PERSPECTIVES

RESEARCH & TIPS TO SUPPORT SCIENCE EDUCATION, K–6

Edited by
Deborah Hanuscin and
Meredith Park Rogers

NSTA press
National Science Teachers Association

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Dedication

Sandra "Sandi" K. Abell, editor of the column "Perspectives" in the National Science Teachers Association (NSTA) journal *Science and Children* from 2006 to 2009, was a Curator's Professor of Science Education at University of Missouri where she directed the MU Science Education Center. She was also a fellow of The American Association for the Advancement of Science (AAAS), an NSTA Distinguished Fellow, a recipient of the Outstanding Mentor Award from the Association for Science Teacher Education, and co-editor of the most recent edition of the Handbook of Research on Science Teaching. Even more, she was a trusted colleague, loyal friend, and advocate.

We lost Sandi to cancer in 2010, but we still feel her influence today through the "Perspectives" column. We created *Perspectives: Research and Tips to Support Science Education, K–6* not only to recognize Sandi's many contributions to the field of science education as a whole but also to honor her first teaching love: elementary science. She was a mentor, a true colleague, and a friend. Sandi's work has helped change the landscape of how science is taught in the elementary classroom, and with this collection, we hope to continue her legacy of improving elementary science education.

Foreword

At times, teaching can feel isolating—just one teacher alone with a classroom of students. However, many teachers can also pinpoint a time in their careers when their view of teaching was influenced by observing, talking, or reading about others' teaching. Successful educators draw on their own experiences, their colleagues' expertise, and research findings to inform their practices. NSTA journals, *Science and Children* (*S&C*) in particular, provide teachers opportunities for self-directed professional development as they read and consider articles in each month's issue.

The S&C column "Perspectives: Research and Tips to Support Science Education" grew from the understanding that the literature published in research journals is not always in an easy-to-read and accessible format for teachers, but that research often has significant implications for teachers' day-to-day work with students. Under the editorship of Chris Ohana, researcher and former elementary teacher Sandra "Sandi" K. Abell took the helm in identifying key classroom issues that elementary teachers face in teaching science and those that research might help shed light on.

Sandi viewed herself first and foremost as an elementary teacher. She taught in the classroom for many years and understood the particular challenges a generalist teacher faces, such as trying to find time to teach science when other subjects receive greater focus, or teaching science as inquiry when that approach contradicts the teacher's own experience of learning science. However, as a researcher, Sandi also understood the need for inquiry in science education and the ways in which this method promotes the kind of critical-thinking and problem-solving skills students need to learn while also providing them with a rigorous understanding of the science content. She had an appreciation for the difficulty in implementing high-quality science instruction and for the importance of classroom talk; formative assessment; and attention to the diverse needs, interests, and abilities of students.

With this dual perspective of teacher and researcher, Sandi approached the "Perspectives" column with the mindset of empowering teachers with approaches and methods that would not only support the teaching of science as inquiry but also the development of scientific literacy for all learners. The "Perspectives" column became a forum for bridging the research-practice gap by targeting primary concerns of classroom teachers with critical and seminal research.

Perspectives: Research and Tips to Support Science Education, K–6 contains 27 chapters, and each chapter presents an article from the "Perspectives" column. Under Sandi's guidance, authors of the "Perspectives" columns were prompted to always approach their chosen topic from the perspective of the classroom teacher. Considering this viewpoint, each chapter in this book begins with a classroom vignette—something that a classroom teacher can perhaps relate to—that helps to set the stage for the remainder of the chapter. Next is a synthesis of key research findings, organized around a series of questions. Each chapter concludes with specific recommendations for teachers that bring new perspectives to elementary teachers who are looking for ways to better support their students' learning in science.

In addition, this compendium is organized into several broad categories, including issues related to student thinking, integration of science with other disciplines, and facilitating instruction. Although the sections are organized around themes, they do not need to be read in a particular sequence. This book serves many functions. It can be used with beginning teachers in the context of a preservice elementary science methods course, with practicing teachers in a professional development context, such as a book study, or even by an individual teacher looking for support as he or she tries to implement innovative practices. Prospective teachers will find that the chapters are accessible means for developing awareness of the research base and understanding the underlying rationales for specific strategies and practices. Practicing teachers will find that the chapters are useful tools for enhancing their own perspectives on teaching and learning, and a way to further improve their practices. For both groups, however, the power of these articles lies in challenging the notion that there is a gap between research and teaching that cannot be bridged. As Sandi so clearly understood, the two must go hand-in-hand.

