to practice, hypothesize, or experiment to learn and further develop scientific thinking skills, with the use of lab experiments, instructional games, and virtual simulations.

Figure 3. Warm-up learning activity

4. Provide corrective and explanatory feedback to students about their acquisition of scientific knowledge with the use of interactive exercises and summative assessments at the conclusion of each stage, or chapter, of learning.
5. Provide dialoguing opportunities and exchange of communications through peer-to-peer interactions, small group discussion, and purposeful forum activities.

Teacher resources for each collaborative online project are accessible through the teacher-dedicated section of the website, and include the following.

1. Lesson briefs provided for each stage of the project. Lesson briefs contain the lesson's objectives, suggestions for how to introduce the varied activities, notes indicating if advanced preparation is required, and concepts and vocabulary that should be emphasized in each lesson.
2. A Strategies section that provides a description of each type of activity in the unit and an overview of the organizational structure of the project. The latter part of this section is devoted to scaffolding ideas for connecting to background knowledge, vocabulary, pre-reading, and developing comprehension.

This section was designed specifically for science teachers who may not have formal language acquisition or language instruction backgrounds. Participation strategies to help organize and pace the unit are also provided. Participation strategies include a calendar and timeline of activities, group and teamwork roles, and media usage guidelines.

3. Tutorials designed to be used during teacher participant training, prior to implementation in the classroom. Tutorials provide teachers with all the information they need to implement the collaborative online projects independently. This section mimics the structure of activities in the student area of the website. The rationale behind the tutorials section and its format is to expose teachers to the flow of the unit as students will experience it. Video demonstrations are also included to model specific instructional activities such as use of forums, the registration process, and website navigational features. Teachers in Mexico and the U.S. who are unable to attend in-person trainings provided by project staff can use the tutorials independently. Teachers who have extensive experience with the use of technology will find online tutorials sufficient.

The *Let's Help Our Environment* Unit

One example of a science collaborative online project developed by the Collaborative Online Projects for English Language Learners in Science project is the *Let's Help Our Environment* unit. In this unit, students are invited to think and learn about the environmental problems in their surroundings and consider what actions they can take to prevent and solve them. The driving question for this unit is "What can I do to help my environment?" Along the way toward answering this question, students conduct investigations to gain insight into the critical environmental problems within their community and offer solutions, while at the same time, acquiring scientific knowledge and skills linked to U.S. National Science and Engineering Standards. Among other skills, students gain practice with the scientific inquiry process and discuss ecosystems using newly acquired vocabulary terms such as limiting factors, populations, habitats, energy sources, variation, and adaptation.

