Teaching Science

BONUS WEB CONTENT to accompany
The ESL/ELL Teacher's Survival Guide, Second Edition
by Larry Ferlazzo and Katie Hull Sypnieski © 2022 John Wiley & Sons

> *NOTE: This chapter appeared in the first edition of The ELL/ESL Teacher's Survival Guide. Although we replaced it with an updated chapter written by another science teacher, we still believe that this is an excellent chapter that readers would find useful.*

A father took his son out in the forest one day to teach him the sights and sounds of nature. When the father spotted an interesting sight—a squirrel, a bird's nest, or a beautiful flower—he would not point it out to his son. Instead, he would nonchalantly position his son where he could see the sights himself. The son could then point out the discoveries to his father.

This type of guided discovery is the kind of instructional strategy emphasized in this book, and in this chapter written by our colleague Lorie Hammond.

ONE SIZE DOES NOT FIT ALL

In a time of "scripted," "standardized," and even "teacher-proof" curricula, the ability of teachers to adapt theirs to the populations they serve has become severely limited in many situations. While there is always a question of how well standardized curricula serve students' needs, the gap between the needs of English language learners and one-size-fits-all texts and activities is often too large for students to bridge. The norm when adapting science curricula for ELL students is to start with a standard science textbook and then to make it accessible through a variety of techniques that simplify the curriculum. The ideas we recommend in this section can be used in that situation, but ideally we prefer a very different approach that does not center on a set curricula but rather on the needs and strengths of the students involved.

This chapter was written by Lorie Hammond, professor of teacher education at CSU Sacramento and the co-founder and academic director of Peregrine School, a project-based bilingual school for preschool through eighth grade in Davis, California (see PeregrineSchool.org).

The hands-on teaching and learning related to science also offers superior opportunities for language learning in the science classroom and in ESL classes. We have often used science experiments in our English classes to generate vocabulary, speaking, listening, and writing activities, as well as to help prepare students for their mainstream science classes. The science approach discussed here follows the five steps of the Organizing Cycle and is written by our talented colleague, Lorie Hammond.

BUILDING RELATIONSHIPS WITH STUDENTS AND ACCESSING PRIOR KNOWLEDGE

Secondary-level English language learners bring with them two sets of experiences that can make science education relevant to their lives: the way of life they experienced in their home countries, which is often minimally related to schooling; and the adjustment they are currently making to life in the United States. Both of these experiences are founded not only in their linguistic and cultural lives, but also in science, if science is interpreted as the relationship between people and their physical and natural environment. A strong relationship can be built between teachers and students through science as a medium, although this is not generally done.

Immigrant students bring a wealth of knowledge about many things from their home countries, from agriculture to house building to cooking to medicinal herbs. Often this “fund of knowledge” is discredited or simply considered irrelevant in the context of schooling (Moll et al., 1994). This is particularly true when students’ knowledge does not come from books but rather from life experience. Students’ funds of knowledge link them to their own culture and to the knowledge their families possess. Relating to those funds can help students connect their previous life to their present life, respect their families’ traditional knowledge, and feel connected to science, a subject that might have had little or no meaning to them before (Paloma-McCabe, 1994).

How can a teacher find out what students already know and what funds of knowledge their prior life experiences contain? One useful tool is *ethnoscience*, an approach used in anthropology in which the relationship of people to a body of knowledge is studied through oral histories. This approach takes students deeper into their prior experience, interviewing family members and community experts about the knowledge their group holds in relation to a particular subject of study. For example, *ethnobotany* is the study of how a group of people relates to plants. It includes all the traditional things one studies about plants, such as how to grow them and their life cycles, as well as more cultural aspects of plants, such as what they mean to people and how they are prepared, stored, and consumed in daily life.

