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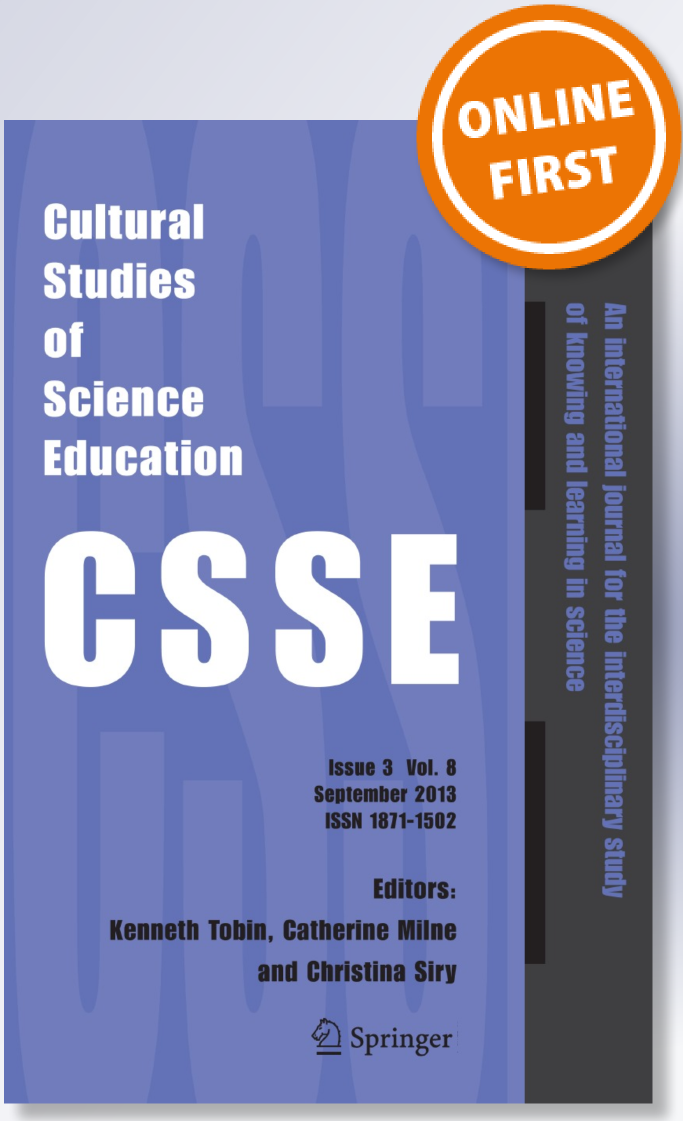

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Abstract This paper summarizes how collaborative online projects (COPs) are used to facilitate science content-area learning for English Learners of Hispanic origin. This is a Mexico-USA partnership project funded by the National Science Foundation. A COP is a 10-week thematic science unit, completely online, and bilingual (Spanish and English) designed to provide collaborative learning experiences with culturally and linguistically relevant science instruction in an interactive and multimodal learning environment. Units are integrated with explicit instructional lessons that include: (a) hands-on and laboratory activities, (b) interactive materials and interactive games with immediate feedback, (c) animated video tutorials, (d) discussion forums where students exchange scientific learning across classrooms in the USA and in Mexico, and (e) summative and formative assessments. Thematic units have been aligned to U.S. National Science Education Standards and are under current revisions for alignment to the Common Core State Standards. Training materials for the teachers have been integrated into the project website to facilitate self-paced and independent learning. Preliminary findings of our pre-experimental study with a sample of 53 students (81 % ELs), distributed across three different groups, resulted in a 21 % statistically significant points increase from pretest to posttest assessments of science content learning, $t(52) = 11.07, p = .000$.

Keywords English learners · Bilingual education · Science learning · Collaborative learning · Technology

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EL Proyecto de Ciencias Colaborativo en Línea para Estudiantes de Inglés como Segundo Idioma (COPELLS, siglas en ingles) es un proyecto llevado a cabo en el Centro de Tecnología Avanzada para la Educación de la Universidad de Oregon en colaboración con el Instituto Latinoamericano de la Comunicación Educativa (ILCE) en México y el Estudio Curricular de las Ciencias Biológicas (BSCS, siglas en ingles) en los Estados Unidos. El proyecto COPELLS recibió financiamiento de la Fundación Nacional de Ciencias para diseñar, traducir, y evaluar Proyectos Colaborativos en Línea (COPs, siglas en inglés) culturalmente y lingüísticamente apropiados para la enseñanza de las ciencias para estudiantes de secundaria que hablan inglés como segundo idioma (ELs, siglas en inglés) y cuyo lenguaje principal es el español. Las metas principales del proyecto son: (a) diseñar ambientes de aprendizaje en línea que son interactivos y multimodales y que toman en cuenta las necesidades culturales y lingüísticas de los estudiantes EL para aprender ciencias y (b) facilitar y mejorar el aprendizaje de las ciencias para estudiantes que hablan inglés como segundo idioma.

