edutopia online
www.glef.org

Appropriate Assessments for Reinvigorating Science Education

by Bruce Alberts

All of us who work in education should recognize the enormous power of assessments. In my nearly 30 years as a professor, I didn't think enough about this important issue. Although I did see some horrible tests, I tended to dismiss them as inconsequential. I have constructed a little theorem about assessment: "What is measured in high−stakes assessments has a profound effect on human behavior." The corollary is, "We must be exceedingly careful to make sure we measure what counts." We cannot expect major improvements in education without major changes in our assessments of both student and faculty performance.

Due to inertia, our system of math and science education is broken. There is much more inertia in human society than in physics where, if you push on something enough, no matter how heavy, it moves a little. However, although talented people have tried to improve our schools, when their projects end, the schools slide back to where they were before. We must all work together to overcome this inertia.

Memorization is Not Understanding

Science education should emphasize inquiry−based learning and problem solving that excite and empower children. In this kind of science, classes look different. My favorite classrooms are noisy, with students challenging each other and the teacher acting as a highly skilled coach, not just standing in front spewing out meaningless knowledge to be memorized.

Science is not the memorization of the parts of a flower or becoming familiar with word definitions and facts. Since I am a biologist, let me give an example from seventh−grade biology, which is often a true horror. One textbook describes the parts of the cell as follows: "Running through the cell is a network of flat channels called the endoplasmic reticulum. This organelle manufactures, stores, and transports materials." The next paragraph is about the Golgi apparatus, and the textbook continues on like that. Sixteen pages later is an end−of−chapter self−test, which purportedly emphasizes what is important to know. The self−test asks, "Write a sentence that uses the word endoplasmic reticulum correctly."

Science words are not science. By defining science education the way we too often do, we are turning middle school kids off to real learning.

Students Learn What is Assessed

For 17 years, I taught a first−year cell biology and biochemistry course to 150 medical students at the University of California, San Francisco (UCSF). These young people were some of the very best students in America. When I arrived there, all the course tests were multiple−choice exams graded by a Scantron machine. The professors noticed that most students really weren't interested in understanding the material, except for wanting us to be very explicit about what they had to memorize for the exams.

So we created a more complicated multiple−choice exam. The answer could be "all of the above," "a and c," or "none of the above." This new test format was difficult to construct and, after a few years, it had not made much difference. Finally, we made half of the exam require short essay answers that could not be graded by machine. Immediately, the students' attitudes changed. They had to understand something. It was my first encounter with the real power of tests and how important it is to get the test right if we want to get the learning right.

Assessment as Investigation

Most of the 50 states are now developing their own assessments and their own science standards. Some are quite remarkable. For example, the Maryland School Performance Assessment Program involves a week of testing every year for third, fifth, and eighth graders. Rather than compartmentalizing science, mathematics, reading, and writing, they test for multiple abilities at once. The following problem was given to all Maryland third graders:

Your teacher has received a bouquet of flowers and is having trouble with them. The leaves are drooping, and the flowers look sick. You decide to do an investigation to discover what might be wrong with them.

Students must then perform the following tasks:

Read two articles about plants and their stem system.
Write an essay explaining how you would study your teacher's flower to determine what's wrong with it.
Draw an illustration that would help other students understand your investigation.
With a partner, use a magnifying glass, look at the cut edge of a bottom of a celery stalk [which is used in place of the flower], make a list of things you observe about the stalk, break the stalk, and describe what you see.
Draw and color a picture of what you think will happen to this celery if it sits in red dye overnight. Explain why you think so.
On the next day, study the celery that was soaked overnight in the red dye. Write a paragraph to explain how the celery is the same or different from what you predicted yesterday.
Write an essay explaining why a scientist might want to do more than one investigation when trying to answer a question about science.
Write a note to your teacher telling what you have learned about flowers and how to take care of them.

This kind of assessment stands in stark contrast to most current assessments. This exam tests for abilities that prepare students for the real world and makes school meaningful. With these kinds of questions, parents can appreciate the relevance of school to their children's lives and its importance for getting a skilled job.

Higher Education Sets the Model for K−12

Having spent 30 years in universities, I have reached the conclusion that if anyone is to blame for the state of K−12 science and math education, it's us −− the faculty of colleges and universities. We set the standards that define education. If we use multiple−choice exams, everybody else is going to use multiple−choice exams. If we only lecture at students with facts about biology and try to cover all of biology in one year without teaching anything in depth, our high schools will emulate us. Middle school biology in turn will emulate the high school.

The National Academy of Sciences and its sister organizations are emphasizing improving college courses through a new Center for Education. This work has resulted in an overview publication, From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology. We have also published a small book called *Science Teaching Reconsidered* for college science instructors.

On the cover is a photo of a lecture hall that might look very strange. The lecturer is using a technique, developed by Eric Mazur at Harvard, which is now spreading around the country. In his large Physics I class, Mazur stops lecturing every 15 minutes to ask a conceptual question that he knows half the class will get wrong. Students raise their hands to indicate their answers. Neighbors inevitably have different opinions and the students then try to convince their neighbors they are right.

After a noisy discussion for two or three minutes, the students vote again. Now, nearly 85 percent get the answer right. Someone who has just learned something can often explain it better than the professor, to whom it is all too obvious. The technique also keeps the students alert and motivated. Evaluations of student learning prove that it works.

The future of this country depends on human capital. If we do not improve our development of human capital in the next 20 or 40 years, we will no longer be the leading nation in the world. My favorite quote about education comes from British mathematician, logician, and philosopher Alfred North Whitehead nearly 80 years ago:

"The art of education is never easy. To surmount its difficulties, especially those of elementary education, is a task worthy of the highest genius. But when one considers in its length and breadth the importance of a nation's young, the broken lives, the defeated hopes, the national failures which result from the frivolous inertia with which it is treated, it is difficult to restrain within oneself a savage rage. A country that does not value trained intelligence is doomed."

Adapted from a speech to the American Association for Higher Education, 1998.

The following Web sites appeared in this article:

Maryland School Performance Assessment Program: www.mdk12.org/mspp/mspap/

From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology.: www.nap.edu/readingroom/books/analysis/

Science Teaching Reconsidered: www.nap.edu/readingroom/books/str/

Published: 1/21/2002