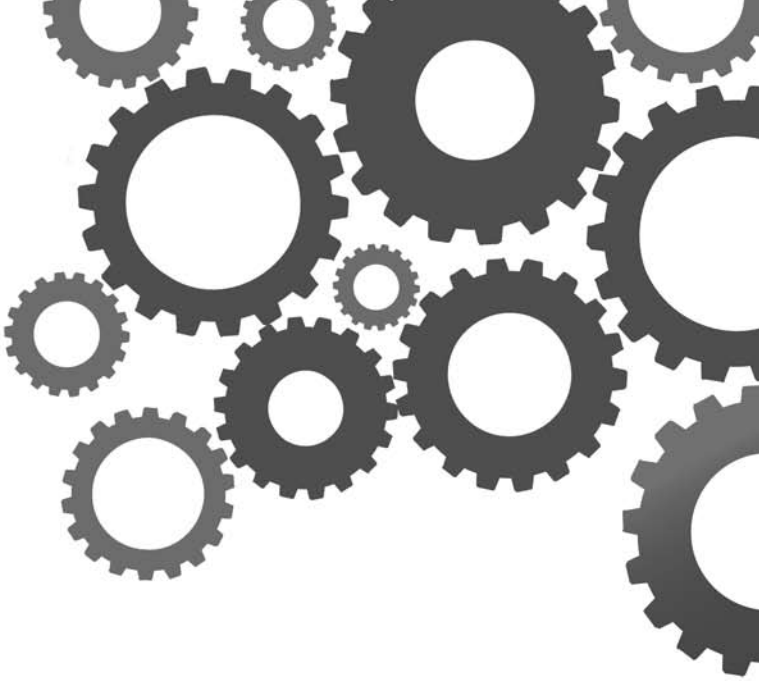

Introduction

Why This? Why Now?

Science teachers, like all teachers, start each school year with high hopes and expectations for students to succeed. They plan their lessons, scramble to get the necessary equipment, and work hard to engage their students. However, despite good intentions and best-laid plans, not all students do well in science classes, and even fewer achieve mastery. We see the effects of this all around us. Student performance on national and international assessments, including science assessments, is poor. More and more adults are unable to understand the scientific issues that affect their lives and society. The media reports that national economic competitiveness is at stake. It's clear that something must be done now to help science teachers put power behind their hopes and expectations for student achievement.

Designing Effective Science Instruction: What Works in Science Classrooms is meant to help teachers focus on what can and must be done. It draws upon recent research in science education, most notably a well-designed study of science classrooms which sheds light on possible reasons for poor student performance in science (Weiss et al. 2003; Banilower et al. 2008). This research study and subsequent report on effective science instruction revealed that in a national sample of science classrooms, about two-thirds of science lessons observed were of low quality. In other words, too many science students sit passively, never being asked to make sense of the content that teachers deliver. Too many science activities masquerade as science lessons and fail to develop students' understanding of science concepts. Too many teachers lower their expectations and avoid teaching a rigorous science curriculum. The pressure teachers feel to meet student achievement goals is immense. With emerging research findings about how students learn and how to teach effectively, guidance for teachers is available.

The Weiss et al. study also tells us that teachers often are unaware that research has identified teacher knowledge and skills that support the development and delivery of science lessons that foster student learning. This and other research

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

on teaching and learning lead us to believe that designing high-quality science lessons that include research-based instructional practices is a logical first step to improving *all* students' science learning. As a result, *Designing Effective Science Instruction* focuses on strategies that science teachers at all levels can use to make their science lessons better.

Educational research on learning and effective science instruction has much to offer us in meeting the challenges of educating students to high standards. What is missing in previous books on effective science lessons and instruction is a synthesis of the research that focuses on the essential findings and the implications for instructional practice. *Designing Effective Science Instruction* provides that bridge between research and practice, and does so in a format that is easy to learn, use, and continue to apply.

This book will describe the characteristics of high-quality science lessons, help you reflect on what is working well with your current approach to designing lessons, and provide recommendations for improving existing lessons or creating effective new ones. Whether you are a novice or veteran teacher, the self assessments and recommendations in this book will provide guidance that supports and encourages you to refine what you do to become a more effective science teacher. You can use this book to decide what practices will work for you and your students, but you are encouraged to work with others as you plan for and revise instruction, interpret student work, and determine what changes you will make to your teacher practices. Planning for your own professional development is one way to use the information contained in this book. Many resources are available to help you plan for meaningful professional development that is ongoing and uses a model that features reflective practice in the real world of teachers. The National Science Education Standards (NRC 1996) for teaching and professional development provide a starting point and helped to inform this book.