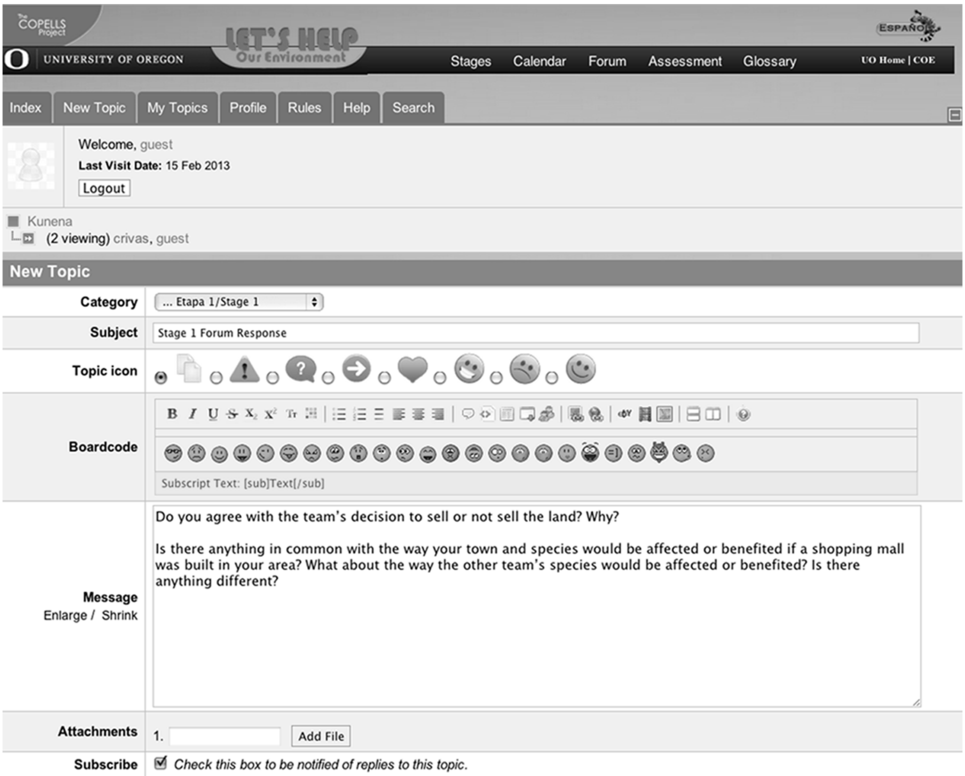
Using the *Let's Help our Environment* unit, we can further illustrate the major instructional components outlined in each collaborative online project (this unit can be accessed through the project website, http://recuperemos.uoregon.edu/). The unit is divided into five stages: (1) Life on Earth, (2) Interactions of Living Things, (3) Responding to Change, (4) Human Impacts, and (5) Investigating Environmental Issues. In Stage 1, students are asked to think about a local environmental concern. As students progress through the unit, learning specific themes and concepts, they are periodically prompted to make connections to that environmental concern. In Stage 2, after students have studied the major relationships among living organisms (e.g., predation, competition, food webs, and limiting factors) students are challenged to play the "Food Fight Game" and build a species population. The goal of the game is for students to build an ecosystem in which animals can grow. Students apply their knowledge about competition, food, and limiting factors in order to be successful in this game. An interactive activity with immediate feedback that is used to gauge students' own knowledge of animals is also presented in this stage. The concept of natural selection is introduced with a simulation of birds shown both in a light and a dark forest. Using this simulation, students collect specific data and draw conclusions about the effects that the light in the environment has on this species. The Zero Food Print Youth Calculator is a virtual lab resource used by students to measure the amount of carbon dioxide and methane that they contribute to the environment and to help them think about actions they can take to reduce their carbon footprint. In the last stage of the unit, students learn about the scientific inquiry process and conduct an investigation into an environmental issue of their choosing. The results of their investigations are summarized in posters or any other reporting format and later uploaded to the forum. In the last forum activity for this unit, students discuss the world's most important environmental problems and the actions that can be taken to address them. Figure 4 illustrates an example of a forum page within the unit.

The *What Your Body Needs* Unit

The overall learning objective behind the *What Your Body Needs* unit is for students to appreciate the internal mechanisms of their bodies so they can build a connection between their bodies' health and their lifestyle choices. This learning objective is accomplished by allowing students to organically acquire interest about their bodies as they learn about the microscopic and macroscopic components from which the human body is made. The unit consists of seven stages titled: (1) The Building Blocks of Life, (2) Cells Are Alive, (3) Bacteria, Viruses, and the Immune System, (4) Organs—Cells Working Together, (5) The Digestive System, (6) Kidneys and the Urinary System, and (7) Interacting Systems.

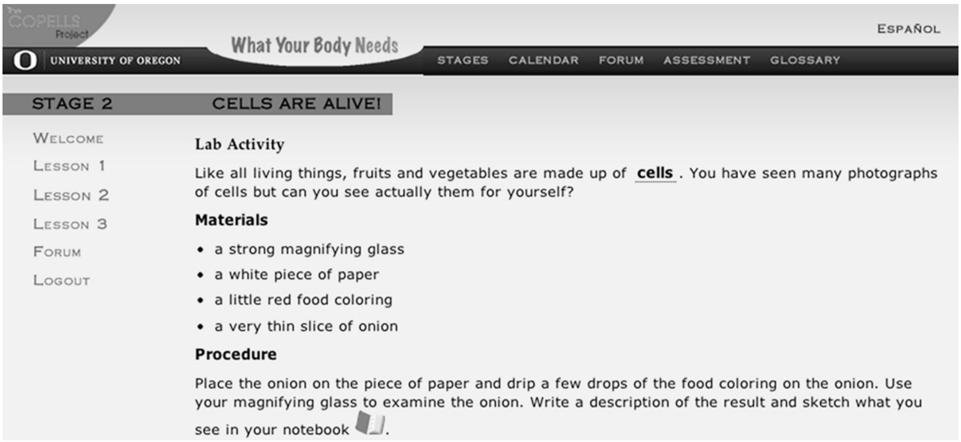
The *What Your Body Needs* unit contains lab activities, teacher-led warm-ups & demonstrations, engaging student surveys, videos, and games. In Stage 1, students comprehend that living things have certain characteristics that distinguish them from inanimate objects. They apply their learning by evaluating different objects against seven characteristics of life. Students are also introduced to the main chemical elements (carbon, oxygen, hydrogen and nitrogen) that are found in living things. They also learn the compounds (carbohydrates, lipids, proteins and nucleic acids) that are formed from the chemical elements. At the end of the stage, students apply their knowledge by designing a t-shirt that communicates their understanding of those concepts. Students have guidelines from which to base the content of their