Los estudiantes ELs frecuentemente no tienen acceso a materiales académicos en ciencias hasta que ellos tienen fluidez en el idioma inglés (Chisholm and Beckett 2003). Diseñar y evaluar materiales curriculares para la enseñanza de las ciencias en colaboración con expertos de ciencias de dos culturas diferentes, puede ser un método efectivo para desarrollar materiales que son culturalmente relevantes para los estudiantes de habla hispana que están aprendiendo inglés como segundo idioma en los Estados Unidos. El objetivo del ILCE es contribuir a la educación en America Latina a través del uso de proyectos colaborativos en línea. Ellos crean y proveen COPs para estudiantes y maestros en diferentes áreas temáticas, incluyendo las ciencias. Los COPs del ILCE se han escrito en español y son actualmente usados para mejorar temas y destresas en las ciencias en escuelas de México y America Latina. Cada COP es una unidad temática con materiales de lectura interactivos que incorporan juegos, imágenes, y videos. En equipos de 2–4, los estudiantes colaboran entre ellos, investigan, realizan experimentos, y se comunican con otras escuelas en otras ciudades y otros países. Los COPs tienen actividades específicas para que los estudiantes intercambien actividades de aprendizaje a través del uso de los foros. Por ejemplo, a los estudiantes se les presentan temas controversiales que otros estudiantes han creado y son invitados a que realicen comentarios y también a que respondan a los comentarios y preguntas que otros alumnos hayan hecho. El papel de los maestros es el de facilitar y organizar los equipos de trabajo, incorporar discusiones relevantes, y evaluar el aprendizaje de los estudiantes. Nuestro otro colaborador, BSCS, es una organización sin límite de lucro que está comprometida a "transformar la enseñanza de la ciencias y el aprendizaje de los estudiantes al hacer y generar investigación que continúe elevando los estándares para el desarrollo de los materiales curriculares de la ciencias" (BSCS 2012). BSCS apoyó el diseño, la creación, y evaluación de dos COPs.

Un pre-experimento fue conducido con una muestra de 53 estudiantes, 81 % fueron estudiantes EL de habla hispana, donde dos maestros implementaron un COP del área de las ciencias naturales para identificar: (a) si los COPs facilitan la enseñanza de las ciencias para estudiantes EL, (b) los componentes de los COPs que son más relevantes para que los estudiantes EL se motiven y aprendan ciencias, y (c) si los maestros y estudiantes creen que los COPs son un recurso apropiado para la enseñanza de la ciencias. Resultados de este experimento indicaron que los maestros implementaron el 71 % de las lecciones y actividades con fidelidad. La razón principal de la falta de cobertura de todos los contenidos se debió a las restricciones de tiempo. Sin embargo, los maestros reportaron un deseo por implementar todas las actividades y lecciones si el tiempo no hubiera sido un factor limitante.

Los componentes de instrucción de los COPs que fueron más relevantes para que los estudiantes EL se motivaran en el estudio de las ciencias incluyeron: (a) el uso de las actividades de práctica, las cuales fueron diseñadas con el propósito de generar discusiones relevantes acerca de la cultura de los estudiantes y activar los conocimientos previos; (b) las imágenes visuales y videos usados en el COP, los cuales fueron seleccionados por su rica representación de la cultura hispana; (c) las actividades interactivas y los juegos, los cuales proveyeron un ambiente de aprendizaje multimodal con el cual los estudiantes se familiarizaron; y (d) el foro, el cual facilitó el intercambio cultural de aprendizaje entre los estudiantes de Estados Unidos y México.

Los maestros y los estudiantes consideraron que el COP que implementaron fue un recurso apropiado para el aprendizaje de las ciencias. Los estudiantes reportaron que a ellos les gustó el foro, las actividades interactivas y juegos, trabajar en equipos, y en general, el usar los COPs para el aprendizaje en línea. Los maestros reportaron que los contenidos fueron apropiados para las edades de los estudiantes, que cubrieron los contenidos curriculares que ellos necesitaban cubrir, y que lo hacían en una manera altamente interactiva y motivante para los estudiantes. Finalmente, los análisis estadísticos indicaron que hubieron incrementos estadísticamente significativos, medidos con pre-post-pruebas de contenido científico, después de que los estudiantes terminaron las lecciones. En promedio, los estudiantes obtuvieron un incremento de 21 % en puntos entre la pre-prueba y la post-prueba de contenidos científicos realizada, $t(52) = 11.07$, $p = .000$.

Science learning outcomes for ELs of Hispanic origin

According to the U.S. Census data for 2009, of the approximately 11,000,000 students aged 5–17 who spoke another language at home, almost 71 % were Spanish speakers. The Latino/Hispanic public school population nearly doubled between 1987 and 2007, increasing from 11 to 21 % of all U.S. students [National Center for Education Statistics (NCES), 2009]. In 2009–2010, 10 % of all students enrolled in U.S. public schools were English learners, compared to 8 % nearly a decade earlier (U.S. Department of Education 2010). The four states with the highest population of ELs, accounting for 14 % or more of the student-aged population in school, were California, Nevada, Arizona, and Texas. Oregon was among the group of 13 states whose EL student population was in the second highest percentage category, those percentages within the range of 7–13.99 %. Oregon's EL student population has increased by 48 % over the last decade. In 2011, approximately 65,000 students received English Language Learner services in Oregon (Oregon Department of Education 2011). Science scores from the National Assessment of Education Progress 2011 science assessment indicate that Hispanic students lagged behind all ethnic groups except for African American students on benchmark assessments at 4th grade, 8th grade, and 12th grade. While there have been improvements over the last 10 years, Hispanic students are still falling behind their peers among mainstream white students, the highest scoring racial/ethnic group.

Current mandates for increasing science, technology, engineering, and mathematics (STEM) competitiveness in the United States recognize the importance of increased access and successful participation for all students. The National Research Council (1996) emphasizes the persistent need to address student diversity in science classrooms, particularly as knowledge of science and technology continue to grow as an important measure of being an educated citizen in the twenty-first century. Because it takes 7–10 years to develop the cognitive academic language proficiency (CALP) to learn successfully in a second language (Cummins 1981), English Learners often do not have sufficient knowledge of "academic" English and science vocabulary to benefit from science instruction provided in English (Garcia 1988). To keep these students from falling behind their English-speaking peers in academic areas such as science, there is a need to integrate and develop English language and literacy skills into science instruction itself (Lee 2005).

