Teaching Teachers

Bringing First-Rate Science to the Elementary Classroom

An NSTA Press Journals Collection

NSTApress®
NATIONAL SCIENCE TEACHERS ASSOCIATION
Arlington, Virginia

NSTA press
NATIONAL SCIENCE TEACHERS ASSOCIATION

Claire Reinburg, Director
Judy Cusick, Associate Editor
Carol Duval, Associate Editor
Betty Smith, Associate Editor
Linda Olliver, Cover Design

ART AND DESIGN Linda Olliver, Director
NSTA WEB Tim Weber, Webmaster
PERIODICALS PUBLISHING Shelley Carey, Director
PRINTING AND PRODUCTION Catherine Lorrain-Hale, Director
Nguyet Tran, Assistant Production Manager
Jack Parker, Desktop Publishing Specialist
PUBLICATIONS OPERATIONS Erin Miller, Manager
***sci*LINKS** Tyson Brown, Manager

NATIONAL SCIENCE TEACHERS ASSOCIATION
Gerald F. Wheeler, Executive Director
David Beacom, Publisher

Featuring sciLINKS®—a new way of connecting text and the Internet. Up-to-the-minute online content, classroom ideas, and other materials are just a click away. Go to page x to learn more about this new educational resource.

Printed in the USA by IPC Communications, Inc.
Printed on recycled paper.

02 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Teaching teachers : bringing first-rate science to the elementary classroom.
p. cm.
"An NSTA Press journals collection."
Includes bibliographical references.
"NSTA stock number: PB167X"—T.p. verso.
ISBN 0-87355-203-2
1. Science—Study and teaching (Elementary)—United States. 2. Science teachers—Training of—United States. I. Title: Bringing first-rate science to the elementary classroom. II. National Science Teachers Association.
LB1585.3 .T415 2002
372.3'5044—dc21

2002003052
CIP

Contents

Strategies for Every Day

Acknowledgments

The thirteen articles in *Teaching Teachers: How to Get First-Rate Science into the Elementary Classroom* all come from the "Teaching Teachers" column in *Science and Children*, NSTA's elementary school-level journal. The column was skillfully edited for many years by Michael Kotar, Science Education Department Head at California State University at Chico.

In addition to reviewing the articles, Maureen Beringer Moir, chair of NSTA's Pre-Service Teacher Preparation Committee and professor of science education and graduate coordinator of elementary education at Bridgewater State College, wrote the introduction and guided the organization. Committee members Julie Gess-Newsome, J. Lawrence Walkup Distinguished Professor of Science Education and Director of the Science and Math Learning Center at Northern Arizona State University, and Marsha Winegarner, director of District V 00-04 and Council Liaison 01-04 for the Florida Department of Education, also reviewed articles and made valuable suggestions.

Betty Smith was NSTA project editor for the book. Shelley Carey, director of periodicals, was instrumental in developing the book. Linda Olliver designed the cover, Nguyet Tran handled book layout, and Catherine Lorrain-Hale coordinated production and printing.

Introduction

The advent of educational reform and the publication of national standards in the various disciplines have brought new vitality and challenges to our nation's teachers. We, as science educators, welcomed the *National Science Education Standards* (National Academy Press 1996) as the guidelines for our activities in the 21st century.

In 1999, as part of its executive restructuring, the National Science Teachers Association (NSTA) replaced its Teacher Education Division with two new positions, Preservice Teacher Preparation and Professional Development. This action recognized the importance that the organization places on assisting teachers at various stages of their careers and the importance on supporting life-long learning.

"Teaching Teachers" has been a featured department in *Science and Children* for several years. It has included articles on issues in teacher education and staff development, discussions of curriculum development and assessment, and pieces on a wide variety of teaching strategies. The thirteen articles in this collection represent exemplary views and practices that support the Standards in practical situations.

The Standards address the need for teacher education at many stages of a teacher's career. It is suggested that teacher needs as learners be considered and built upon to increase confidence in science teaching and understanding of content.