Figure 4. Forum



t-shirt but they are given creative freedom to communicate that understanding. In the stage that follows, students learn about the basic function and properties of cells and organelles through various multimodal activities. An important component of this stage is a virtual lab activity and an actual lab activity where students examine and diagram onion cells (See Figure 5 for an example of this). In Stage 3, students spend time comparing what they learned in the previous stage about animal and plant cells to a new type of cell, bacteria. Students are exposed to examples of how bacteria can be beneficial or harmful. Returning to the discussion of living and nonliving things from Stage 1, students are challenged to evaluate viruses through the criteria for living things. Students also begin to make connections between cells, viruses, bacteria, and the immune system in this stage. In Stage 4, students are introduced to the idea of cells working together to perform a job and are introduced to the vocabulary words tissues, organs, and organ systems. The main objective is for students to gain awareness of the basic functions of their bodies' organs and to value their complexity. Similarly, in Stage 5, students see how their nutritional choices affect the functioning of their systems, specifically the Digestive System. In

Figure 5. Lab activity



Stage 6, students learn about the process of diffusion by examining another organ system that uses this process to do its job, the Urinary System. Finally, in Stage 7, students examine and consider how the different body systems, rather than working in isolation, work together to create the organized and complex organism that is the human body. Students carry out a final project to examine any of the concepts more in-depth, as guided by their teacher and own personal interests.

A Case Implementation Study

The *What Your Body Needs* unit was implemented by two participating teachers in the U.S. and by over 50 teachers in Mexico. In the U.S., one 6th-grade teacher and one 7th-grade teacher implemented the unit with a sample of 53 students, 81% of whom were English learners of Hispanic origin. The implementation extended over a period of 10 weeks in which students completed all seven stages of the unit, participated in forum activities, and completed the accompanying assessments. The Collaborative Online Projects for English Language Learners in Science project supported this implementation with the goals of identifying: (1) Whether the collaborative online projects facilitated science content learning for English learners; (2) the collaborative online projects' components that were most relevant for English learners' engagement with science learning; and (3) whether teachers and students saw the collaborative online projects as good resources for learning science.

The 6th-grade teacher, from now on referred to by the pseudonym of Mr. Torres, implemented the collaborative online project unit with one group of 29 students, but only 23 complete data sets were obtained, and the 7th-grade teacher, from now on referred to by the pseudonym of Ms. Jimenez, implemented the unit with two groups of 30 students each, and 30 complete data sets were obtained for a sample size of 53. Descriptions of each group setting follow.

Mr. Torres teaches a self-contained 6th-grade classroom as part of a Two-Way Immersion program. The Two-Way Immersion program at this district is offered at four schools, three K–4th schools and one 5th–6th school, and has been in existence for 15 years with the objective to have fully bilingual and bicultural students in English and Spanish upon entering seventh grade. Students in the program are mostly native Spanish-speakers, but there are also native English speakers and students from bilingual households. To participate in the program, parents enroll their students in kindergarten and the students continue through each grade level in a designated Two-Way Immersion classroom. Academic instruction is given in both languages equally; however, the manner in which students receive their instruction varies by school. In the model that Mr. Torres followed, he planned and balanced each subject area so equal instruction in English and Spanish in all subject areas was provided throughout the year. One of the reasons Mr. Torres was eager to participate in the Collaborative Online Projects for English Language Learners in Science project was due to the availability of the curriculum in English and Spanish, thus allowing him to maintain flexibility in when he taught in either language. Mr. Torres has an English for Speakers of Other Languages endorsement and more than 20 years of classroom experience. In his responses to a pre-survey regarding his use of technology in the classroom, he answered that his students had never used technology in his classroom for blogs, forums, or webquests, but that they sometimes used technology for Internet research purposes and completing projects in teams.

