Using Technology to Promote Science Inquiry

Professional education organizations in every discipline agree that students should learn basic science content in addition to being actively engaged in the inquiry process. Anne Tweed, 2004 president of the National Science Teachers Association, has this to say about inquiry-based learning in science:

Inquiry-based instructional strategies lead to student investigations that can, in turn, lead to greater conceptual understanding. Direct instruction alone cannot replace the in-depth experience with science concepts that inquiry-based strategies provide. Students must create mental models that connect their learning experiences to the science concepts. Learning cycles that allow students to explore a concept in depth support students’ sense-making of their observations (Tweed, 2004).

IN BRIEF

This article makes the case for infusing technology into the five stages of the science inquiry process established by the National Science Education Standards—engagement, planning, investigating, analyzing, and communicating.

Technology provides powerful tools to help teachers lead their students through the inquiry process.

Elizabeth R. Hubbell and Matt Kuhn
Infusing technology into science education can help clarify ways to use inquiry methods in coordination with education standards—thereby improving the efficiency and viability of the inquiry process.

Science Inquiry
Science inquiry, once synonymous with the scientific method, now subtly differs in several ways. The scientific method outlines a specific linear process during which students conduct experiments, whereas science inquiry allows for more flexibility because it is a continual cycle of questions, student-centered investigations, and further explorations. Implementing the inquiry method into classroom instruction helps students to more closely parallel the processes employed by researchers and scientists (National Science Foundation, 2000).

Science as inquiry, one of eight categories of content standards outlined by the National Science Education Standards, requires students to develop abilities necessary to understand and perform scientific inquiry within the grade clusters K-4, 5-8, and 9-12 (National Academy of Sciences, 2000).

Stages of the Inquiry Process
The inquiry process has five general stages:

1. **Engagement.** The learner, through observation, raises scientifically oriented questions.
2. **Planning.** The learner uses previous research and background knowledge to plan an investigation.
3. **Investigating.** The learner performs guided investigation, experimentation, and observations in an attempt to answer the questions.
4. **Analyzing.** The learner analyzes his or her findings, organizes the data, and makes predictions while evaluating them in light of alternative explanations.
5. **Communicating.** If the conclusions in step 4 do not require repeating the cycle from step 2, the learner communicates and justifies his or her explanation.

After communicating the explanation, the learner might find that the communication process has prompted more questions, thus restarting the cycle.

Engaging the Learner
Engaging the learner is the first phase of the inquiry process. When teachers capture students’ attention through demonstrations, movies, and other activities, students begin asking questions. Teachers can use these responses to encourage learners to consider the course of their inquiries and to con-template questions about scientific concepts, patterns, or phenomena.

As shown in a meta-analysis of effective instructional strategies, activating students’ prior knowledge by the use of cues, questions, and advance organizers provides a powerful learning experience by scaffolding previously learned concepts with those they are about to learn (Marzano et al., 2001).

The authors also point out that higher-level questions produce deeper learning than lower-level questions, and that questioning students can be a powerful learning tool in and of itself, prior to a learning experience (Marzano et al., 2001).

The teacher has the most active role and does the most direct instruction during the engagement stage. In subsequent steps, the teacher takes on the role of facilitator or coach, guiding students to meaningful discoveries.

Using Technology to Plan
Planning an investigation is the second phase of the inquiry process. During this phase, the teacher and students typically discuss what they already know, what they want to know, and how they plan to find it. This is also the time to address misconceptions and prepare an investigative plan that includes available materials, technology, and methods.

One of the most useful features of technology is the range of nonlinguistic representations available to a variety of learners. Research shows that the majority of traditional instruction is delivered in linguistic form, either as a lecture or as written material, leaving the learner to create his or her own nonlinguistic representation. Helping students to create nonlinguistic images is an effective instructional strategy that enables learners to better understand and retain new knowledge (Marzano et al., 2001).

Web resources and software provide access to people, places, and simulations that otherwise would be impossible to implement in the classroom. Access to professional knowledge, whether by e-mail or videoconferencing, or on a Web site, provides authentic information for students.
Another benefit to using technology in science instruction is the accessibility of resources to help students practice what they have learned. Research shows that students need an average of 24 practice sessions in order to master 80 percent competency in a new skill (Marzano et al., 2001). Before students can effectively conduct an inquiry, they need some level of background information and basic understanding of a concept.

Exemplary Web sites and software can help students learn the vocabulary and basic concepts of their inquiry topic. For example, students who are about to conduct experiments using certain chemicals must make certain that they know the chemicals’ elements and basic reactions. They may visit sites such as the WebElements Periodic Table (www.webelements.com), a rich resource that has information, pictures, movies, and possible reactions for each element.