The articles in the first section discuss two critical issues in science education reform. In the first, "Science is Part of the Big Picture," Greenwood discusses the need to convince already-busy experienced teachers that effective strategies are worth the time and effort required. In the second article, "Reaching the Reluctant Science Teacher," Colburn and Henriques present a preservice program for future teachers who feel unequipped to teach science.

Curriculum integration has become the cornerstone of educational reform. The Standards remind us that unifying concepts and processes give students strong ideas that help them better understand the natural world. These unifying concepts, when linked to other content or connected to other disciplines, can be used at any grade level. The Standards also remind us that teachers must put more emphasis on scientific concepts and the development of inquiry. The integration of all aspects of the science content in the context of technology, personal and social awareness is encouraged.

Section Two presents four models for curriculum integration. In "Curriculum Integration" Kotar et al. describe a preservice project for the development of a thematic unit in science with cross-curricula connections. One of the many strengths of this program is the fact that the preservice teachers actually develop the unit and test it during their field experiences.

Another model for use with preservice and practicing teachers focuses on the premise that the integration of technology into a science methods course can be valuable. In "STEPS into Learning," Sillman et al. emphasize the criticism of and dissatisfaction with traditional courses and describe a successful course that both acquaints students with several technological applications and increases their understanding of the teaching and learning of science. In another integrated model, French and Skochdopole present the use of the learning center in the study of a well-researched life cycle to teach preservice teachers in an engaging manner. "It's a Salmon's Life" incorporates several content Standards within the Standards and describes many cross-curricula applications suggested by the students and instructors.

In "Teaching Science When Your Principal Says Teach Language Arts," Akerson discusses the benefits of teaching practitioners to combine instruction in science and the language arts. She documents how students can write about science ideas in order to correct misconceptions and promote understanding.

More than ever, assessment is a critical part of the teaching and learning cycle. The Standards call for more authentic assessment of what is valued in our curriculum. Alternative assessment has become more popular in recent years. In Section Three, several forms of alternative or nontraditional assessment are discussed. In “Assessment for Preservice Teachers,” Lehman suggests anecdotal observations, reflective journals and problem solving, integrated math and science data selection, and cooperative learning as possible assessment tools. In “Standards Direct Preservice Teaching Portfolios,” Mosely describes an exemplary portfolio project for preservice teachers.

The final section of this collection features articles that suggest a wide variety of methods for use in preservice classes and staff development workshops. Some of these strategies are tried and true; others are newer or less known. All can be employed to enhance our application of the Standards.

In “Using Effective Demonstrations for Motivation,” Freedman reminds us of the power of the use of a good demonstration or discrepant event in the elementary classroom. He also suggests that these demonstrations allow elementary students to see inquiry in action.

Few educators argue against the efficacy of hands-on science experiences. In “Managing Hands-on Inquiry,” Rossman describes a survey in which there was a significant discrepancy between teacher beliefs and actual practice. His suggestions for a more effective approach are extremely valuable. Gay and Wilcox discuss another increasingly popular approach in “Science Discovery Centers.” Preservice teachers design and present a center in which an appropriate topic is taught through interactive materials in actual school settings. A particularly effective part of this exercise is the adaptation of materials for age-appropriate groups and students of varying abilities.

Two especially challenging articles conclude this section. Bird describes the use of alternative modes of communication in “Talk Less, Say More.” The author points out that this method affords her science-shy students special benefits and increased involvement. In “Never Give ‘Em a Straight Answer,” Ward suggests that educators should capitalize on the natural curiosity of students of all ages – and teach with careful questioning.

Our preservice and practicing teachers are among our nation’s most valuable resources. Their ongoing professional development is critical. This collection suggests diverse ideas for consideration. All of them can be used to help us teach in the spirit of the promise expressed in the National Standards! “Teaching the Teachers” is still a rewarding and challenging task.

Maureen B. Moir, NSTA Teacher Preparation Director
Professor, Science Education, Bridgewater State College
February 2002

Teaching Teachers brings you *sci*LINKS, a new project that blends the two main delivery systems for curriculum—books and telecommunications—into a dynamic new educational tool for children, their parents, and their teachers. *sci*LINKS links specific science content with instructionally rich Internet resources. *sci*LINKS represents an enormous opportunity to create new pathways for learners, new opportunities for professional growth among teachers, and new modes of engagement for parents.