Ms. Jimenez is a science teacher in the district's sole 7th–8th grade school. She implemented the project in two class periods of a science discovery program. Discovery classes embed literacy throughout the curriculum and work toward the development of related skills in thinking, reading, writing, self-advocacy, and speaking. Students are placed in discovery classes based on test scores and teacher and administrator recommendations. Ms. Jimenez has a Master's degree and is in her fourth year of teaching. In her pre-survey responses, she indicated that she often used technology projects that required teamwork and sometimes used technology in the classroom for students to conduct Internet-based research. Similar to Mr. Torres's class, she had never used blogs, forums, or webquests previously in her teaching.

Teacher Training

In order to implement the units, teachers participated in a one-day training provided by project staff. Prior to the meeting, they were asked to review the online tutorials offered at the teacher section of the unit's website. Teachers were informed that for a successful implementation of these collaborative online projects, their role would also include that of a content facilitator who helps to clarify questions posed by students, encourages student curiosity, and promotes further investigations into a theme. Because group work is one of the key features of a collaborative online project, teachers were presented with techniques for how to facilitate discussion and help problem-solve within group dynamics. Suggestions for assigning student roles and responsibilities were also presented. All of these techniques were referenced in the teacher section of the website.

When the implementation began, students were trained by project staff on how to properly use the equipment provided by the project, including its general operation, how to navigate through the website, and how to use the downloaded applications. Students were also provided with an orientation to the forum. This forum training began with demonstrating and practicing the process of signing on to the forum, then transitioned to posting pictures and text, and ended with students replying to other forum posts. Project staff was present throughout the implementation of the unit, more often at the beginning of the implementation (approximately twice a week), and less often toward the end of the implementation (every other week). Staff provided on-site and immediate remote support to the teachers and assisted students with the activities during class time. Staff took notes on the daily activities and results of the class, and in general, observed all aspects of the implementation of the *What Your Body Needs* unit.

Data Collection Instruments

Fidelity of implementation measures. A teacher journal, a classroom observation protocol, and a completion checklist were developed to collect data on fidelity of treatment implementation. Teachers filled out journals at the end of each stage of instruction in which they reported whether all the lessons were completed and the reasons why they might not have been, if that was the case. The journals also asked teachers to share issues they encountered and their overall experience with each lesson.

The classroom observation protocol tracked data for both teacher and student behavior. Teacher behaviors observed were the following: (1) the manners in which teachers made use of the project website to deliver instruction, (2) the lessons that teachers used from the unit (including whether or not they completed all the activities in that lesson), (3) presence of strategies to facilitate team work, (4) how teachers activated student background knowledge, (5) use of vocabulary supported definitions from the website, and (6) use of the Spanish website.

Student behaviors observed included the following: (1) frequency of use of English and Spanish resources, (2) teamwork dynamics, (3) usage of vocabulary-enhanced definitions, and (4) engagement in learning activities via the website. The completion checklist listed all the stages and lessons to be completed during the implementation and was filled out by project staff based on the information collected from the teacher reflections and classroom observations.

Teacher interviews and student surveys. In order to identify components of the unit that were most relevant to English learners' engagement with science learning and to determine if teachers and students saw it as a good resource for learning science, project staff collected interview and survey data. During the teacher interview, we collected information about how the teacher had been teaching life science prior to the study, how frequently he or she used technology in the classroom, and how satisfied he or she was with the various aspects of the project, including identifying those factors that helped make the implementation successful.

The student survey gathered information such as language spoken at home, and asked for students to provide feedback on what features they liked and did not like about the unit. These surveys were designed as straightforward, information-gathering instruments, not to assess a latent attitude, so reliability analyses were not necessary. However, to ensure that the questions were indeed asking what was intended for gathering relevant information, a methodology consultant with experience in survey development carefully reviewed the questions for clarity.