Research has shown that it is important for science instruction to take into consideration prior linguistic and cultural knowledge in relation to science disciplines (Lee 2005). This integration is critical given the climate of standards-based instruction, high-stakes assessment, and accountability. However, appropriate high-quality materials that are also linguistically and culturally relevant and meet current science education standards are difficult to find (National Science Foundation 1996). Particularly, Robertta Barba (1993) reports from observations made in 57 randomly selected elementary Hispanic/Latino bilingual classrooms that students mostly receive science instruction using materials that are not relevant to their language and culture. Despite the efforts being made to develop science curriculum materials for ELs (Hampton and Rodriguez 2001), as well as relevant computer-based curriculum materials (Buxton 1999), more research is needed. Project COPELLS has been contributing to this effort with the design and analysis of COPs in science.

Research and theoretical foundations of COPs

The literature indicates that ELs' science learning is affected by a variety of factors, including cultural beliefs and practices, cognitive processes such as scientific inquiry and reasoning, and underlying linguistic processes. These factors are explored below. A model relevant to ELs for learning in multimedia environments is also presented and discussed.

Science learning and ELs

The shared, learned, transmitted, and adaptive culture of a 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 Steven Rakow and Andrea Bermudez (1993), culture even influences the way we perceive or 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 and Bermudez 1993). These stereotypic images influence how teachers view and approach their students, and the learning outcomes they expect. Mary Atwater's (1994) review of the literature indicates that while cultural partners can affect science learning in groups, the partners' expectations are often inconsistent with those of the school. Furthermore, Ohkee Lee and Sandra Fradd (1996a) found evidence to suggest that the communication and interaction patterns of nonmainstream students were inconsistent with those typically expected in a public or private school. We hypothesized that science learning embedded in culturally and linguistically relevant collaborative online projects (COPs) would assist ELs' communication and interaction with science content because curriculum design and delivery would take into account their cultural backgrounds.

Assumptions about school science instruction indicate that students have certain prior knowledge or beliefs with regard to scientific practices. For instance, while students are expected to ask questions, carry out investigations, find answers on their own, and formulate explanations in scientific terms, such practices may not be equally encouraged in all languages and cultures. Latin Americans for example, are taught to respect, obey and defer to elders and family values (Slattery 2004), which may discourage them from asking questions or conducting investigations in ways consistent with a Western scientific worldview (Lee 2005). In addition, studies that focused on linguistic influences on science learning of ELs in either bilingual or mainstream classrooms, indicate that their limited proficiency in English constrains their science achievement when instruction and assessment are undertaken in their second language (Torres and Zeidler 2002). These studies demonstrate the importance of providing language minority students with opportunities to acquire the language of science alongside native language tools (Lee 2005). The COPELLs Project hypothesized that having all instructional materials immediately available in both English and Spanish would help ELs access scientific content and also improve their science literacy in both languages.

Cognitive-affective theory of multimedia learning

Project COPELLS proposed to develop and evaluate materials that capitalize on the rich multimedia capacity of the Internet. In addition to designing collaborative projects accessed online, the content materials were embedded with multimedia supports and links between the two language versions to facilitate bi-literacy development related to science content. Roxana Moreno and Richard Mayer (2000) propose a cognitive-affective theory of multimedia learning (CATML) that borrows principles from the Dual-Coding Theory, Cognitive Load Theory, and Constructivist Learning Theory, all of which are relevant to the proposed project. CATML is based on the assumption that:

> (a) Working memory includes independent auditory and visual working memories (Baddeley 1986); (b) each working memory store has a limited capacity, consistent with John Sweller and Chandler's (1994) cognitive load theory; (c) humans have separate systems for representing verbal and nonverbal information, consistent with Allan Paivio's (1986) dual-code theory; (d) meaningful learning occurs when a learner selects relevant information in each store, organizes the information in each store into a coherent representation, and makes connections between corresponding representations in each store (Mayer 1997). Figure 1 depicts a cognitive theory of multimedia learning with these assumptions (p. 1).

This theory is particularly relevant to the COPELLS project because it states that active learning occurs when a learner engages in three cognitive processes: (a) selecting relevant words for verbal processing and selecting relevant images for visual processing, (b) organizing words into a coherent verbal model and organizing images into a coherent visual model, and (c) integrating corresponding components of the verbal and visual models. During the content material design phase of the project, techniques for presentation of verbal and visual information that minimizes working memory load and promotes meaningful learning were used.

Additional components of CATML include the instructional design principles for interactive multimodal learning environments. Multimodal environments are those that use two different modes to present content knowledge such as verbal and nonverbal (i.e., text and images). These modes of presentation, in combination, have been demonstrated to enhance student understanding of text (Mayer 2001). Interactive multimodal environments are those in which what happens (actions and learning) depends on the actions of the learner. However, the learners' actions need to foster learning, and the environments must create a related predisposition to learning (e.g., teachers' supervision, adequate structure of resources). Moreno and Mayer (2007) describe five types of interactivities in multimodal learning environments: (a) dialoguing: learners are allowed to ask questions and receive answers or feedback; (b) controlling: learners determine the pace and/or order of presentations; (c) manipulating: learners set parameters for simulation, zooming in and out, moving objects around the screen; (d) searching: learners engage in information seeking, selecting options, finding new materials; and (e) navigating: learners move to different content areas by selecting from various available information sources.

The above design principles for interactive multimodal learning environments were critical to the design of the interactive features of the COPs. On the project's website (http://copells.uoregon.edu) students have the opportunity to dialogue with other students in other schools, cities, and countries by using the forum, which is an integral part of the COPs. Although instruction is guided by teachers, students determine their pace of learning while interacting with the website and completing all the interactive activities on their own or in groups. Finally, students search and navigate within the parameters of the website to obtain information required to perform the COPs activities and objectives. Together, cultural beliefs, cognitive-linguistic processes, and multimodal environments make COPs suitable tools to enhance Spanish-speaking ELs' learning of scientific knowledge and acquisition of scientific literacy.