In this *sci*LINKed text, you will find an icon near several of the concepts being discussed. Under it, you will find the *sci*LINKS URL (*www.scilinks.org*) and a code. Go to the *sci*LINKS website, sign in, type the code from your text, and you will receive a list of URLs that are selected by science educators. Sites are chosen for accurate and age-appropriate content and good pedagogy. The underlying database changes constantly, eliminating dead or revised sites or simply replacing them with better selections. The *sci*LINKS search team regularly reviews the materials to which this text points, so you can always count on good content being available.

The selection process involves four review stages:

1. First, a cadre of undergraduate science education majors searches the World Wide Web for interesting science resources. The undergraduates submit about 500 sites a week for consideration.

2. Next, packets of these web pages are organized and sent to teacher-webwatchers with expertise in given fields and grade levels. The teacher-webwatchers can also submit web pages that they have found on their own. The teachers pick the jewels from this selection and correlate them to the National Science Education Standards. These pages are submitted to the *sci*LINKS database.

3. Scientists review these correlated sites for accuracy.

4. NSTA staff approve the web pages and edit the information provided for accuracy and consistent style.

*sci*LINKS is a free service for textbook and supplemental resource users, but obviously someone must pay for it. Participating publishers pay a fee to NSTA for each book that contains *sci*LINKS. The program is also supported by a grant from the National Aeronautics and Space Administration (NASA).

Science Is Part of the Big Picture

By Anita Greenwood

Recently, while leading a science workshop for elementary teachers, I experienced that "Aha!" moment of understanding that we educators always hope our students will have.

During a break, one workshop participant had described to me the demands being placed upon teachers in her school. "We are being told to use whole language, to try portfolio assessment, to teach hands-on science, to prepare thematic units, and to integrate mathematics and science," she said. "I don't even know where to start! There are so many things to do that it's like being asked to complete a jigsaw puzzle when each piece comes from a different puzzle and nothing seems to fit together." Her comments lead me to believe that I might finally understand one reason why inservice workshops often fail to have an impact on science teaching, and why even experienced teachers relegate science to the end of the day or avoid it altogether (McShane, 1995).

What Needs to Change?

Teachers consistently tell me that even though they know that letting children do hands-on science is beneficial, they nevertheless avoid teaching it or treat it as an add-on to the "core" of the elementary school curriculum. These teachers, typified by the workshop attendee who had given me such insight, do not see the links among the many new things they are being asked to incorporate into their teaching. Other workshop participants expressed the opinion that ideas presented to teachers during staff-development sessions are often just the latest fads, which tend to fizzle and die like spent firecrackers on the fourth of July. Then and there, I recognized that I, too, had failed to provide these teachers with the theoretical background that informs practice. In other words, I had launched into the "how to" of science teaching and had ignored the "why."

As a result, I restructured my workshop series so that teachers would become real science *learners,* struggling with their own ideas about the phases of the moon, seasons, living and nonliving things, and so on as they designed experiments and shared theories with their peers. Teachers designed experiments to test their *own* ideas, and they discussed their old and new conceptions in relation to scientifically accepted models.

For example, in a workshop relating to density, teachers generated two competing ideas for why objects float and sink: objects float because they contain air, and objects sink because they have more mass than objects that float. To test their ideas, one group of teachers took jars and filled them with varying amounts of rocks until the jars sank; however, as everyone could see, the jars still contained air. Another group of teachers tested objects of the same mass but of different shape, and they discovered that mass alone was not the determining factor in sinking or floating. Working with their own ideas, teachers were more willing to search out alternative explanations, leading them eventually to conclude that while sinking and floating are related to mass and to the space taken up by an object, they are dependent on an object's density, which is reduced with the inclusion of air.

In another workshop, teachers kept a moon journal and generated a list of related "I wonder" questions, including

- I wonder where the moon is when I cannot see it;
- I wonder if the moon rotates, because I always seem to see the same face;
- and, I wonder what causes a lunar eclipse.

