Foreword

Elizabeth Hammerman has identified eight essentials for approaching the teaching of science as inquiry. This has been an illusive goal for most science educators in the United States for nearly 100 years. Most yearn for a more complete and accurate view of the human enterprise called science to be in evidence in classrooms in addition to the typical focus upon the major constructs that most in a given discipline accept. However, too often science is equated with the information that has amassed over time and is found in discipline-bound packages in textbooks. The assumption is made that students learn science if they can recite definitions from textbooks or repeat what they have read or remember from teachers' lectures.

Hammerman's book provides excellent research evidence to establish the importance of students experiencing science as inquiry. The reports from cognitive scientists indicate forcefully the folly of casting science only as content to be learned in classical ways. After the National Science Education Standards were published in 1996, the National Research Council sponsored the collection and analysis of the learning research and published the book *How People Learn,* a resource that is central to understanding and using inquiry. They have also published a monograph on inquiry that is larger than the 262 pages comprising the standards.

Although inquiry was basic to the major reforms of the 1960s following the Soviet exploits in space and the moves of the National Science Foundation to invest heavily in new K-12 science materials, it too often was ignored—or taken to mean a taxonomy of skills to be learned (replicated) outside of any real-world contexts. The National Standards and Hammerman's new book emphasize the importance of viewing science concepts and processes in concert with each other. In fact, the view of the whole science enterprise must be cast in even broader terms if it is to have meaning and utility for students. Such a broader view is central to the visions elaborated in the National Standards.

Science means that students will use their own questions and personal curiosity about the objects and events encountered in daily living. When

these objects and events include the human mind in addition to the natural world, there is even more chance for success. Once there is curiosity there is something about the human-made world that makes every human try to do something about the curiosity that gets the brain to work. Unfortunately, these initial explanations are often wrong in terms of what scientists have come to accept as established explanations. But, the personally constructed explanations are fine in terms of religious beliefs, art, and human expressions (poems, stories, music).

The human activity called science demands more than the personally constructed explanations; evidence must be provided to establish the validity of explanations created by individuals. Doubt with the initial thinking and guesses is fundamental to science. Another feature is communicating the ideas and the evidence to others to get concurrence about which a community of scientists can agree. In terms of K-12 education, teachers and parents and students should always proceed to raise questions about whether anyone else has ever offered explanations and evidence that concur with what student groups, whole classes, or others have offered as explanations of objects and events in nature. This should appease persons concerned that students will produce "wrong" explanations if they are not given the commonly accepted ones as starting points (or corrected by the teacher, who knows the correct explanation).

Hammerman's book is rich with ideas, suggestions, and activities, all designed to energize students in doing science by formulating questions, offering explanations, testing ideas, extending investigations, and communicating results. Assessment is essential to science itself; it exemplifies inquiry.

When students choose to learn, they learn basic concepts as well as the process and thinking skills needed to learn science with meaning and understanding. Science is a cyclic enterprise. Although the cycles may vary in terms of labels, the efforts mirror the total enterprise called science.

Hammerman points out that there are two conflicting features of science; namely that it is open to questioning, which also means undoing the orderliness of what we think we know and accept as a feature of the enterprise. These features by definition are missing in most classes labeled science and most textbooks chosen for study. Teachers and textbooks present science information; they do not encourage students to experience any aspect of the whole enterprise.

Hammerman's Eight Essentials illustrate well the complexities and problems with teaching science as information and skills unrelated to the lives and experiences of learners. The questions, activities, and suggestions are designed to help teachers and professional development providers with the needed changes. Such changes are critical both in the preparation

of new teachers and with professional development providers who are involved with the continuing education of all teachers. Hammerman cites Iris Weiss's 2003 study of 350 lessons from a national sample of teachers where only 15% of the lessons of high school teachers and 7% of the lessons of middle school teachers could be rated highly with regard to inquiry teaching. This means that 85% of the high school teachers and 93% of the middle school teachers in the United States need experience with the eight essential features of approaching science teaching as inquiry. Hammerman's new book is designed to help resolve this most significant problem. It is a book that should be used in the nearly 1,300 institutions where science teachers are prepared and in the important task of dealing with the continuing education of all K-12 science teachers.

—Robert E. Yager
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