Website features

Project COPELLS constructed a bilingual website that capitalizes on the rich and diverse culture of Hispanic/Latino students by incorporating vivid colors, patterns, and illustrative images—some of which were largely created in Mexico by artists at ILCE—that welcomes students to a friendly and interactive age-appropriate learning environment. This website serves as the space in which visitors all over the globe can access general information about the project and as the space in which the project publishes all its current and future COPs for the free use of the public. Every single page in the website is available in both English and Spanish accessed by clicking on a toggle icon, the content contains culturally relevant examples for student learning, including images that reflect students' culture, teacher-guided discussions that help students connect with their own heritage, and specific scientific terms that are enhanced with English and Spanish definitions appearing in pop-up

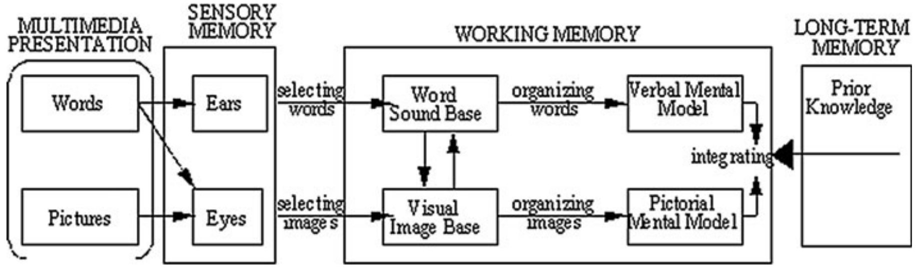


Fig. 1 Depiction of a cognitive theory of multimedia learning (Moreno and Mayer 2000)

windows when students hover their computer mice over them. Each COP unit has its own space with instructional materials for teachers found by clicking the teacher's link and content learning activities for students found by clicking the student's link.

Teacher link

The teacher area of the website consists of three sections:

(a) Strategy, where an overall "big picture" of the unit is provided. This includes 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 that teachers can use with their ELs for connecting to background knowledge, learning vocabulary, doing pre-reading activities and developing comprehension. This section was designed specifically for science teachers who do not have ELs training and needed to learn of ways to support their students when interacting with the COPs.
(b) Lesson briefs, composed of a table of information, divided into rows by stage. Each row includes a suggested timeline for the completion of the stage, a printable lesson guide, a printable version of the student assessment, and a link to a teacher reflection log. Lesson guides are provided for each stage of the project and contain the lesson's objectives, suggestions for how to introduce the varied activities, specific notes for teachers regarding things they need to have prepared before introducing the lesson, and concepts and vocabulary that are necessarily emphasized in a particular lesson.
(c) Tutorials, designed to be used during teacher participant training, prior to implementation in the classroom. This section mimics the structure of activities in the student area of the website. The rationale behind the tutorials section and its format is, then, to expose teachers to the flow of the unit as students will experience it. Teachers in Mexico and the U.S. who are unable to attend in-person trainings provided by project staff can use the tutorials independently. Tutorials cover all the important aspects of the project that teachers need to be aware of for its successful implementation. Video tutorials were included to model specific skills such as use of forums, students' registration process, and website navigation.

Student link

The student area of the website consists of five sections:

(a) Stages, where students access all the content (divided into 5–7 stages of learning). It is the key place where instruction and learning occur;
(b) Calendar, composed of a table of information divided into rows by stage so students can follow the timeline of activities;
(c) Forum, where students conduct guided activities that promote discussion and collaborative learning;
(d) Assessments, where summative and formative assessments are accessed by students; and
(e) Glossary, where students can access all the vocabulary words that are enhanced with definitions throughout the content.

COPs instructional components

Each COP unit contains five to seven stages that contain all the content to be learned by students in an interactive and multimodal environment. A stage of learning is like a chapter in a book, which represents a snapshot of the overall theme to be addressed. Stages are organized by lessons, and the lessons are divided into strategically named activities. These present the content to be learned in different modes in order to: (a) activate students' background knowledge with the use of *Warm-up* activities; (b) teach the content to students, using activities such as reading content combined with comprehension questions or summaries, teacher-guided discussion, and video tutorials; (c) allow students to practice, hypothesize, or experiment to learn and further develop scientific thinking skills, with the use of lab experiments, instructional games, virtual simulations; and (d) provide timely feedback to students and teachers on their acquisition of the content with the use of interactives and stage formative assessments.

One example of a science COP developed by the COPELLS project and used in this study is the What Your Body Needs unit. In this unit students are invited to become familiar with, value, and better understand their bodies so they can learn to nurture and protect their bodies while building healthy lifestyle choices. This COP 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. This unit was designed to be completed in 10 weeks. An example of a lesson is presented in the Appendix to illustrate its instructional organization.

In order to perform the specific COP lesson's activities, students generally work in groups of 2–4 students, sharing a computer when resources are limited, conducting experiments, running simulations, watching videos, reading and discussing information, and producing artifacts. The major role of the teacher is to facilitate/organize groups, incorporate discussions into their lectures based on the stage objectives, and evaluate students' learning. Teachers also plan their science time so that students can interact with the website, write in their science notebooks and post to the forum.

Features of a COP implementation study

Using a two-group pretest–posttest, pre-experimental design we investigated the following research questions: (1) Do the COPs facilitate science content learning for ELs? (2) Which COPs' components are effectively relevant for ELs' engagement with science learning? and (3) Do teachers and students see the COPs as good resources for learning science? The independent variable in this design was the COP unit, which consisted of 10 weeks of online science instruction guided by teachers with students working in collaborative teams. Measures of the dependent variables included pre-post science content assessments, fidelity of implementation checklists, teacher satisfaction surveys, and student satisfaction surveys.