The teachers then explored each question through the use of models, working in a darkened room with an electric light representing the sun and a large plastic-foam ball on a wooden stick representing the moon. By holding the ball at arm's length and passing it around their own bodies, which represented Earth, the teachers were able to observe the reflection of light simulating the phases of the moon. This activity caused teachers to conclude that a lunar eclipse occurs every month! Knowing that this was not the case, the teachers used their models and further discussion to work out for themselves that the orbit of the moon around the Earth must be tilted with reference to the Earth's axis.

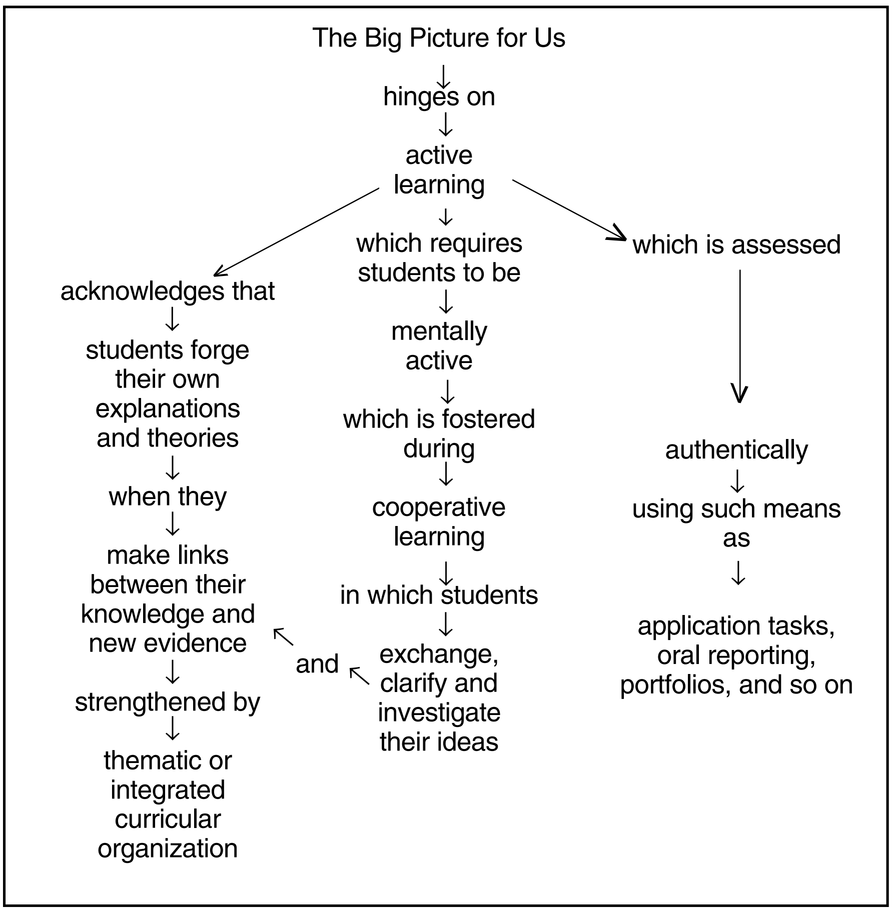
Through additional modeling and discussion, the teachers were able to resolve their conceptual difficulties related to the moon's phases and its rotation.

At the end of these redesigned workshops, we discussed what it was like to learn science and how that experience would affect their own classroom teaching. Through this new approach, teachers in my workshops began to recognize the "big picture" that frames the pedagogical changes they are being asked to implement.

Science Methods in Motion

If you believe that children are constantly attempting to explain all that they see and do, that they are trying to come up with theories about their world that make sense to them, then you already acknowledge that they are *active learners*. Active learning refers not only to physical activity, but also to mental activity. The teacher's role is to spark this mental activity by helping students connect what they already know with new experiences encountered in the classroom. This view of learning is part of the movement in science education known as *constructivism* (Driver and Oldham, 1986). When learning is recognized as a constructive activity, it provides a rationale for using cooperative grouping, alternative assessment, thematic teaching, and active learning in science.

This concept map shows how pedagogical ideas are linked.



