Foreword

Accomplished science teachers are a joy to watch in the classroom. They pose engaging questions, they use students' ideas and experiences as stepping-stones for knowledge construction by the whole class, and they allow students to test their emerging theories through experiment and conversation. They do all this while pressing young learners, gently but relentlessly, to develop coherent and evidence-based explanations of the natural world.

But what often appears to be a spontaneous teaching performance is really the product of careful planning. The classroom activity itself is guided by instructional goals and principles for in-the-moment decision making that may not be evident to an observer. In fact, much of what contributes to expertise is invisible. For those of us who are passionate about the continual improvement of teaching, we want to know what is going on "below the surface" of classroom activity that allows some educators to consistently open up opportunities for learning, and to do so for all students. The authors of this book have clearly been hard at work on this puzzle.

We too, at the University of Washington, have been interested in the trajectories of teachers' practice over time, and the transitions from mere survival in the classroom, to competence, to instructional excellence. Several years ago we followed dozens of novice educators from our teacher preparation program into their classrooms and observed how they planned lessons and interacted with students. We found, in one case after another, that our young teachers struggled to manage instructional conversations with students. It wasn't that they could not get talk started, as they were quite able to get it under way. For example, one of our teachers asked his sophomore biology students why they thought physical traits in humans sometimes appeared to skip a generation ("Who has their grandfather's nose?"); a middle school teacher asked her students to speculate why some very heavy objects would float in water (ships) while some not-so-heavy things (a grain of sand) would sink. These questions initiated a lot of hypothesizing, but in a matter of minutes our novices were responding to students with remarks like "OK," "Uh-huh," "That's interesting," and "Shall we make a list of these ideas?" When we interviewed them after class they reflected on their discussions in the same way one might talk about a hiking trip gone awry: "I started us off OK but then lost track of where we were going," "The kids went in directions I was not expecting," or "I had no idea where we were supposed to end up."

This marked the beginning of our research group's focus on classroom talk as a tool for supporting student reasoning. We continued to study our beginning teachers, but we also studied science educators who were highly skilled at talk, and we began to notice that the more expert the educator, the more prominent the students' roles in the conversations were. Experts actually talked less, but they were strategic in how they responded to students' ideas. We also could see that experts at classroom discourse had a clear goal for the talk, even though it seemed they were letting students control much of the dialogue.

It should be clear by now that we and the authors of this book share a passion about classroom discourse, and it is no surprise that there have been some interesting convergences in our ideas. Here's my sense of what we agree on, based on the rich examples of teaching practice in the pages that follow.

First, carefully orchestrated talk promotes deep and robust reasoning. Put more simply, talk mediates thinking, and students need more chances to talk, but with specific forms of guidance. Managing talk is also critical for engaging learners in the characteristic activities of science—that is, specialized forms of language are needed to formulate questions that interest students; to build and critique theories; to collect, analyze, and interpret data; to evaluate hypotheses through experimentation; and to communicate findings. This is actually unnatural talk for students; they need to have modeled for them how one expresses hypotheses in response to observations, how a person argues about evidence, and how they might critique another person's scientific model.

Second, a teacher has to anticipate what kinds of activity and talk will be needed to accomplish particular instructional tasks. But being smart about anticipating means that you interrogate your own understanding of the subject matter. We urge the teachers we work with to base their units of instruction on a complex phenomenon and then, working in groups together, develop a full causal explanation for that event or process before they start planning lessons. The examples in this book portray students who are involved in high cognitive demand activities, and it is clear in the exemplar vignettes that the teacher has deepened her or his understanding of the content to help them interact with students' ideas. These teachers are prepared.

Third, we seem to agree that teaching is "working on students' ideas." This means that teachers have to elicit what students are thinking and make that thinking public and visible in some form. They need to ask students to compare ideas, critique the ideas of others, change ideas in response to new experiences and concepts, be able to identify where the gaps in their current understandings are, and identify resources that will move their thinking forward.

And finally, great teaching is "learnable," especially if it can be represented as principled practices and if teachers get chances to try out these strategies with students over an extended period of time. This is the utility of having a focused set of teaching practices, such as the five in this book, that can be enacted with any kind of science subject matter—you get better at them with repeated and varied attempts. In our experience, students also get better at the discourses, and in the process they adjust to the higher expectations for intellectual work.

Occasionally when I help teachers work on their practice, I reflect back on my own thirteen years of middle school teaching. I was a popular educator—I knew my subject matter, I was organized, and I enjoyed working with young learners. But at that time there was little known about the power of talk in classrooms or about being mindful of something called cognitive demand. At that time you just taught what was in the curriculum! When teachers in my school attended professional development, it was generic and rarely (as it remains today) about effective teaching practice. Instructional excellence remained an idea, an aspiration, and it was never embodied in rich classroom examples of rigorous and responsive interactions with students.