Participants

Participating teachers were recruited from a rural district in Oregon that serves almost 6,000 students, 22 % of whom are identified as English Learners. One 6th-grade teacher and one 7th-grade teacher implemented the COP unit with a sample of 53 students, 81 %

of whom were English Learners of Hispanic/Latino origin. The 6th-grade teacher, from now on referred with the pseudonym of Mr. Torres, implemented the COP unit in one group of 29 students, but only 23 complete data sets were obtained, and the 7th-grade teacher, from now on referred with the pseudonym of Ms. Jimenez, implemented the unit in two groups of 30 students each, but 30 complete data sets were obtained. Descriptions of each group setting follow.

Mr. Torres teaches a self-contained 6th-grade classroom as part of the two-way immersion program (TWI). The two-way immersion (TWI) program at this district is offered at four schools, three K–4th schools and one 5–6th school, and has been around for 15 years with the objective to have fully bilingual students in English and Spanish upon entering 7th grade. Students in the program are mostly native Spanish speakers, but there are also native English speakers and students from bilingual households in the program. To participate in TWI, students enroll in kindergarten and continue through each grade level in a designated TWI classroom. The manner in which students receive half of their instruction in English and half in Spanish varies by school. The model that Mr. Torres's class follows has him planning and balancing each subject area so that there would be equal instruction in English and Spanish throughout the year. One of the reasons Mr. Torres was drawn to participate in the COPELLS project was that the curriculum was available in English and Spanish and he could therefore comfortably maintain accustomed flexibility in when and how he taught in either language. Mr. Torres has an ESOL 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 never use technology in his classroom for blogs, forums or webquests, but that they sometimes use technology for Internet research purposes and completing projects in teams.

Ms. Jiménez is a science teacher in the district's 7–8th 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 through the use and practice of "respect talk." Students are placed in discovery classes based on test scores and teacher and administrator recommendations. Ms. Jiménez has a Master's degree and is in her fourth year of teaching. In her pre-survey responses, she indicated that she often uses technology projects that require teamwork and sometimes uses technology in the classroom for students to conduct Internet-based research. Similar to Mr. Torres' class, she had never used blogs, forums or webquests in her teaching and, as a result, felt some initial discomfort integrating those specific components into her classroom program.

Teacher training

Prior to the implementation, teachers participated in a one-day training. During the training, teachers were provided with technology to assist then and their students with the implementation of the project. Ms. Jiménez received one MacBook Pro and one iPad for personal use and one class set of 22 iPads and eight MacBooks for students. Mr. Torres received one PC laptop for personal use and 15 PC laptops for students. They were given overall instructions about how to use the equipment and how to solve common problems. Each teacher required a varied level of support in handling the new equipment and learning its features.

During training, teachers received an orientation to two websites: the project website and the What Your Body Needs website. The teachers were also provided with a detailed description of the research project's aims and objectives, funding sources, partnerships, and a brief history of previous implementations. Later, teachers were given step-by-step instructions about how to prepare and what to expect in each stage of instruction, including directions for where to access the lesson briefs, a description of each stage's objectives, how to view the student content, and when and how to incorporate the forum. Project staff also reviewed the expectations and role of the teachers. Teachers were given a handout called "COPELLS Project Information" that included specific teacher expectations along with other reference information such as project staff contact information.

In order to help teachers become familiar with the features of the What Your Body Need*s* website, teachers worked through a self-guided tutorial developed specifically to immerse teachers in a sample lesson. Every 20–30 minutes, project staff asked teachers to pause their activities and checked in with their progress. This generated opportunities for questions and discussions about the activities assigned. The self-guided tutorial was fashioned so that it would mimic how students progress through lessons. It included the same intra-lesson titles, such as "Check It Out" and "Read and Discover," as in the student content. During this time, project staff served as facilitators, modeling the role the teacher participants would assume in their classroom during the implementation period.

To conclude the training, project staff addressed technical and logistical issues. Project staff together with teachers carefully reviewed the contents of the student and parent consent letters, equipment agreement form, and teacher participation agreement form. This time was also used to arrange equipment delivery dates, pre-testing and week 0 activity implementation dates with each teacher.

COP implementation

The COP was implemented by the two participating teachers in the U.S. and by over 50 teachers in Mexico. Teachers in Mexico were not considered part of the study; however, they were active forum users and this type of involvement had a positive effect on U.S. teachers and students. As the project began, project staff trained students on how to properly use MacBook, iPad, or PC laptops in this project, including general operation, how to navigate the browser, and how to use the downloaded applications. Students were also provided with an orientation to the forum usage in a separate session. This training began with demonstrating and practicing the process of signing onto the forum, then transitioned to posting pictures and text, and ended with students replying to others' forum posts. The implementation took a total of 10 weeks in which students completed all seven stages of the COP, participated in forums, and completed assessments.

COPELLS staff was present throughout the implementation of the COP, 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 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 COP.

Data collection instruments

Fidelity of implementation measures

A completion checklist and a classroom observation instrument were designed to collect data on fidelity of treatment implementation. The completion checklist listed all the stages and lessons to be completed during the COP implementation. Teachers filled out logs 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. Those logs were used to fill out the completion checklist. The classroom observation protocol tracked data on both teacher and student behavior. Teacher behaviors observed were: (a) how they used the COP's website to deliver instruction, (b) what lesson teachers worked on (including whether or not they completed all the activities in that lesson), (c) facilitation of team work, (d) how teachers activated student background knowledge, (e) their use of vocabulary-enhanced definitions on the website, and (f) use of Spanish website. Student behaviors observed included: (a) whether or not they accessed the English or Spanish website, (b) teamwork dynamics, (c) usage of vocabulary-enhanced definitions, and (d) engagement in learning activities via the website.

Teacher interviews and student surveys

In order to identify components of the COPs that were most relevant for ELs' engagement with science learning and to determine if teachers and students saw them 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 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 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 COPs facilitated science content learning for ELs, we collected pre-post data of science content assessments developed by project staff. This assessment consisted of 31 items related to the content covered in the COP unit, presented in various forms, including multiple choice questions, fill in the blanks, open 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. As a general rule, an alpha coefficient of .7 or higher is considered acceptable.