The move toward thematic teaching acknowledges that children do not naturally categorize what they learn by subject; rather, they separate their knowledge into "little boxes" because of the way we organize the school day. By the time they reach high school, students so compartmentalize their learning that they don't relate the mathematics they learn during second period to the mathematics skills they need for their sixth-period science class! Making science part of a thematic or interdisciplinary unit helps students to forge appropriate connections and makes their learning more meaningful.

How, then, should we go about designing the science part of such interdisciplinary units? One way to start is by probing students' prior knowledge. Research has shown that students come to class with their own theories about how the world works (Asoko, 1993; Driver, Guesne, and Tiberghien, 1985). Such strategies as concept mapping, poster development, predict-observe-explain, line drawings, and sequence chains can elicit children's ideas (White and Gunstone, 1992), and then the teacher can focus instruction accordingly.

Most teachers believe that science lessons should involve students in inquiry, but they do not know how to change textbook exercises into active, challenging investigations. One approach is to rephrase as a question the title of a textbook exercise. In the primary grades, questions should lead to children developing their science process skills. The teacher might ask, for example, "What can you find out about feathers using a ruler, a hand lens, an eyedropper, a timer, and graph paper?" In grades 5–8, an appropriate question would be, "What factors affect how well lemonade crystals dissolve in water?"

Children should work cooperatively in groups to investigate these questions—exploring their ideas with peers, developing ways to test their thinking, and presenting findings from their data to the class. Activities that contradict children's misconceptions (identified by the teacher through the probing strategies described above) will lead students to question their prior understandings. From these initial explorations, students themselves generate more questions leading to further investigation.

Of course, there are questions that classroom investigations cannot answer. Such questions may become the subject of a student research project or a carry-over to their work in science the following year, or they may provide fodder for an e-mail conversation with a scientist.

Children should review their learning by revisiting the concept maps or other work they created at the beginning of a given unit of study and then revising these materials in light of what they've learned. This gives students concrete evidence of their learning and provides the teacher with a useful assessment tool.

Finally, there is little point in encouraging students to think, share, investigate and develop explanations if they are only going to fill in the blanks on a test sheet. Instead, teachers should use authentic assessment, in which students can apply their learning and teachers can evaluate their performance—to what degree they follow directions, organize the data they collect, use measuring instruments appropriately and accurately, and develop explanations for their observations. In addition, portfolios are an excellent way for students to select evidence and maintain a record of their developing skills and knowledge.

Teachers as Learners

Once I had restructured my workshops so that the attending teachers experienced science as *learners* would, workshop participants began to consider changing their own instructional strategies. They recognized that when their ideas were challenged and sometimes shown to be false, the teachers became intensely interested in their learning. Additionally, workshop attendees saw how the pedagogy advocated in a variety of professional development workshops assisted them in learning science. For example, cooperative learning is more than a grouping strategy; it provides an atmosphere conducive to the exchange of ideas and to inquiry.

By becoming active learners themselves, these teachers recognized that science is part of the "big picture," and they were able to link newly constructed ideas about active learning to other pedagogical initiatives (see figure). At the same time, I learned a valuable lesson, too: that I must not neglect theory if the teachers I train are to develop a model that assists them in modifying their instructional approaches and makes sense of professional development activities.

Resources

Asoko, H. (1993). First steps in the construction of a theoretical model of light: A case study from a primary school classroom. *Proceedings of the Third International Seminar on Misconceptions in Science and Mathematics Education.* Ithaca, NY: Misconceptions Trust.

Driver, R., Guesne, E., and Tiberghien, A. (Eds.). (1985). *Children's ideas in science.* Milton Keynes, United Kingdom: Open University Press.

Driver, R., and Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education, 13,* 105–122.

Grennon Brooks, J., and Brooks, M. (1993). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Design.

McShane, J. (1995). Editor's note: Science is a priority. *Science and Children, 32*(4), 4.

White, R., and Gunstone, R. (1992). *Probing understanding.* Bristol, PA: The Falmer Press, Taylor and Francis.

ANITA GREENWOOD is an assistant professor of science education at the University of Massachusetts Lowell.