Science content assessments. In order to identify whether or not the units facilitated science content learning for English learners, we collected pre-post data of a science content assessment developed by project staff. This assessment consisted of 31 items related to the content covered in the unit. Questions were presented in various formats, including multiple choice, fill in the blank, open-ended questions, true and false statements, and item organization. Chronbach's alpha was computed to determine the test's reliability, which resulted in a reliability score of .71.

CURRENT CHALLENGES FACING THE ORGANIZATION

Case Study Analysis and Results

Pre-post content assessments were analyzed with a paired sample t-test to determine if student participants made statistically significant improvements in their scientific knowledge as measured with a pre- to posttest assessment of science content. Teacher and student surveys were analyzed with a cluster analysis of qualitative data where, after major categories of responses were identified, frequencies of specific responses were calculated in order to have an overall representation of this categorical information. Finally, qualitative analyses also involved descriptive information drawn from a completion checklist and classroom observations to demonstrate that teachers and students used the technological resources effectively and completed the unit's activities with fidelity.

Fidelity of Implementation

Results of this study indicated that teachers implemented 71% of the lesson activities with fidelity. The main reason, as reported by teachers, for lack of completion of a particular lesson was due to time constraints. However, teachers reported their desire to implement all of the lessons if time was not a constraining factor. Teachers felt the need to skip some activities in order to follow the unit's timeline. Also, some of the activities within a lesson were optional, and it was up to the teacher's judgment whether to complete them. From a total of nine random observations conducted with both teachers, it was found that teachers used the unit's website while delivering instruction in eight out of the nine observations. Teachers showed behaviors that facilitated teamwork during six observations, conducted activities to generate background knowledge in four of the observations, encouraged the use of vocabulary-enhanced definitions in four of the observations, and were not observed encouraging the use of the Spanish website during any of the class time. Student behaviors in those nine observations included using the English website exclusively, demonstrating effective teamwork skills, and frequently accessing the vocabulary-enhanced definitions available through the website.

Critical Components of Collaborative Online Projects for English Learners' Engagement with Science Learning

The components of instruction that appeared to be relevant to English learners' engagement with science learning included the following:

1. Warm-up activities that were designed to generate culturally relevant discussions of prior knowledge and experiences.
2. Visuals and videos that were selected by virtue of their rich representation of the Hispanic culture. Teachers thought visuals and videos were a great support for student learning. Comments given by teachers included: "They made students interested like you wouldn't believe," and "Students had more desire to learn and complete the activities."
3. Interactives and games that provided a highly engaging, multimodal learning environment. These resources were greatly accepted by students. One teacher reflected, "My students are a targeted group of kids who largely have very

low reading levels, and these interactives and games were so-o-o-o engaging." Similarly the other teacher stated, "Kids love the simulations; the National Geographic "Body" website also has really great simulations, which the kids love."

4. The forum that facilitated communication between students in the U.S. and Mexico was also considered an important component of student engagement with learning activities. In regards to the forum space, teachers reported that: "Students loved talking to other kids." "Students were intrigued when somebody said something to them." "Students had a space for sharing their knowledge."
5. Vocabulary enhanced definitions that provided immediate access to scientific definitions appropriate for the age group featured were often accessed by students. Teachers also used them as an opportunity to teach new concepts.