What we learned

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 pre- to posttest assessments 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 those categorical responses. Finally, qualitative analyses also involved descriptive information drawn from a completion checklist and classroom observations to demonstrate that teachers and students use the technological resources effectively and completed the COPs activities with fidelity.

Fidelity of implementation

On average, teachers implemented 71 % of the lesson activities provided in the What Your Body Needs unit. In their teacher reflections, they reported that the most common reason for lack of completion was related to being "crunched for time." Teachers felt the need to skip some activities in order to follow the COP's timeline. Also, some of the activities within a lesson were optional, and it was up to the teachers' judgment whether to complete them. From a total of nine random observations conducted with both teachers, it was found that teachers used the COP's website while delivering instruction in eight out of the nine observations. Teachers encouraged 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. Students relied on the English website only, worked effectively in teams, and frequently used the vocabulary-enhanced definitions available in the website.

COP's critical components for ELs' engagement with science learning.

The components that teachers identified as making the COP uniquely relevant for ELs' science learning included:

(a) Warm-up activities, which were deemed critical for generating discussions to activate background knowledge.
(b) Strong visuals including images and videos, which teachers thought were a great support for student learning. Specifically, teachers reported that "they made students interested like you wouldn't believe," and "students had more desire to learn and complete the activities."
(c) Interactives and games, which 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."
(d) Forums were also considered an important component for students to be engaged with learning activities. "Students loved talking to other kids." "Students were intrigued when somebody said something to them." "Students had a space for sharing their knowledge."
(e) Assessments also were considered an important part of the unit. Teachers reported that "students took them very seriously" and they were always looking forward to seeing their progress with the program.
(f) Vocabulary and enhanced definition features were often accessed by students, and teachers used them as an opportunity to teach new concepts.
(g) Teamwork was an implicit component. While teamwork was always used and encouraged by the teachers, it was not reported as being critical for the COPs. The teachers believed that working in teams is always helpful; however, some activities could have been carried out independently as well.
(h) Unexpected to us, the Spanish website was not taken advantage by students. Even though Mr. Torres was teaching in a Two-Way Spanish Immersion class, and sometimes his instruction was provided in Spanish, students opted for using the English website when completing interactive activities independently. Mrs. Jimenez was a native English speaker with limited Spanish proficiency so this was not really an option for her. Students in her science classes were at the highest levels of English Language development or were monitored students, so it's perhaps understandable

> that they did not employ the Spanish resource as much as we expected. However, the forum was a space for U.S. students to exchange communications with students in Mexico, and interestingly, most of those communications were done in Spanish by the students in Mr. Torres class.

Teachers also 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 units and meet the timelines.

Students reported liking the forum, the interactive games, working in groups, and using the COP 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 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 cell model," "I liked that there were a lot of fun activities and because I understood it more."

Effect of COPs in ELs' science content learning

Figure 2 shows the gains that students made in science content assessments before and after they participated in the COP 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 Mrs. Jimenez' class also had a statistically significant gain of 19 % more 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 COP 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 COPs. However, students did not experience any negative effects nor did their science content learning decrease after being part of the implementation.

Future research agenda

Collaborative online projects (COPs) for English Language Learners in Science (COPELLS) 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 (ILCE) in Mexico and biological sciences curriculum study (BSCS) in the United States. Project COPELLS received funding from the National Science Foundation to design, translate, enhance, and evaluate culturally relevant and linguistically appropriate COPs in science for secondary level Spanish-speaking English Learners (ELs). The project's two major goals are to (a) design interactive multimodal media-rich online learning environments that address both the cultural and linguistic needs of ELs to learn science, and (b) facilitate and improve science content-area learning for ELs.

The COPs were designed to provide media-rich, culturally and linguistically relevant, and collaborative science instruction. Students had the option to see every page in English or Spanish with the click of an icon. Although the projects were designed for EL students in the USA, more than fifty classrooms in Mexican schools used the COPs at the same time as the US classrooms so science learners in both countries could share their learning using the project's forum.

Results of our pre-experiment conducted with a sample of 53 students, indicate that the two participating teachers implemented 71 % of the lesson activities. Lack of time in the context of other teacher-classroom requirements was the most common reason for lack of completion of a COP. Both teachers and students enjoyed the strong visual nature of the COP as well as the interactivity provided by online games and simulations. Forums were an important factor for student engagement and motivation. With them, Oregon ELs were able to have cross-cultural learning exchanges with Mexican students.

Many words on every page revealed enhanced definitions when students clicked on the word. Students often used these enhancements, and teachers used them for immediate just-in-time learning. Although students and teachers by-in-large did not often access Spanish versions of webpages, students often used Spanish to communicate in the forum.

Student science content gains between pretest and posttest (24 and 19 % increases in scores for each participating teacher) were statistically significant, which strongly suggests that it would be worthwhile to conduct further investigations for the implementation of COPs. This study was conducted with the main purpose of learning about the feasibility and usability that a COP would have for being implemented by teachers and whether users considered it a potentially useful resource in which to provide enhanced science instruction to ELs. This study was also conducted to gather data to identify the most appropriate components for student learning when using COPs. A quasi-experiment is being conducted at the time of publication of this article. Plans are in place for conducting true-experiments with a randomized control trial design.

