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Strategy 15: Teach model-based inquiry over the scientific method.

What the Research Says

Wong and Hodson (2008) sought to identify the key features of the nature of science embedded in authentic inquiry. In their study, 13 well-established scientists responded to an open-ended questionnaire regarding the nature of science and participated in in-depth interviews focused on the nature of science from a curricular standpoint. The researchers found striking contrasts in the scientists' descriptions of their practice of science and the image of science and inquiry usually described in science curriculum, textbooks, and classrooms. Wong and Hodson felt the stories that these scientists tell offer considerable potential as teaching resources to enhance and enrich the typical science classroom's understanding of the nature of science and for the design of more effective laboratory and field work.

It was pointed out by a number of scientists in the study that the textbook notion of the "scientific method" or the scientific inquiry process is grossly oversimplified as presented in a linear fashion. For example, the participating high-energy physicist stated, "I don't do experiments. . . . The experiments in physics have become larger and larger in scale, especially in my specialty. It is difficult for scientists to deal with both theoretical and experimental issues at the same time" (Wong & Hodson, 2008, p. 117). He went on to say that Fermi was the last physicist to be both a theorist and an experimentalist, and the approach taken in scientific investigation can be flexible and depends on the particular circumstances. Some scientists develop experiments, while others use more naturalistic observations and studies, historical reconstructions, or computer simulations and/or modeling tools. All scientists in the Wong and Hodson study stated that creativity and imagination are also very important at all stages of scientific investigation—experimental planning and design, data collection, and data interpretation.

Furthermore, in a report based on a national observation survey, Weiss, Pasley, Smith, Banilower, and Heck (2003) reported students in U.S. math and science classrooms are often busy but engaged in tasks that require little understanding of content on their part. In some 55% of the observed lessons, students had limited to no intellectual engagement with the conceptual ideas necessary to understand the content represented in the lesson. How is this related to the discussion of the teaching of a universal scientific method?

The following four areas that emerge from the data by Wong and Hodson (2008) can be singled out for attention:

inquiry-based investigations focused on selected basic questions. These types of units can be constructed by teachers or, better yet, by groups of teachers to embed standards into inquiry and a more authentic context. They are summarized here (Geier et al., 2008):

1. *What is the quality of the air in my community?* Students examined sources of air pollution in their communities and used archived data to compare Detroit air quality with air quality in other cities. The unit focused on the factors that influence air quality, along with the basic science content such as the particulate nature of matter and its chemical and physical properties.

2. *What is the water like in my river?* Students acquired an integrated understanding of science concepts such as watersheds, soil movement (erosion and deposition), and the chemistry concepts of pH and dissolved oxygen.

3. *Why do I need to wear a helmet when I ride my bike?* A physical-science-based unit was designed to develop the students' understanding of force, velocity, acceleration, and Newton's laws. This is all within the context of examining the nature of collisions in the real world and developing strategies for interpreting and visualizing physical phenomena graphically.

Precautions and Potential Pitfalls

The really positive message here is that standardized tests and engaging students in inquiry have been shown to coexist per the research by Geier et al. (2008). This research also concluded that the teaching style within the study exhibited the potential to close a male-female achievement gap. Many in science and science education have emphasized the importance of involving students in the processes of scientific knowledge making or inquiry. The goal is to have students learn the processes and content of science by actually engaging in guided inquiry.

While the Geier et al. (2008) study looks promising, many teachers will still be concerned that standardized test preparation and positive performance don't mix well in classroom instruction with an inquiry emphasis. If teachers are not experienced or knowledgeable about inquiry, experimental design, or the related scientific reasoning, it is difficult for them to develop these units on their own without help or significant motivation and resources.

Teaching within an inquiry-based pedagogy can be rewarding and yet frustrating at times when developed from scratch. Teachers in Detroit benefited from significant professional development before implementing the curriculum. If inquiry or problem-based learning works, as shown in this study (not conflicting but enhancing test preparation), science teachers will have wider choices to make in their professional development and choice of teaching resources. It is clear that inquiry more clearly represents how science is practiced outside the classroom. Inquiry learning enhances the metacognitive skills and motivates students in ways that chapter marches and lecture cannot.

The researchers also examined the factor of teacher bias. Researchers discussed the potential nature of the type of teachers that choose to participate and felt that the reform efforts might favor teachers who show a greater level of commitment to self-improvement and bring a greater range of techniques to the classroom.

Also, sadly, the research did not provide the details of class management or organizations within the units or any other instructional or content details. It is assumed the experimental design was very structured and developed by adults, not students. This raises the question on how much "inquiry" was truly experienced by the students versus an activity with a procedural emphasis only.

Sources

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Geier, R., Blumenfeld, P. C., Marx, R. W., Krajcik, J. S., Fishman, B., Soloway, E., & Clay-Chambers, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. *Journal of Research in Science Teaching, 45*(8), 922–939.

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Strategy 38: Align instruction and assessment tools to state curriculum standards.

What the Research Says

Liu and Fulmer (2008) report on an analysis of alignment between the New York State core curriculum and the New York Regents tests in physics and chemistry. The investigation found that overall there was a high alignment between New York core curriculum and cognitive levels and the New York Regents test, and the alignment was said to remain fairly stable from test to test. However, there were considerable discrepancies in emphasis on different cognitive levels and topics between core curriculum and the test. Questions were raised about the nature of the alignment and the nature and validity of the content standards. The implications for science curriculum and instruction were also examined.