Secondary students are capable of gathering this kind of ethnoscientific information themselves from their own communities and chronicling it. This approach accomplishes two things: (1) the students involved learn to relate to science as active researchers who produce knowledge and (2) their teachers learn about the students and can then find ways to link standards-based school science concepts to what students already know. Perhaps most important, ethnoscience creates a respectful exchange between funds of knowledge in students' cultural communities and new knowledge embodied in Western science. After traditional knowledge has been explored, a thoughtful teacher can build curriculum experiences that point out connections and discrepancies between traditional and "scientific" ways of exploring the natural world, and in the process can create meaningful dialogue (Barcenal et al., 2002).

This approach can be used with all students in a variety of activities. These include having a student or community garden using different growing techniques; asking students to use popsicle sticks and other materials to construct model homes from their cultures, placing them outside in the sun with a thermometer for a few hours and then determining which kind of construction is most energy-efficient and why; and having students do a similar experiment with different kinds of boats.

In addition to building on their traditional knowledge, immigrant students face the challenge of understanding science in their new country. Many newcomer ELLs at the secondary level have not experienced standard elementary science curricula and therefore may not know about health, nutrition, hygiene, household chemicals, and other practical matters essential to successful American life. They may also lack the background knowledge that will allow them to be informed citizens for environmental decisions and to assess information about weather, space, transportation systems, and other aspects of modern life. They also might not be familiar with measurement systems used in the United States, such as Fahrenheit thermometers and scales.

Getting to know one's students involves not only knowing their cultural backgrounds but also talking to them about what they need to know to live their lives with more confidence. Teachers need to establish trust before students will talk to them about their concerns, especially in areas like health. Teachers can help students immeasurably through science classes that provide the basic knowledge students need to cook, predict the weather, and learn about their own bodies. Such basic science information can then be used as a springboard for studying the more abstract and complex science concepts generally taught in high school science classes. It is harder for students to approach it the other way: to apply abstract knowledge to their own lives. Often science can seem remote to ELL and other students, but they may engage in it more readily if science is related to their lives and their daily needs.

IDENTIFYING AND MENTORING STUDENTS' LEADERSHIP POTENTIAL

Science can be a disempowering or an empowering experience for ELL students. If students are placed in a regular science class without special assistance, they can flounder and feel disempowered. Similarly, if they are not acclimated to Western scientific approaches, they can feel culturally alienated by science, as described in the previous section.

To promote an engaging and empowering experience in the science classroom, a teacher will need to apply the many instructional methods already discussed in this book, including the use of visual images, three-dimensional models, kinesthetic interpretations, videos and other nonlinguistic communication approaches, as well as ways of simplifying language (but not concepts) through word banks, speaking slowly, and conscious choices of vocabulary.

It is critical for students to acquire academic language in order to be successful in secondary and post-secondary schools. Elements required include vocabulary development and mastering the ability to use academic language in speaking and writing. Vocabulary development can include both science vocabulary in particular (such as "volume") and common vocabulary (such as "cloud") that English learners may not know. In addition, it can include two other types of vocabulary usually ignored. One is conceptual vocabulary, such as "density," which can be best understood through inquiry activities. A second type is process vocabulary, such as "predict" and "infer," which applies to various topics in science and other academic subjects. This vocabulary is perhaps most important of all, because it allows students to participate in academic discourse.

Teachers can further help students develop a sense of self-efficacy (or self-confidence), a key quality of leadership, in the following ways:

1. Create study groups of students who speak the same language, so that they can share science concepts with each other in their primary language and then record their work in English.

2. Create a word wall that shows the key concepts in the science unit being studied. It should always be displayed in the classroom and have either clear definitions or pictures to illustrate the words that are listed, or both.
3. Create a chart on the wall listing key words translated into the other languages spoken in the classroom that students can use as a reference.
4. Make handouts that have similar patterns, such as lab sheets that are always the same, so that ELL students catch on to the process of science and can repeat it while studying various topics.
5. Post photos and other visuals illustrating key concepts being studied in science.

When the language and concepts of science are made more accessible to students, they will feel that they are not limited by their still-developing English proficiency. They may then feel more confident about engaging in the class, becoming more intrinsically motivated and more willing to take risks.

