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You're Teaching, but How Do You Know They're Learning?

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Although most instructors would like to believe that their students fully understand every biological concept explained in class, this is often not the case. Gary Wisehart, chair and professor of biology at San Diego City College, knows this from firsthand experience. "Students get very good at telling you what you want to hear," he says, "so it is important to assess the real impact you are having on students' understanding." To do that, Wisehart has been using concept inventories, diagnostic tools designed specifically to uncover lingering misconceptions.

Wisehart first learned of concept inventories in the late 1990s when colleagues at City College and San Diego State University were field-testing the concept inventory in natural selection (CINS). He used the CINS with students in his biology course for nonmajors and learned a great deal in the process. "It really makes you aware of how students have embedded perceptions that are difficult to change," he says, "and this is probably most significant regarding their understanding of natural selection and descent with modification." Once he got over the shock of how strongly his students held to their preconceptions, he sought ways to challenge the alternative conceptions revealed by his students' CINS responses.

Concept inventories can be used at the beginning of a unit or course to gain insight into what students understand before instruction, or afterward to determine whether students have made conceptual gains (or at both times). Each question has multiple-choice options for the students to select, but the incorrect choices are not simply distracters. "There is one scientifically accurate answer, and the other answers were developed from extensive research on known student alternative conceptions," says CINS coauthor Dianne Anderson, a biology professor at Point Loma Nazarene University. Originally published in the *Journal of Research in Science Teaching* in 2002, the CINS has undergone modifications and is now available online (*www.pointloma.edu/Biology/Biology_Graduate_Program.htm*).

The first step to correcting students' alternative conceptions is to recognize that current teaching methods are not working. The next steps, however, can be daunting. "The CINS is very easy to administer in the classroom," Anderson explains. "The challenge is how to adjust your teaching based upon the results." Anderson has used the CINS in different formats and ways with her students, and over time she has significantly restructured her general biology class for nonmajors. Though her syllabus reflects the traditional topics, she discusses examples of natural selection throughout the course to reinforce the concept. "The key to changing students' preconceptions, or alternative conceptions," Anderson says, "is to provide different examples and give them a chance to practice using the concept in novel situations."

April Maskiewicz, an assistant professor of biology at Point Loma Nazarene University, knows how easy it is to be overly optimistic about student learning. Surprised to learn how little her students understood after their exposure to traditional teaching methods in the 1990s, she became a biology education researcher. "Students have very robust conceptions about topics such as natural selection, but their conceptions are not scientific ones," she says. The CINS, she adds, is one of many tools that instructors can use to identify those naive conceptions and modify instruction.

Maskiewicz suggests that instructors provide multiple opportunities for students to engage in discussions in which they share their conceptions and seek coherence with data and evidence. Instead of assuming that students who hold on to their alternative conceptions are simply not "biology majors material," instructors can transform the way they are teaching by finding resources that have been developed specifically to challenge students' intuitive ways of thinking. "No one would do bench research without exploring what other research has been done," says Maskiewicz, but instructors do that all of the time with their teaching methods.

Using a concept inventory and then adapting teaching approaches requires a significant commitment of time, Anderson cautions, but layering more sophisticated ideas on top of naive conceptions is simply not productive. As additional concept inventories and sets of diagnostic questions are developed for other areas of biology (*http:bioliteracy.net/CABS.html*) and in related disciplines (*https://engineering.purdue.edu/SCI/links.htm*), instructors will be better equipped to determine how best to use their time. Focusing on key biological concepts and assessing whether students retain naive conceptions, instructors may have less time to cover detailed content. Yet knowing that students thoroughly understand what they have learned in class, and that they are prepared to understand more—even beyond an academic setting—is well worth the investment.

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