No matter what grade level you teach, you will benefit from learning the Content-Understanding-Environment (C-U-E) instructional framework described in this book. We believe that if you understand and apply this framework, you will be able to approach lesson planning with confidence and develop well-planned, effective science lessons. In addition, you will be able to pinpoint aspects of your instructional practice that need improvement and seek out the content knowledge and experiences that will be most helpful in making you a more effective teacher. Together these will lead to positive teacher and student attitudes toward science learning and positive science achievement results for all students.

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

Organization of *Designing Effective Science Instruction* book

Designing Effective Science Instruction: What Works in Science Classrooms (DESI) is organized into five chapters. The next four chapters introduce the C-U-E instructional framework and provide details about each of its three elements (Content, Understanding, Environment). The contents of chapters 2 through 5 are described briefly below.

Chapter 1. Building the Framework. This chapter focuses readers on the following questions as the three components of the C-U-E framework are introduced:

- Effective science teaching: What does it mean and how does it look?
- What are the barriers to effective instruction?
- What does research say about effective science instruction?
- Why the Content-Understanding-Environment framework?

This chapter emphasizes that all three elements must be addressed during lesson design and implemented effectively when delivering science instruction.

Chapter 2. Identifying Important Content. This chapter focuses on identifying important content, clarifying student learning goals, sequencing learning activities to achieve those goals, and aligning assessments with content. This necessitates thinking about ways to prune the curriculum and determine student prior knowledge and preconceptions.

Chapter 3. Developing Student Understanding. Using the research on how students learn science, this chapter will help readers learn how to make lessons learner-centered, help students make meaning and build connections among science concepts, and develop each student's ability to learn. To support sense-making, we include strategies that address misconceptions, that make student thinking visible with classroom discourse and that encourage formative assessment processes to identify student learning and provide feedback.

Chapter 4. Creating a Learning Environment. Interactions, routines, and informal feedback that occur every day in the classroom can undermine or enhance learning. This chapter presents strategies related to teaching students to take responsibility for their thinking and learning and to developing positive working relationships with others. Student engagement and motivation are critical components of collaborative classroom environments, and strategies that address these components are included in this chapter also.

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

Chapter 5. Teacher Learning: A Beginning Teachers continue to learn throughout their lifetimes. All teachers can learn just as all students can learn. To move from "surviving to thriving" we need to look at how the instructional framework applies to us. The key to this work is establishing an environment for ourselves that promotes learning—learning and thinking about the content we teach, learning about content-specific strategies that move students' thinking forward, and learning how to keep a balance but still move forward.

The Audience for *Designing Effective Science Instruction*

First and foremost, this book is valuable for science teachers, both veteran and novice, at all grade levels. It is also of value to anyone concerned with improving science education and nurturing effective science teaching. This latter group includes principals and department heads, curriculum specialists, science mentors, professional development providers, and professors in schools of education. Different science professionals will use the information in this book differently, depending on their goals for improving science instruction.

Teachers at different grade levels and with different levels of experience will focus on different aspects of the book. This is not meant to be a prescriptive, one-size-fits-all book. All teachers will take away lessons that meet their individual needs and promote self-examination of their current instructional practices. For example, if you're a veteran high school teacher, you probably have significant content knowledge; thus, you will benefit most by focusing on lesson design and developing student understanding. In doing so, the biggest change for you may be shifting from a teacher-centered classroom to a student-centered environment. All teachers, though, whether novices or veterans, will want to learn more about how to promote effective science instruction that focuses on important content, engages students in science inquiry, promotes student sense-making using science discourse, and involves students in formative assessments and student self-assessments so that both students and teachers will know if learning is taking place.

Principals and department coordinators, who are responsible for ensuring that science lessons are of high quality, can use the recommendations in this book when analyzing curriculum, providing professional development for staff, and helping teachers create a community of support for instructional change. Without such support from principals and department coordinators, even well-intentioned and highly qualified teachers may become discouraged and some may choose to leave the profession altogether.

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

Other professional development providers, too, can use the information in *Designing Effective Science Instruction: What Works in Science Classrooms* to create professional development experiences that directly address the strategies in the framework or to help teachers develop a deeper understanding in each area of the framework. All professional development providers who use the research base and proposed strategies in this book, whether principals, department coordinators, or teacher leaders, are responsible for creating the conditions for teachers' success—making the appropriate connections between professional development experiences, helping them understand how all the pieces fit together, and providing them with opportunities to implement, then reflect on, new strategies as they develop a new repertoire of instructional practices.