In summary, this study has provided the researchers with: (a) a model for how partnerships with educators in Mexico can benefit science learning for ELs in U.S. schools, (b) a model for how online science curriculum in the form of COPs can take advantage of rich multimodal learning environments for the benefit of ELs' science learning in U.S. schools, (c) a model for how electronically enhanced vocabulary embedded within online science materials can improve science learning for ELs, and (d) a model for how person-to-person learning opportunities, within classroom collaboration as well as online

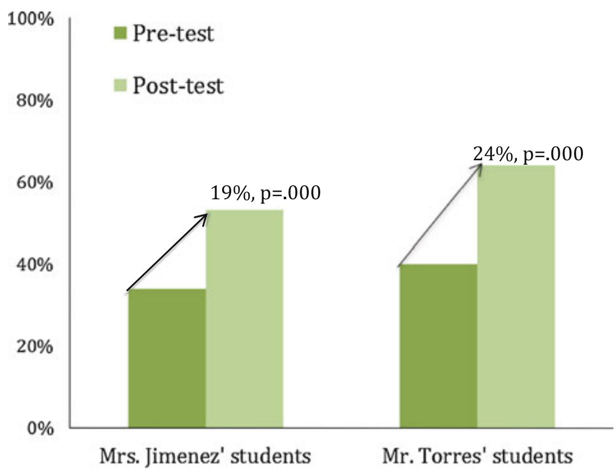
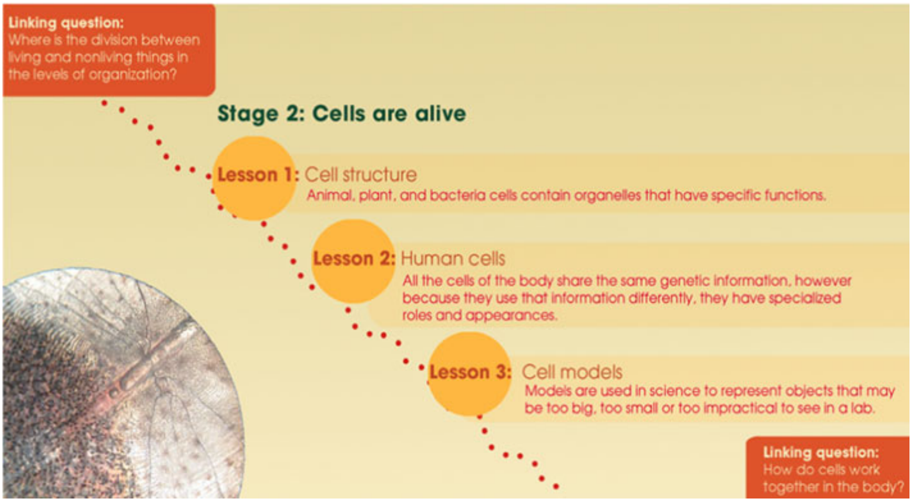


Fig. 2 Pre-post science content assessment gains for COPs participants

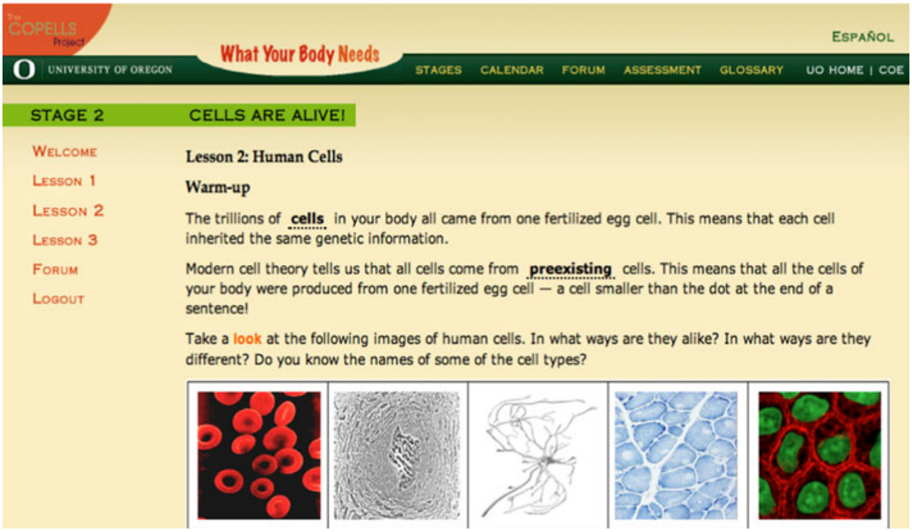
and across-borders collaboration, can improve motivation and science learning for ELs in U.S. schools.

Appendix

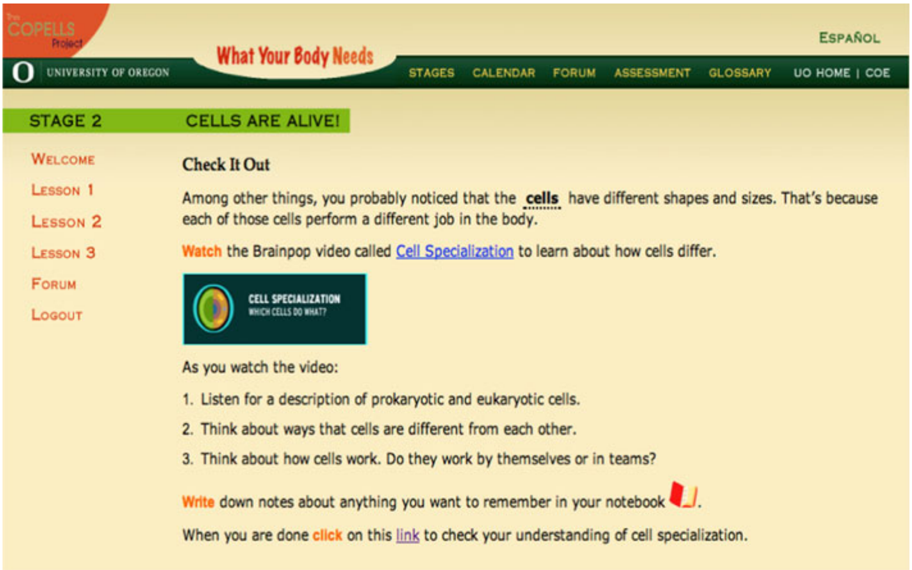
What Your Body Needs, Stage 2, Lesson 2—Outline



