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THE WAR OF THE WORLDS
When Students' Conceptual Grasp Clashes With Their Professors'

By Diane F. Halpern

If you like horror stories, this one should terrify you: In a random telephone survey of more than 2,000 adults, conducted by the Public Opinion Laboratory at Northern Illinois University, 21 per cent of the respondents said they believed that the sun revolved around the earth; an additional 7 per cent said they did not know which revolved around which.

I have no doubt that virtually all of these adults were taught in school that the earth revolves around the sun; they may even have written it on a test. But, in fact, they never altered their incorrect mental models of planetary motion because their everyday observations didn't support what their teachers told them: People see the sun "moving" across the sky as morning turns into night, and the earth seems stationary while that is happening.

Students can learn the right answers, even recite them in class, and yet never incorporate them into their working models of the world. The objectively correct answer that the professor accepts and the student's personal understanding of the world can exist simultaneously, each unaffected by the other. Outside of class, the student continues to use the personal model because it has always worked well in that context. Unless professors address specific errors in their students' naive models of the world, the students are not likely to replace their own models with the correct one promoted by the professor.

Students' personal notions of how the world works influence what they learn in every academic discipline. In a now-classic study conducted in the late 1970s, two University of Minnesota psychologists, Mark Snyder and Seymour Uranowitz, presented short stories about a woman named Betty to two groups of undergraduates. The stories were identical, except that one group read an additional sentence in which they were told that "Betty is now a lesbian."

One week later the students returned for a test on the story they had read. The group that had read that Betty was a lesbian was much more likely than the other group to recall reading that "Betty never dated men." In fact, both groups had read that she dated men occasionally. Students' beliefs about the world -- in this example, about lesbians -- influenced what they recalled from a simple story.

Perhaps one more example will convince you. Have you ever waited with a group of people for an elevator? Invariably, someone will keep pushing the call button. If you ask the button-pushers why they continue pushing, they will explain their belief that the elevator will come more quickly if it "knows" they are impatient. This sort of naive belief is highly resistant to change, because it is repeatedly confirmed in real life. In fact, after an interval of button pushing, the elevator arrives, just as the button-pusher predicted.

Cognitive psychology provides models of human learning and knowing -- that is, how people acquire, organize, retrieve, and use information -- that can help us teach students to put aside their naive models of the world. To educate our students successfully, we must incorporate into our teaching an understanding of the way in which learners organize knowledge and represent it internally, and the way in which these representations resist change when learners encounter new information.

But despite all that cognitive psychologists now know about what happens when people learn, the urban planner Donald Schon's observation in *The Reflective Practitioner* remains true: Most teachers "have gained relatively little from cognitive psychology." It seems that even cognitive psychologists apply to their teaching very little of what they know about their academic discipline. The gap between empirically validated theory and practice is wide. One of my favorite examples of this is the deadly dull three-hour lecture I once sat through on the shortness of people's attention span.

Let me suggest some basic principles of human cognition that should serve as a guide for college-level instruction:

* What and how much students learn in any situation depend heavily on their prior knowledge and experience. We must not think of our students as blank slates, but as slates that may need to be edited, updated, and revised to reflect new, correct information.

* To change students' incorrect or incomplete mental models, we need to understand their implicit and explicit beliefs and design our instruction so that we expose the errors explicitly and make the benefits of the new models obvious. Otherwise, students may be able to produce a correct answer on a test, but their underlying understanding of the phenomena involved may not change.

* Learning and remembering involve multiple, interdependent processes. No single set of learning principles will help all students learn in every situation, particularly because what students learn and recall partly depends on what they already "know." So educators must be prepared to use different pedagogical methods if they see that their students are having trouble absorbing and retaining information. Some types of learning -- such as mastering the plot of a popular movie -- occur without our conscious awareness; the learning seems effortless and automatic. Other types -- such as memorizing the names of the facial nerves or understanding how to multiply in matrix algebra -- require a great deal of concerted effort and may call for a variety of teaching methods.

* Experience often "teaches" us things that are, in fact, wrong, but our daily lives do not always provide immediate feedback that demonstrates the errors. To promote critical thinking about the judgments we make, educators need to provide systematic and corrective feedback. For example, research indicates that most jurors believe that they can tell from a person's demeanor whether she or he is telling the truth. Yet Paul Ekman, a psychologist at the University of California at San Francisco who studies lying, has found that people generally can't tell when someone is being truthful or not. We may not find out that someone has lied to us, though, and without evidence that our judgments about someone's honesty have been wrong in the past, we are overconfident about our ability to detect deceit. A technique that Ekman has used successfully to dispel students' assumptions about this ability is to have convincing liars "testify" to law students during a class -- and later on in the session admit their deceit.

* Because students frequently fail to apply what we have taught them in class to the real world, we must focus part of our teaching on "transferability." For instance, virtually all students who have taken courses in the social sciences or statistics can tell you that a correlation between two variables doesn't necessarily mean that a change in one variable causes a change in the other. Most students wo have had course work on this topic can compute a correlation coefficient for a set of data and provide examples of positively and negatively correlated variables. But when, for example, they read a newspaper report of a study that found that children who eat breakfast are better readers by the end of first grade, many of these same students don't recognize that eating breakfast did not necessarily cause the first graders to be better readers. Making frequent use of real-life examples in class helps students recognize the principles we are teaching when they encounter them operating outside of school.

Applying these principles of cognitive psychology in our classrooms can begin at the start of each semester. The teacher can start by having students give their own explanations of the subject to be studied -- for example, state how they believe selected topics in psychology are linked, describe what would happen if a certain chemical were heated, or explain how they would determine the value of a variable. Students often are surprised to discover that they already have beliefs about such topics.

Then the teacher can present the facts, stressing the ways in which reality is similar to or different from the students' initial understanding of it. Using a few real-world examples that require the students to apply underlying principles will help insure the replacement of old understanding with correct information. Later in the semester, the teacher can again ask the students for their own explanations of important principles and how their understanding differs from their original conceptions. Having students reflect on their prior knowledge, subsequent learning, and their current understanding increases the likelihood that they will internalize what they are taught in class.

The most important reason for making sure that our students can apply to the real world what we are trying to teach them in class is that the world is changing at an accelerating rate. As specific situations change, the importance of the underlying principles -- and students' ability to recognize and apply them to new settings -- becomes even more critical.

Demand is increasing for a new type of employee, sometimes called "knowledge workers" or "symbol analysts." They need to be able to carry out multi-step operations, manipulate abstract symbols and ideas, acquire new information efficiently, and remain flexible enough to recognize new paradigms. If we fail to address the fact that too many students leave our classrooms unable to transfer principles and understanding to new domains of knowledge, we will create a work force for tomorrow that is superbly prepared only for yesterday's problems.

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