SCIENCE EDUCATORS' ESSAY COLLECTION

Learning SCIENCE and the Science of LEARNING

Edited by Rodger W. Bybee

Hawker Brownlow EDUCATION

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to provide feedback to students and teachers. Such strategies include questioning, concept maps, reflective journals, written tests, observations, drawings, performance, and interviews. Assessment practices should be inclusive of all students as well as congruent with learning goals and instructional strategies.

Part 5

Professional Development and the Science of Learning

The authors consider the important relationship between standards-based curriculum implementation and professional development. They begin by looking at the key recommendations about student learning and then discuss how curriculum materials can embody these recommendations. Because the result is nontraditional curriculum materials, they then consider the role of professional development for increasing the effectiveness of those materials. Finally, they discuss a professional development strategy that begins with selecting materials for curriculum reform.

Groundbreaking research on learning and cognition has produced many new insights into how people learn. These findings conclusively dispel the idea that short-term and isolated learning experiences can produce powerful learning. This is especially true for teacher learning, given the complexity of teaching and the multifaceted role expert teachers must play. Teacher learning programs must become more collegial, in-depth, and longer in duration and must be tailored to the experience levels of the learners, be they novice or expert teachers.

Preface

Science teachers today face numerous initiatives, ranging from "No Child Left Behind" at the national level to assessments for each student in local classrooms. Teachers of science have the daunting task of translating these varied, and sometimes contradictory, efforts to improve science education into actions they can apply. I have found it interesting that all the initiatives have student learning as an ultimate aim. Granted, the clarity of this goal varies considerably, but regardless of the proposed solution to a perceived problem, the recommendations assume that students will learn more science. Professional developers assume their work will help science teachers enhance student learning. Publishers claim their science textbooks will increase learning. Ironically, even some agencies responsible for assessments assume the tests will result in greater learning!

Many concerns expressed by teachers also center on the challenges of helping their students learn science. Challenges can arise for a variety of reasons—when teachers hold the highest ideals of learning, believing that all students should understand the basic concepts of physics (or chemistry, biology, or Earth sciences); when they have misperceptions, such as thinking that inquiry-based instruction takes too much time away from learning essential content; and when they are faced with practical considerations, such as the need for students to do well on state or local assessments. In light of these challenges, it is in the interest of all teachers of science to understand and apply the basic principles of learning in their classroom practices.

The chapters in this yearbook explicitly use as their centerpiece a National Research Council (NRC) report, *How People Learn: Brain, Mind, Experience, and School* (Bransford, Brown, and Cocking, eds. 1999. Washington, DC: National Academy Press). The NRC report represents over four years of work and a landmark synthesis of research on human learning. To state the obvious, *How People Learn* has significant implications for how our society educates; for the design of curricula, instruction, assessment, and professional development; and, ultimately, for individual science teachers. Here, I will not review findings from the NRC report. Individual authors of the yearbook chapters do that in the context of the themes they address.

After an introduction by Harold Pratt, NSTA president 2001–2002, the yearbook chapters are grouped according to the following themes: How Do Students Learn Science?; Designing Curriculum for Student Learning; Teaching That

Introduction

"Learning Science and the Science of Learning," the title of this yearbook and my theme as NSTA president, was chosen with the assumption that virtually every science teacher is a learner and wants to improve his or her practice. Most teachers believe that their personal learning is never finished. This book is dedicated to you, the professional science teacher, who makes a career of learning—your own and that of your students.

The yearbook was inspired by the recent seminal publication, *How People Learn; Brain, Mind, Experience, and School,* published by the National Research Council's National Academy Press (1999). This book was produced by a committee of scholars and practitioners under the leadership of John Bransford, Vanderbilt University. Although written by researchers about the results of research, *How People Learn* is a very readable, practical, and useful guide for practitioners that explains in everyday language how people of all ages learn. There are specific sections on learning science, mathematics, and history. The book not only addresses how students learn, but has chapters devoted to how teachers learn their content and how to teach it.

Three overarching research findings provide a framework of what educators know about learners and learning and about teachers and teaching. Although the language of these findings speaks of students, they come from our knowledge of how people of all ages and professions learn. I think it will be instructive to view these three findings from the perspective of science teachers continuing to learn their content and their practice of teaching.

> *Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside of the classroom.* (*How People Learn*, p.14)

As science teachers and science educators, we approach teaching, curriculum development, and assessment with our current conceptions about how the world of the classroom works, namely, how teachers should teach and how students learn. Our job as professionals is to find ways to take our current conceptions about learning and place them against new research, concepts, and information about learning as a way of examining and improving our practice. Our roles as professionals include internalizing new views of teaching and learning and therefore teaching in new effective ways and not simply engaging in new language.

> *To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of the conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.* (*How People Learn*, p.16)

This finding can be applied to our knowledge of science and of pedagogy. Outstanding teaching requires teachers to have a deep understanding of the subject matter and its structure, as well as an equally thorough understanding of the kinds of teaching activities that help students understand the subject matter in order to be capable of asking probing questions (*How People Learn*, p.188). Learning science means more than a superficial set of facts or explanations in most textbooks. It means understanding what we teach beyond what the textbooks provide us as content. It means being able to evaluate both the content and the learning activities suggested for the students. The interplay between content knowledge and understanding of pedagogy challenges the misconception about teaching that claims effective teaching means knowing the content and a generic set of teaching strategies that can be applied almost universally.

Too often the "facts" of our pedagogy are the tried and true methods we have used for years but are not grounded in a deep conceptual framework of the research on learning. The authors in this volume offer us an opportunity to reshape our deep foundation of pedagogical strategies in the research of learning rather than depending solely on our past practice.

In addition to inviting us to examine our own knowledge and practice, the authors offer us a context and framework through which we can examine our curriculum and the policies of our district and state that affect our teaching lives. Knowing the science of learning empowers teachers with the resources to argue for and support the decisions for curriculum and assessments that control much of their professional lives and the success of their students.

> *A metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.* (*How People Learn*, p. 18)

Just as we should allow students the opportunity to verbalize and reflect on their own thinking, we as professionals must do the same. We must demand the time and support to set our own professional development goals and the opportunity to meet and discuss, plan, and review our teaching practices with the research on learning in mind.

With these three findings in mind, the content of the yearbook is useful and appropriate to a number of audiences.

- Schools and school districts will find the content useful as they consider what constitutes professional development and how organizational policies must change to support professional development programs.
- Professional developers will find the content useful as they design professional development opportunities.
- Science teachers will find the yearbook useful as they become more insightful consumers of professional development. They will become competent and discriminating in their selection and use of curriculum, instructional materials, teaching strategies, and assessments.
- Science educators in all roles will find the content useful as they become more effective proponents of enlightened policy and legislation that affect them and their students.
- Funding agencies and policymakers will find the yearbook useful as they decide what projects are worthwhile investments.

This yearbook is the result of the collaboration and contributions of the editor, authors, and the NSTA staff. My deep gratitude goes to Rodger Bybee, who suggested that yearbooks be reinstituted at NSTA and willingly agreed to edit and contribute to this volume. His leadership and contribution to this work, to the science education community throughout his career, and to me personally for many years is deeply appreciated. My thanks to Gerry Wheeler, NSTA's executive director, and David Beacom, NSTA' s publisher, for enthusiastically accepting and supporting the idea of the yearbook. I thank the authors who willingly and capably accepted the assignment to write to my theme as president in such profound ways.

Harold Pratt
NSTA President 2001–2002