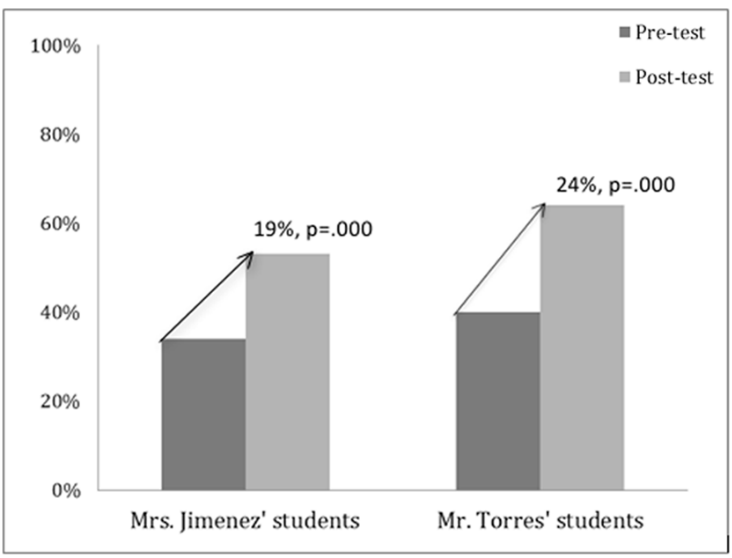
Unexpected to us, the Spanish website resources did not appear to be a relevant component for student engagement with science learning. Even though Mr. Torres was teaching in a Two-Way Spanish Immersion class--and sometimes his instruction was provided in Spanish--students opted to use the English website when completing interactive activities independently. However, the forum was a space for U.S. students to exchange communications with students in Mexico, and interestingly, most of those communications by the students in Mr. Torres' class occurred in Spanish. Ms. Jimenez, a native English speaker with limited Spanish proficiency, did not view the Spanish website as an option for her during instructional time. Students in her science classes were at the highest levels of English language development or were monitored students (monitored refers to a status designation of an English learner who has recently stopped receiving English language services through their school), so it is perhaps understandable that they did not employ the Spanish resource as much as we expected. While teamwork was always used and encouraged by the teachers, it was not reported as being critical for the units. The teachers believed that working in teams is always helpful; however, some activities could have also been carried out successfully had they been completed by students independently.

The components of the curriculum appeared to have been accepted by the teachers. Teachers reported that the unit was "pretty well thought through" and "the content was awesome." The only thing they would change would be allocating more time to cover all the content so they would not be rushed to complete the unit and meet the timelines. Students reported liking the forum, the interactive games, working in groups, and using the framework for learning online in general. Students made statements such as, "I like the forum because you could talk with people in other places," "I like the interactive parts so I could learn and have fun at the same time," "I like everything in the unit," "I like the videos and games because it was easy to not have [to] read so much," "I like the unit because it tells you how the body works and how your system works," "I like making the yellow [*sic*] cell model," and "I liked that there were a lot of fun activities and because I understood it more."

Effect of Collaborative Online Projects in English Learners' Science Content Learning

Figure 6 shows the gains that students made in the science content assessment before and after they participated in the implementation. Overall, students in Mr. Torres' class scored 24 more percentage points from pretest (M = 40%, SD = 12%) to posttest (M = 64%, SD = 15%) in measures of science content, which were statistically significant, $t(22) = 9.01$, $p = .000$. Students in Ms. Jimenez's class also had a statistically significant gain of 19 more percentage points from pretest (M = 34%, SD = 16%) to posttest (M = 53%, SD = 17%) in measures of science content, $t(29) = 7.14$, $p = .000$. These results do not demonstrate a causal effect between the use of the collaborative online project and an increase in science content learning due to the fact that we were conducting a pre-experiment that lacked a control group. This pre-experiment strongly suggests that it is worthwhile to continue conducting further investigations for the implementation of collaborative online projects. However, students did not experience any negative effects nor did their science content learning decrease after being part of the implementation.

Figure 6. Pre-post science content assessment gains for collaborative online project participants



SOLUTIONS AND RECOMMENDATIONS

Collaborative Online Projects for English Language Learners in Science is a project conducted at the Center for Advanced Technology in Education at the University of Oregon in partnership with the Instituto Latinoamericano de la Comunicación Educativa in Mexico and the Biological Sciences Curriculum Study group in the United States. The project received funding from the National Science Foundation to design, translate, enhance, and evaluate culturally relevant and linguistically appropriate collaborative online projects in science for secondary level Spanish-speaking English learners. The project's two major goals are to (1) design interactive multimodal media-rich online learning environments that address both the cultural and linguistic needs of English learners to learn science, and (2) facilitate and improve science content-area learning for English learners.

The resultant collaborative online projects were designed to provide culturally and linguistically relevant, media-rich, and collaborative science instruction. In creating the collaborative online projects, constructivist approaches were combined, including the Cognitive-Affective Theory of Learning with Media and Project-Based Learning. The Cognitive-Affective Theory of Learning with Media was particularly relevant to the design of the collaborative online projects as it takes into account factors associated with media literacy, such as cognitive load and instructional design principles for interactive multimodal learning environments. In addition, Project-Based Learning was used in the development of the collaborative online projects' lessons to allow students to create their own learning experiences when solving real-world problems in collaboration with others in a digital environment. Within the project website, students were provided with culturally and linguistically relevant instruction. Students had the option to access any web page in English or Spanish with the click of an icon. Although the projects were primarily designed for English language students in the U.S., more than 50 classrooms in Mexican schools also participated in these units, allowing science learners from both countries to synchronously progress through the curriculum and communicate through the forum.