Suggested Uses

Below, we share two examples of how we have used chapters from *Perspectives: Research and Tips to Support Science Education, K–6* in our own work with preservice and practicing teachers. The possibilities for how to use this compendium to support elementary teachers' thinking, reflection, and views toward teaching inquiry-based science are not limited to these. We encourage you, whether alone or working with colleagues, to explore how the research synthesized in these chapters has relevance and potential application to your teaching. Our hope is that by bringing all of these columns together, Sandi's passion for science and the teaching of science will provide readers with the inspiration and support to improve their science teaching for the benefit of their students.

Example Use: Professional Development

In workshops with teachers, we use Chapter 5 "Examining the Learning Cycle." Many of the teachers we work with already use hands-on activities, as suggested in the classroom vignette at the beginning of the chapter, but they still aren't satisfied with their students' learning. Reading and discussing this chapter opens up opportunities for teachers to consider why some approaches to using hands-on activities may not be effective and introduces them to the research base in support of the learning cycle approach. Thus, teachers are provided a rationale for exploring the impact of this approach with their own students. As suggested by Brown and Abell, teachers peruse examples of learning cycle lessons related to their units of science instruction (see Chapter 5 References on page 23). After trying these with their students, teachers report their experiences within their professional learning communities (PLCs) and compare this approach to how they might have traditionally approached the lesson in past years. By working together, teachers support one another in taking risks to try new things and in critically evaluating the impact of changes in their instruction. The chapter is a springboard for this type of professional development, but we have also found that the chapter itself becomes a tool for teachers to communicate with others (e.g., principals, colleagues, and parents) about what they are trying and why.

Example Use: Preservice Teacher Education

For many beginning teachers, the skill of asking productive science questions that generate classroom talk, promote student-centered learning, and inform teachers of students' scientific thinking, can be a difficult skill to learn. Many do not realize that there is an art to asking good questions until they read Chapter 25 "The Art (and Science) of Asking Questions." The vignette that begins this chapter demonstrates the difficulties that classroom teachers can sometimes face when they want to ask questions that will spark rich conversations about science concepts, but instead the questions result in limited or no discussion at all. This chapter provides the foundation for why developing good questioning skills is important to science teaching and learning, and sets the stage for what it can look like in a classroom. The research highlights the types of questions that work and don't work to promote students' scientific thinking. Building from the suggestions at the end of the chapter on how to become a better questioner, we use the methods class then to work through a series of activities in which the preservice teachers practice forming questions that serve various purposes and explore different scientific phenomena. They also learn to critique their own questioning skills and those of their peers through a mock interview workshop. As they move to teaching science in their early field experience, the preservice teachers are once again reminded at the end of the chapter of the tips for becoming a better questioner. They are challenged to select two or three skills that they want to work on over the five weeks during which they are teaching science to children in schools. After teaching, they reflect on how they perceive the use of those skills has helped them to build their knowledge and practice of becoming a better questioner and, thus, a better science teacher.

Conclusion

What we have shared are just two ways, albeit within different contexts, of how the chapters from this compendium can be used with teachers to support and further develop their understanding of how to teach science. Even though the chapters are grouped into topical themes, each has the potential to stand on its own and can provide teachers with a new perspective for thinking about their science teaching. We encourage all educators to think about how these articles can not only be used as an introduction to a topic but also as an anchor for discussions on effective, research-based elementary science practices.

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Assessing and Addressing Student Science Ideas

By S. Rená Smith and Sandra K. Abell

"A colleague and I were talking about our recent science units. He mentioned that several of his students still had some 'wacky' ideas about certain concepts. I noticed from my pre- and posttests that a few of my students still had misconceptions too. What can we do to assess and address students' science ideas?"

Where do students' "wacky" science ideas come from?

Our students are not blank slates. They come to school with a wide range of experiences that have shaped their science understandings—reading books, watching TV, playing video games. Sometimes these sources get the science wrong (for example, the popular Pokemon game uses the term *evolution* instead of *metamorphosis* when referring to creatures going through life stages). In a study of 79 children's books, Trundle and Troland (2005) found that many books reinforced misconceptions about Moon phases and contained incorrect pictorial representations. Everyday language also contributes to scientific misunderstandings. Phrases such as "shut the door or you'll let the heat out" can cause students to think that heat is a substance, not a form of energy. Interactions with phenomena can lead to inaccurate scientific understandings. For example, although any two objects will fall at the same speed in a vacuum, in everyday life a feather falls more slowly than a coin because of air resistance. Finally, students can construct inaccurate meanings from science instruction itself. Students can ignore teacher talk, use "noises that sound scientific" to represent incomplete understanding, or be confused by mismatches between their language and the teacher's (Osborne and Freyberg 1985). From many years of research about student science ideas, we know that student science misconceptions are prevalent, strongly held, and highly resistant to change.