I think that back then, if I had access to the ideas in *5 Practices for Orchestrating Productive Task-Based Discussions in Science,* I might have marched down to the principal's office and asked that our science department create its own professional development experiences, using the ideas in this book as a framework. If you think similarly after reading this book, here are some steps that we've seen teacher groups follow that helps them to structure their work together. They begin with a self-study, spending a few weeks observing one another's practice and doing a quick analysis of the patterns of talk that currently characterize their classrooms. They sometimes look at the kinds of work that students produce as a result of classroom talk to use as a baseline for later comparisons. They set some goals for experimenting with new ways of teaching. They try to take "first steps," changing some aspects of their classroom discourse, giving it a try three or four times before assessing where they were making headway and what adjustments are needed. These teachers make good use of video to capture conversations with students, and they play it back later to ask each other, "What were my students thinking here, and what might I have done differently to challenge them?"

Today the basic ingredients for advancing one's practice are often ready at hand. You need willing colleagues, a cooperative administrator to give you time to meet, access to some technology, and perhaps most importantly, you need a set of ideas to work on together. The illuminating vignettes, generative frameworks, and helpful tools in this book are a great set of resources to support you in this journey.

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Preface

In this book, we present and discuss a framework for orchestrating productive discussions in science that are rooted in student thinking and that emerge from students' work on demanding tasks. Such tasks provide opportunities for students to engage in the disciplinary practices described in the Next Generation Science Standards (Achieve, Inc. 2013) while also developing understanding of key patterns and/or concepts in science. The framework presented throughout the book identifies a set of instructional practices that will help teachers effectively use student work as the launching point for discussions in which students address important science ideas, consider alternative explanations, identify contradictions between evidence and claims, and develop or consolidate understandings of new concepts. The premise underlying the book is that the identification and use of a codified set of practices can make student-centered approaches to science instruction accessible to and manageable for more teachers. By giving teachers a road map of things that they can do in advance and during whole-class discussions, these practices have the potential for helping them to more effectively orchestrate discussions that are responsive to both students' thinking and core practices and ideas within science disciplines.

Throughout the book, we illustrate the instructional practices with episodes that take the reader inside science classrooms. In particular, we make significant use of three narrative cases: the Cases of Kelly Davis, Nathan Gates, and Kendra Nichols. We introduce the Cases of Kelly Davis and Nathan Gates in chapter 2 to contrast the quality of instruction that does and does not utilize the Five Practices framework. We explore the Case of Kendra Nichols in considerable depth in chapters 3 and 4 as each of the five practices is examined in detail, and refer to it again in subsequent chapters as we consider broader issues related to integrating the five practices into everyday instruction. These cases, and other vignettes that appear in the book, are based on real events and are intended to make salient certain types of teacher-student interactions and the level and type of thinking required to teach with understanding. As such, these episodes of teaching reflect what we have observed, and they should be thought of as composites that have been enhanced at times in order to bring out specific aspects of instruction we wish to highlight.

Following research that has established the importance of learners' construction of their own knowledge (Bransford, Brown, and Cocking 2000), we have designed this book to encourage the active engagement of readers. In several places, we have provided notes (titled "Active Engagement") that suggest ways in which the reader can engage with specific artifacts of classroom practice (e.g., narrative cases of classroom instruction, transcripts of classroom interactions, instructional tasks, or samples of student work). Rather than passively read the book from cover to cover, readers are encouraged to take our suggestions to heart and pause for a moment to grapple with the information in the ways suggested. By actively processing the information, readers' understandings will be deepened, as will their ability to access and use the knowledge flexibly in their own professional work. In addition, within some chapters we have provided suggestions (titled "Try This!") regarding how teachers can explore the ideas from a chapter in their own classrooms.

Although the primary focus of the book (chapters 2, 3, 4, and 7) is the Five Practices model first established in *5 Practices for Orchestrating Productive Mathematics Discussions* (Smith and Stein 2011), we also explore other issues that support teachers' ability to orchestrate productive classroom discussions. Specifically, in chapter 1 we emphasize the need to set clear goals for what students will learn as a result of instruction and to identify a task that is consistent with those learning goals prior to engaging in the five practices. In chapter 5 we focus explicitly on the types of questions that teachers can ask to challenge students' thinking and the moves that teachers can make to promote the participation of students in whole-class discussions. We situate the Five Practices model for facilitating a discussion within the broader context of instructional design in chapter 6. The book concludes with chapter 7, in which we describe the lessons learned by beginning secondary science teachers as they endeavored to conduct task-based discussions in science using the five practices.

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