Last but not least, *Designing Effective Science Lessons* contains valuable information for prospective science teachers. This book could be used as part of a course for preservice teachers, laying the foundation for effective science instruction and high-quality lessons as they learn how to teach. The instructional framework and recommended strategies could help preservice teachers set appropriate goals, envision effective science instruction, and learn how best to approach planning their lessons.

How to Get Started With the Book

The first step to getting started with this book is to get familiar with the C-U-E framework in Chapter 2. Because the C-U-E instructional framework represents a coherent whole, make sure to pay attention to all of its parts. Incorporating any one of the strategies in lesson design will increase lesson effectiveness, but this approach will not be as effective as using the entire framework to design your lessons. At the same time, selecting one or two strategies to practice at a time to see how they work can be a good approach initially. The strategies you choose as a focus will most likely relate to your biggest challenges. Your unique classroom and community context will determine how you will get started. The key to remember is that you will want to be able to answer the following three questions:

1. What essential learning are you including in your lessons and unit of study? (Content—C)
2. What learning experiences will you provide to develop student conceptual understanding? (Understanding—U)
3. How will you and your students support a positive classroom environment that supports learning by all students? (Environment—E)

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

Depending upon your prior teaching and learning experiences, some of the strategies may not be new to you. So, how do you know what you don't know? The first step is to take the self-assessment found in *Chapter 1: Building the Framework*. The results of this assessment, along with your knowledge of your students' needs, will help you select and prioritize the areas on which you will work first. After working on your highest priority, you can revisit your self-assessment results and pick up the next-highest priority area to reinforce the initial progress you will make.

As with anything new, the first time you try something in class, you may not achieve an instant solution to the instructional problem you were trying to solve. To avoid disappointment, we recommend that you take the approach of a learner when trying to improve your use of these strategies. That is, learn about the strategy, try it, reflect on it, practice and reinforce what is working well. You can also engage your students in a discussion of strategies that you are trying and ask for their feedback and suggestions. This will help students understand what is going on in class and alert them to the possibility of instructional experiences that might be different from what they are used to. And if you have the capacity to work with other teachers, engage in peer discussions and reflection as part of a continuous process of improvement.

Bear in mind that the areas in which educators most need to improve will be those with which they are least comfortable. Tackling areas that are difficult for you can lead to significant changes in instructional practice, but it will take time and practice to use new instructional strategies effectively. Engaging in action research—trying lesson revision strategies, gathering data about their effectiveness, reflecting on implementation, and perhaps involving students in evaluating what's working—is one way to help you persevere. Though the process of change is difficult, relying on the research and experiences behind the recommendations will also help keep you going.

A Personal Note

I believe that if you use the C-U-E framework, you will improve your teaching and your students' learning. I believe this because the C-U-E framework addresses essential aspects of effective science instruction and high-quality science lessons. If the lessons you use every day in your classroom are designed around this framework, positive results are highly likely. Although some of the strategies in this book are ones that you have already mastered, you may find that the way those strategies are organized represents a new approach to instruction for you. All the

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.

parts are put together into one complete framework that is easy to follow, practical, and empowering. And it is tried and tested; it reflects what I have learned over three decades of teaching and professional development combined with—and confirmed by—the practices of the best teachers that I know and the most recent research findings available.

Whether you are in a classroom teaching students, working with other science teachers, or learning on your own, I trust that you will find this book informative, relevant, credible, and enjoyable to read. My goal is not to provide an educational "silver bullet" for science teachers but, rather, to help build a community of science teachers willing to try new things and dedicated to helping all students learn.

References

Banilower, E., K. Cohen, J. Pasley, and I. Weiss. 2008. *Effective science instruction: What does research tell us?* Portsmouth, NH: RMC Research Corporation, Center on Instruction.

National Research Council. 1996. *National science education standards*. Washington, DC: National Academy Press.

Weiss, I., J. Pasley, S. Smith, E. Banilower, and D. Heck. 2003. *Looking inside the classroom: A study of K–12 mathematics and science education in the United States*. Chapel Hill, NC: Horizon Research, Inc.

Copyright © 2009 NSTA. All rights reserved. For more information, go to www.nsta.org/permissions.