SCALE Key Concepts

This series of articles illustrates key concepts of the SCALE five year National Science Foundation-funded project.

The SCALE partnership aims to improve K-12 mathematics and science teaching and learning working with four urban school districts: Los Angeles Unified School District, Denver Public Schools, Madison Metropolitan School District, and Providence Public School District. Other partners include California State University, Dominguez Hills; California State University, Northridge and University of Wisconsin-Madison. These articles reflect the major themes of the National Science Foundation's Math and Science Partnership (MSP) Program: Partnerships Across Institutions; Challenging Courses and Curricula; Evidence-based Design and Outcomes; Teacher Quality, Quantity and Diversity; and Institutional Change and Sustainability.

Science Immersion Can Open Students to Lifelong Learning Skills

Learning how to ride a bicycle is a joyful experience most of us remember. Perhaps it was a parent or older sibling who first held the bike while you tried to pedal without falling. It may have taken several times over consecutive days before you got the hang of it, then the guiding hands were dropped and suddenly you seemed to fly.

Now try to imagine this learning process without ever touching a pedal or seat—entirely by listening to an instructor who tells you how to ride. He might talk about the concepts of balance, gravity and motion. Then the instructor demonstrates before asking you to try it. Fortunately for our elbows and knees, most of us didn't learn how to ride a bike that way!

But this lecture-based approach is used in countless classrooms all over the nation to teach science, a discipline that begs to be tried, sometimes again and again, before understanding takes place.

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These science classes may also feature experiments in order to teach the scientific method. A frequent but unintended outcome of these experiments is that students will simply memorize the procedural steps without understanding the underlying concepts or principles.

Without engaging their imaginations, it's no wonder that many students think of science as "dry and mechanical." In fact, one study showed that student perceptions of science indicate that "they see scien-

tific work as dull and rarely rewarding, and scientists as bearded, balding, working alone in the laboratory, isolated and lonely." (American Association for the Advancement of Science, 1993)

The SCALE science immersion theory counteracts many of these negative findings by applying cognitive research and an inquiry-based approach designed to engage active imaginations. One important concept underlying the immersion approach is metacognition, or the awareness of one's own thinking. Metacognition has also been called a problem-solving skill in which students use strategies to monitor their learning and control their attention. These skills not only help students engage in the classroom, they also strengthen higher level thinking skills for future learning.

Because students are engaged in concrete activities right away in the immersion approach, students soon discover that the scientific process, and inquiry, are very creative, exciting ways to learn. Even scientists find the approach to be pleasantly enticing. A professor who was involved in a science immersion implementation team last year trying out new experiments for a unit on density and buoyancy found himself "having so much fun with it because, you know, we ended up doing things that weren't quite in the directions…" In other words, his curiosity got the better of him and he started wandering down paths to see what would happen. "You know, it showed me that 'wow, no matter really where you're coming from [he's a professor of earth sciences] if you get the chance to investigate this on your own, you get very engaged with it and even when you know what the outcome is going to be in some ways.'"

Metacognition strategies in science immersion include teachers as well as students questioning observations. This strategy, second nature to most scientists, means asking such questions as "How do you know that is true?" "Does this make sense?" or "How is this outcome different from others?" SCALE researchers have found that even kindergarteners can be taught to question their own thinking by these strategies.

But researchers have also found that students need guidance in learning how to stand back and think about subjects being taught, and not by simply asking what it is. The immersion unit supports this sometimes slow, fitful, reflective thinking that lecture-based teaching simply cannot. Here is an example of how this process allows deeper understanding taken from an immersion unit on animals taught to kindergarteners:

Teacher: How do you know that snail is a daddy snail?
Student: Because it's the biggest one in the tank.
T: Do you think that boys are always bigger than girls?
S: Yes.
T: I am a girl and you're a boy and I am bigger than you.
S: Yeah, but you're old.
T: Do you think that your big snail could just be older than your other snail?
S: Probably, but it might be a boy, right?
T: It might be. Do you think that explains why it's bigger?
S: No. Some girls are bigger. How can I tell if it's a boy? They all look the same.

(*Science and Children,* vol. 44, p. 22)

Inquiry-based science immersion is one way to help students learn to reason, use information effectively and distinguish between evidence and opinion.

This student came to the conclusion himself that more information is needed to find the answer. He is now primed to search out the answer, and the teacher is ready to help him find it. As this student gets older, if he continues inquiry-based learning, he will learn to ask and answer his own questions for understanding, just like a scientist. This is why it is important to teach even the youngest learners to ask relevant and penetrating questions.
Another aspect of the science immersion unit is that students will be more often paired up with other students, or in whole class discussions, which helps facilitate stronger thinking skills. Because analyzing is such an internal activity, teachers may have a hard time assessing students' abilities in this area. A process called "thinking aloud" while solving problems allows classmates to watch while a student explains their line of reasoning or to catch errors in someone else's thinking. Teachers also benefit from hearing students' misconceptions, which can be addressed and corrected through further inquiry.

In another study, SCALE researchers found that students in science immersion classrooms engaged in more analysis and interpretation of scientific data and made more observations and classifications than students in non-immersion science classrooms. These activities suggest that higher level thinking skills are being used. Although no teaching approach is a panacea, inquiry-based science immersion is one way to help students learn to reason, use information effectively and distinguish between evidence and opinion—or, like riding a bicycle, skills that you never forget. *—August 2007*

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SCALE
SYSTEM-WIDE CHANGE FOR ALL LEARNERS AND EDUCATORS