Another essential way students can be empowered by science is through a constructivist learning experience, which we will describe as "learning by doing" (Schleppegrell and Colombi, 2002).

LEARNING BY DOING

Constructing knowledge is the central activity in inquiry science instruction, since science educators generally agree that students need to construct their own knowledge through experience and experimentation, rather than learning things directly from teachers or books (Osborne and Freyberg, 1985). The premise of "constructivist" approaches to teaching—which apply to all students—is that science is a culture that must be learned, involving a complex combination of skills, assumptions, and procedures that can only be learned by "acting like a scientist." In short, learning science standards as "facts" to be memorized is like reading only the last page of a mystery novel. The process of science *is* science. Conclusions reached through experimentation are reduced to meaningless factoids unless they are experienced by the learner, who can only understand them through experience.

The constructivist nature of real science instruction is one of the things that can make science a perfect subject for engaging English language learners and other students who might have other challenges with school engagement. However, hands-on activities do not in themselves produce motivation in all students. Many students become motivated only if they know "what science is for" and "who it serves" (Barton and Osborne, 2001). It is the *connection* of science to daily life, and to issues facing a community, that makes it meaningful to all students, including ELL students.

Science experience can typically be gained in two ways:

1. Science experience can be gained through *guided discovery,* which has similarities to the inductive approach discussed often in this book. The best kind of guided discovery is exemplified by the story that began this chapter of the father positioning his son to be the primary discoverer of new things.
2. Science experience can be gained through *inquiry,* when students participate in an experimental process using the scientific method. Science experiments provide a great way to empower students, especially if students work in groups to solve a problem together. Students can be encouraged to collaborate, to assume roles as members of a team, and to make decisions about various aspects of their experiment, from the research question to the results. All of these roles help students to develop the executive function, which is the mental process we all use to apply what we have learned in the past to our actions in the present and in the future. Strengthening this ability in our students can lead them to be more capable learners in their future lives.

REFLECTION

Science is not only a process of doing, but also of dialogue. Too often learning by doing emphasizes activities that motivate students, especially English language learners, but do not necessarily communicate the concepts students need to learn. The key to making a science lesson not only engaging, but also academically successful, is that discussion follow experience, so that students have a chance to integrate the experiences they have had with key concepts in science.

How can English learners describe their science experiences? Many ELL students cannot write freely about these experiences in English. A structured prompt is essential. Lab sheets that require students to respond to each part of their experiment in drawings and writing, and then require a reflective response at the end are very useful. If the same lab sheet is used repeatedly, students' progress in writing in English can be monitored along with their understanding of science concepts (Merino & Hammond, 2002).

Various tools can be used to measure student success in science. If students are very new to English, they can be asked to make diagrams or drawings with labels, or cartoon-type drawings with story lines, to describe what happened in an experiment or to illustrate something that has been observed. Students can also be placed in small groups or in pairs with others who speak the same primary language to discuss their work, since they can do so fluently in their own language, and then translate their conclusions as a group into English. An inventive teacher will need to figure out alternative ways to elicit students' ideas even if their English is limited.

It is important that students who have worked hard on understanding science be successful at expressing what they have learned, even if they do not yet have enough English proficiency to express it through standard tests or essays.

AN IMPORTANT FINAL NOTE

The teaching strategies that make up the Organizing Cycle help all students, not only ELL students, to succeed. Instead of teaching in a deductive style, involving lectures, textbooks, and worksheets and then working overtime to accommodate ELL students, it is more effective to create an inductive hands-on, minds-on teaching style for all students. All students will be more successful, since constructivism is how people learn best, and science will be accessible for ELL students as well. Tying science to students' lives, incorporating their background experiences, and engaging students as active learners will improve the science program for *all* students, while simultaneously creating a program in which ELL students can shine.

Additional resources, including links to interactive online science exercises, can be found on our book's web site at www.josseybass.com/go/eslsurvival guide.

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