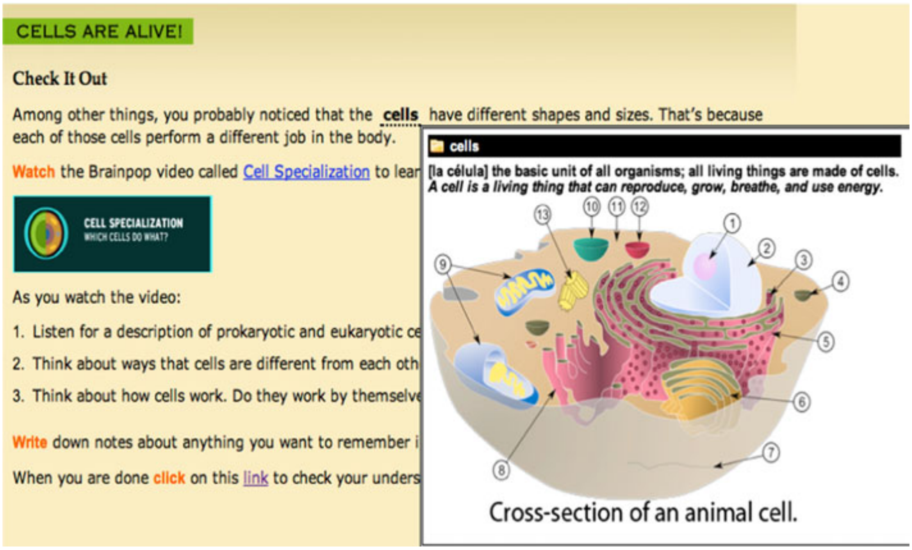
What Your Body Needs, Stage 2, Lesson 2—Warm-up



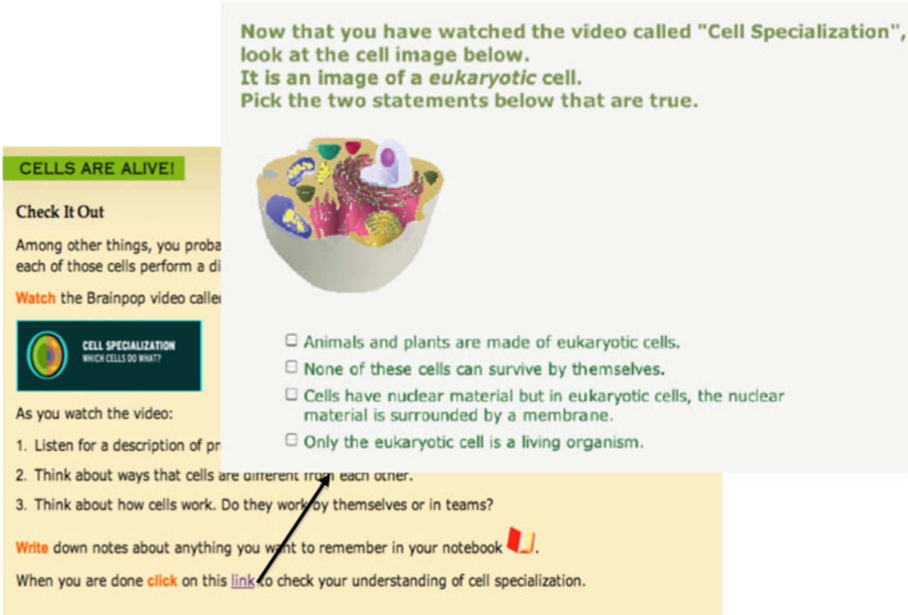
What Your Body Needs, Stage 2, Lesson 2—Learning the content



What Your Body Needs, Stage 2, Lesson 2—Enhanced vocabulary

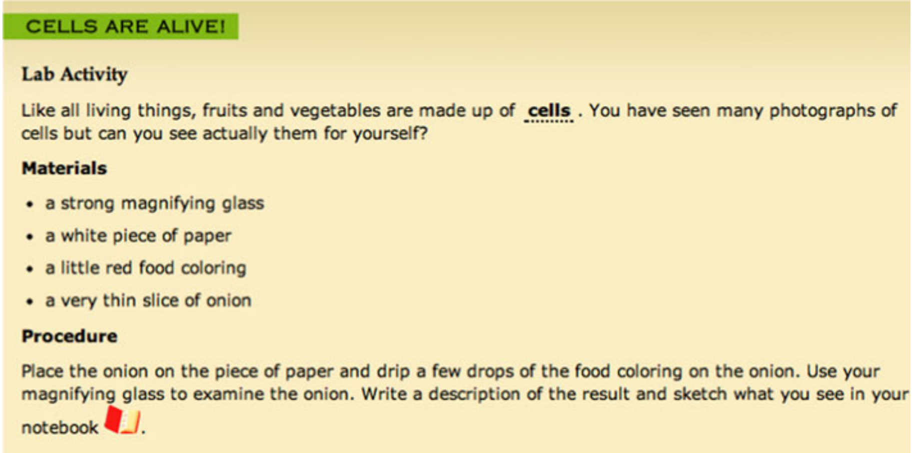


What Your Body Needs, Stage 2, Lesson 2—Interactive



What Your Body Needs, Stage 2, Lesson 2—Interactive Microscope

What Your Body Needs, Stage 2, Lesson 2—Lab Activity


CELLS ARE ALIVE!

Lab Activity

Like all living things, fruits and vegetables are made up of **cells**. You have seen many photographs of cells but can you see actually them for yourself?

Materials

- a strong magnifying glass
- a white piece of paper
- a little red food coloring
- a very thin slice of onion

Procedure

Place the onion on the piece of paper and drip a few drops of the food coloring on the onion. Use your magnifying glass to examine the onion. Write a description of the result and sketch what you see in your notebook.

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