How do I find out what misconceptions my students hold?

Researchers have used a number of strategies to assess student science ideas. The most common strategy is the individual interview (Osborne and Freyburg 1985). Interviewers ask students to explain phenomena and probe for more information. Or they provide words and pictures for students to sort based on their understanding of concepts like animal, living, matter, and electricity. However, the individual interview strategy may not be practical for the classroom. Other useful tools for assessing student science ideas include the two-tiered test (in which a multiple-choice item is followed by the opportunity to explain one's reasoning), open-ended questions that lead to children writing and drawing about their ideas, and concept maps. Page Keeley and her colleagues (2005, 2007) designed a set of formative assessment probes to uncover student ideas. However, the simplest way to assess student ideas might be to listen to the students during class discussions and pay attention to what they write and draw in their science notebooks.

What misconceptions can I expect?

Teachers do not have to interview or test every student to find out their ideas—many science misconceptions are quite common and can be predicted. The internet is a valuable resource for delineating possible student misconceptions before the start of a unit. For example, some university science teacher educators have websites that list student science ideas (Hanuscin 2001). Some researchers have compiled the findings from numerous studies of children's ideas in various science topic areas (see Driver et al. 1994). Other books describe in-depth studies of student learning in one area, like Shapiro's (1994) study of fifth graders learning about light. Some science curriculum materials also list common student misconceptions. For example, in a unit about force and motion, it is common for many students to think that a force is needed to keep an object that is moving in motion; students also have trouble understanding how a wall or a table can exert a force on their hands. When teachers are aware of these areas of potential difficulties, they can begin to plan instruction that will address student misconceptions.

What strategies can I use to address students' misconceptions?

There is widespread agreement among science education researchers that the first step in students changing their conceptual understanding is becoming dissatisfied with their current ideas. Activities that challenge students' ideas, such as discrepant events, create disequilibrium that students want to resolve. Furthermore, students need to be presented with new concepts that are reasonable and meaningful to them (Shapiro 1994). Many researchers have found that a learning cycle approach (Brown and Abell 2007), with opportunities for exploration and science talk, can lead to conceptual change. For example, Gang (1995) found that using a learning cycle with middle school students to help them understand Archimedes' principle was more effective than traditional presentation and demonstration. Hardy and colleagues (2006) investigated third-grade student learning about floating and sinking. They found that students who received high instructional support in the form of discussion, reflection, and connecting concepts developed more coherent understandings of floating and sinking than students with less instructional support. Maria (1997) followed one boy from kindergarten through third grade, tracking his understanding of the causes of day and night and the seasons. Developmentally appropriate instructional scaffolds (e.g., exploring models, engaging in hands-on activities, and discussing what he read) helped him restructure his ideas. Good science instruction can lead to conceptual change—that's what Trundle and her colleagues found (2007) when studying fourth graders learning about phases of the Moon. What we learn from all of these researchers is that when students actively participate in science by doing and thinking and communicating, conceptual change is possible.

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RESEARCH & TIPS TO SUPPORT SCIENCE EDUCATION, K–6

"This book provides research-based justification for the types of inquiry-based science practices we want K–6 teachers to be doing. It answers the questions 'Why does science need to be an elementary classroom?' and 'What are the most effective approaches to teaching science in an elementary classroom?' "

—Editors Deborah Hanuscin and Meredith Park Rogers

Here's a time-saving way to learn what research tells you about teaching elementary science and applying the findings both inside and outside your classroom. It's a collection of 27 "Perspectives" columns from *Science and Children*, NSTA's award-winning elementary-level journal. The book is organized in six science-specific sections, including general teaching goals, strategies to facilitate learning, student thinking and misconceptions, and your own professional development. The columns are written to make it easy to grasp the material and then use what research tells you about issues of specific interest to K–6 science instruction. Each column

- starts with a classroom vignette highlighting a particular challenge—from using analogies to blending science and reading instruction to effective ways to ask questions;
- provides a synthesis of key research findings, organized as a series of questions; and
- concludes with specific advice you can use right away.

This useful compendium is ideal for K–6 teachers as well as science supervisors and preservice elementary science methods professors who want more students to benefit from what research tells us.

Grades K–6

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