Younger students might use the planetarium application, Stellarium, to see how the moon’s rising and setting times change as it goes through its phases. Another excellent resource during this phase of the inquiry process is ExploreLearning’s Gizmos (www.explorellearning.com). Gizmos are small, interactive applications that help students to better understand science concepts.

Using Technology to Analyze

During the data collection phase of the inquiry process, teachers and students typically discuss effort and performance rubrics for inquiry outcomes. The teacher facilitates the implementation of the learners’ investigative plans and guides them in organizing their data and observations.

Using data collection software in this phase enables students to focus on higher-level activities rather than on tedious, low-level data collection activities in which mistakes are often made. For example, in many elementary classrooms students are required to use an analog thermometer to gauge the daily temperature and plot the information onto a graph. When the focus of the lesson is to make predictions based on this data, it is imperative that it be accurate and timely.

During the data collection phase of the inquiry process, learners scrutinize data on Web sites and blogs, or create multimedia presentations to share their findings. When teachers use these tools in science classrooms, they provide optimal learning environments for their 21st century students.

Using Technology to Communicate

A fundamental principle of scientific inquiry is to defend and share one’s findings. During the last phase of the inquiry process, learners prepare to report their questions, predictions, research, investigations, and findings. Ideally, they have an opportunity to defend their findings to an audience of their peers, teachers, parents, or community. In this way, the inquiry process continues as others read the findings and are compelled to further investigate, dispute, or revise the findings.

Traditionally, students have been limited to communicating their findings in schoolwide science fairs. Now, they also are able to post their findings online in a variety of ways. For example, they can create documentaries, post their data on Web sites and blogs, or create multimedia presentations to share findings and gather feedback from global audiences.

Technology can provide powerful tools for science inquiry by helping students to ask questions, investigate, and share their findings. When teachers use these tools in science classrooms, they provide optimal learning environments for their 21st century students.

Elizabeth R. Hubbell is a senior consultant of educational technology at Mid-continent Research for Education and Learning (McREL). Her e-mail address is ehubbell@mcrel.org.
Matt Kuhn is a senior consultant of educational technology at McREL. His e-mail address is mkuhn@mcrel.org.

References

WEB RESOURCES
For additional information regarding the National Science Education Standards, visit the National Science Teachers Association Web site.
www.nsta.org.

You may also wish to read Inquiry and the National Science Education Standards: A Guide for Teaching and Learning from the National Academy of Sciences.
www.nasonline.org

STATEMENT OF OWNERSHIP
Principal (ISSN 0271-6062) (Act of August 12, 1970; Section 3685, Title 39 United State Code.) Date of filing: 30 September 2007.
Frequency of issue, 5 issues per year. Annual subscription price $195 with membership. Publication and general business offices, 1615 Duke Street, Alexandria, Virginia 22314-3483. Editor, Raven Padgett. Known bondholders, mortgagees, and other security holders, none. The purpose, function, and non-profit status of the National Association of Elementary School Principals and its exempt status for federal income tax purposes have not changed during the preceding 12 months. During the preceding 12 months, the average number of copies printed for each issue was 33,854; the average number of copies distributed, 35,506. The figures for September/October 2007: 57,768 copies printed; 57,768 total paid circulation; 810 copies for free distribution; total number of copies distributed, 58,578.

WE MUST SAVE OUR CHILDREN!
BLACK STUDENTS-MIDDLE-CLASS TEACHERS
by Dr. Jawanza Kunjufu $15.95

KEEPING BLACK BOYS OUT OF SPECIAL EDUCATION
by Dr. Jawanza Kunjufu $15.95
Is there a relationship between special education and prison? Is there a correlation between illiteracy and incarceration? Why are males placed in special education more than females? Is special education the new form of segregation?

AN AFRICAN CENTERED RESPONSE TO RUBY PAYNE’S POVERTY THEORY
by Dr. Jawanza Kunjufu $15.95
Are we studying poverty · or educational excellence? What are successful schools doing in low-income areas? What is more important, the educational background of the mother or the teacher?

For credit card orders only, call: 1-800-552-1991 Order the set $39.95 FREE SHIPPING!

SCHOOL SETS
Educators’ Library $199.95 I Multicultural Videos $99.00
Black History Curriculum $595.00 I Hispanic History $320.00
Math $399.95 I Biographies $1,499.95 I Posters Set of 230 $399.99
Parent Set $199.95 I Respect/Manners/Home Training 199.95
Purchase orders must exceed $100.00

AFRICAN AMERICAN IMAGES P.O. Box 1799, Sauk Village, IL 60412
voice 708.672.4909 fax 708.672.0466 e-mail Customer@AfricanAmericanImages.com
Visit our web site at www.AfricanAmericanImages.com

"Educating the African American & Hispanic Male Child National Seminar"
December 11-12, 2007
March 4-5, 2008
May 20-21, 2008
9:30am-3:00pm

www.naesp.org Principal November/December 2007 27