The forum was an important factor for student engagement and motivation. English learners in the U.S. were able to have cross-cultural learning exchanges with Mexican students. Thus, the forum allowed for both collaboration in learning science content as well as a safe digital environment for students to practice their Spanish or English language skills. Although students and teachers by and large did not frequently access Spanish versions of the website, U.S. students often used Spanish to communicate in the forum. Students had the option to use their native language and could decide on their own when to use their native language and when to practice English.

Another language support included in both collaborative online projects was vocabulary enhanced definitions, identifiable by their bold font and dotted underline formatting in the student content. For both collaborative online projects, targeted vocabulary words were selected for enhancement. Words that were selected for enhancement were either topic specific words (such as *ecosystem*) or functional words (such as *analyze*). All of the words included a translation of the word and most words had accompanying images or example sentences. The case study revealed that students often used these enhancements, and teachers employed them for immediate just-in-time learning opportunities.

The case study was conducted with a sample of 53 students. Results indicate that the two participating teachers implemented 71% of the lesson activities with fidelity. Lack of time was the most common reason for being unable to complete all collaborative online project activities. Both teachers and students enjoyed the strong visual nature of the collaborative online project as well as the interactivity provided through online games and simulations. Overall, the collaborative online project was associated with positive gains in English learners' understanding of science. Student science content percentage point gains between pretest and posttest (24% and 19% increases in scores for each participating teacher) were statistically significant, strongly suggesting that it would be worthwhile to conduct further investigations on the implementation of collaborative online projects. This study was conducted with the main objectives of learning about the feasibility and usability of a collaborative online project when implemented by educators in an authentic classroom setting; and, whether students and teachers considered it a potentially useful resource with which to provide enhanced science instruction to English learners. This study was also conducted to gather data to identify the most appropriate components for student learning when using collaborative online projects. A quasi-experiment is being conducted at the time of publication of this chapter. Plans are in place for conducting true-experiments with a randomized control trial design.

In summary, the collaborative online project units were implemented with a high degree of fidelity and were associated with gains in science content understanding for Spanish-speaking English learners. This study has provided the researchers with: (1) a model for how online science curriculum in the form of collaborative online projects can take advantage of rich multimodal learning environments for the benefit of English learners' science learning in U.S. schools, (2) a model for how electronically enhanced vocabulary embedded within online science materials can improve science learning for English learners, (3) a model for how partnerships with educators in Mexico can benefit science learning for English learners in U.S. schools, and (4) a model for how person-to-person learning opportunities, within classroom collaboration as well as online and across-borders collaboration, can improve motivation and science learning for English learners in U.S. schools.

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KEY TERMS AND DEFINITIONS

Cognitive-Affective Theory of Learning with Media: A theory of learning to provide researchers with specific design principles for multimedia instruction based on cognitive assumptions.

Cognitive Load: The amount of information that is currently being used by working memory.

Cognitive Tools: Supports (e.g., computer-based laboratories, hypermedia, graphic applications, and telecommunications) that help students to represent ideas.

Collaborative Online Projects: Learning and teaching activities to facilitate content-area learning through the use of collaboration in a digital environment.

Culturally Relevant Instruction: Teaching that occurs when student cultural factors (e.g., traditions, paradigms, beliefs, and perceptions) have been intentionally and thoughtfully considered into the planning and delivery of academic content.

Dialoguing: Solving a problem or task through discussion and examination from multiple perspectives.

English Learners: Learners who have a first language other than English and are acquiring English as their second or other language.

Meaningful Learning: Type of learning that occurs when a learner is engaged in the process of gaining new information and integrating the new information with previously gained knowledge.

Native Language Tools: Supports that can be used by English Learners such as online dictionaries and translators that allow for the additive effect of native language while acquiring a new language.

Project-Based Learning: Type of learning that occurs when learners create their own education experiences. To do this, learners use technology to access and analyze information globally to solve real-world problems while gaining collaboration skills.

Working Memory: The part of the mind that is currently engaged in thought (e.g., problem-solving or accessing information).