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Starting a Science Education

By William Banko, Michael E. Jabot, Patricia B. Molloy, Arnold Serotsky, & Bruce Tulloch

Is it possible that our country has been teaching science backwards? Scores from the 2006 Program for International Student Assessment, or PISA, on which the United States ranked 25th in math and 21st in science out of 30 developed nations, certainly seem to indicate that our overall approach is not working. Now we have objective evidence of what does work in the learning and teaching process, which opens a new approach that can be applied to science instruction. Research in the fields of neuroscience, psychology, education, and machine learning is demonstrating that young children have the capacity to learn more than anyone previously imagined.

This research into a "new science of learning," examined in the July 17, 2009, issue of *Science*, has shown that acquisition of information by the human brain is most rapid and efficient from birth to the preteenage years. For example, a second language is learned effortlessly and without an accent between the ages of 3 and 7, according to the researchers. Yet our current approach to science education follows very much the opposite of this natural learning pattern. The majority of our formal science education is focused on the 9th through 11th grades. During this three-year period, students are afforded the benefits of specialized teachers and resources to learn physics, chemistry, biology, earth science, algebra, geometry, and trigonometry. By this point, however, we have not only missed the optimal learning period for children, we are nearly a decade past it.

We now have an unprecedented opportunity to revamp science curricula across the country and deploy this growing body of learning research. The United States has embarked on an ambitious program of education reforms that will include, for the first time, the potential of having as many as 48 states implement K-12 science education standards based largely on a conceptual framework being developed by the Board on Science Education of the National Academies. This project released in draft form its first document, **"A Framework for Science Education,"** on July 12. Though the work is separate from the Common Core State Standards Initiative of the National Governors Association and the Council of Chief State School Officers, organizers say they hope the effort will play an important role in reshaping state science standards. **("Panel Moves Toward 'Next Generation' Science Standards,"** July 13, 2010.)

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We believe it is imperative that this framework be modeled around teaching fundamental science concepts during the ideal learning period-between kindergarten and 4th grade. Although the current draft document identifies young children's capacity to reason scientifically and places emphasis on the importance of learning core ideas, it does not specify that children can intuitively learn these core concepts through carefully designed activities.

Yet research funded by the National Science Foundation as part of its Science of Learning initiative (and outlined in the July 2009 *Science* report) provides evidence that children learn most efficiently through activities that offer opportunities for social interaction and imitation. We therefore propose that national education reforms follow three basic strategies.

First, there needs to be a consensus among everyone involved in the process that the beginning of a student's education represents the ideal learning period, and is thus the single most important phase in the education system. The developers and implementers of the core standards for science need to acknowledge this "sensitive period for learning" during the primary grades and clearly define the fundamental concepts that primary school students need to master to have a solid foundation in science. The development of these concepts through a learning-progression approach will support students' acquisition of basic science literacy in primary school and take advantage of the sensitive period for learning, much like learning a second language during early childhood.

Countries that routinely outperform others in education are teaching science before their students even learn to read and write, by using classroom activities that demonstrate scientific principles. All of these activities take advantage of three fundamental aspects of science: observation, inference, and verification. These concepts can be easily taught in primary school through carefully designed activities and a common language, namely, measurement. Children who understand that measurement is simply a comparison to a known standard have the necessary foundation for learning more-advanced science concepts in later years.

Second, we need to thoroughly train primary school teachers in basic science principles and processes. The foundation that underpins all of science can be understood by mastering relatively few concepts. By learning how to communicate these concepts to the youngest of students, primary school teachers can become the single most important factor in improving science education in this country.

Third, after fundamental science concepts are introduced in primary school, we need to thoroughly and appropriately assess students' science knowledge and skills. The challenge of assessing students who have not yet mastered reading and writing can be met simply by having them demonstrate their knowledge and comprehension through physical activities designed to illustrate a specific science concept.

There is a peak window of opportunity for teaching basic science concepts at the *beginning* of the elementary school experience that we can no longer afford to ignore. Providing a *solid* science foundation *before* children enter secondary school should be the single most important step in improving science education in this country. When young students acquire basic science literacy in primary school, they will apply their early science knowledge throughout their lives. They will be more likely to become STEM capable, able to master content in science, technology, engineering, and mathematics, and will be better prepared for college and career. Most significantly, they will be drawn to the beauty of the scientific explanation of the universe from the onset of their earliest educational memories.

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