Foreword

Probe- *n. 1. A slender surgical instrument for exploring a wound, 2. investigation, 3. Spacecraft, etc. used to get information about an environment- v. 1) explore with a probe, 2) investigate-* ***prob'er*** *n.*

—*Webster's New Pocket Dictionary* (2000)

Teachers face the challenging and complex task of linking important ideas in mathematics, research about how students learn, and the myriad thinking styles students bring to the classroom. How do we bring together these three critical components—content, cognitive research, and our own students' thinking—in a way that informs teaching and supports learning for all students? The solution lies in the unique two-tiered diagnostic and formative assessment probes, along with supporting teacher background material, provided in the chapters that follow. This book instructs teachers to systematically use formative assessment probes as they build and refine their use of assessment *for* learning to answer the pivotal question, *what and how are my students thinking in relation to the mathematics I am teaching?*

The first question you might have asked when you read the title of this book is, what is a "probe"? According to the *Webster's* definition above, it is an instrument that can be used to explore a health problem in the body. In the context of this book, it's a diagnostic instrument that allows us to explore student thinking in order to understand a learning problem. *Webster's* also defines a probe as an investigation. In mathematics, we use probes to investigate the ideas and modes of reasoning students use to make sense of mathematical problems. Furthermore, *Webster's* describes a probe as a tool that gives us information about the environment. Probes provide teachers with information about the effectiveness of the teaching and learning environment so that instructional strategies can be matched to students' learning needs. And finally, *Webster's* indicates that "probe" can also be used as a verb. When we probe in mathematics, we are exploring students' thinking and becoming investigators of learning in our classrooms. In essence, the probes in this book are specially designed questions that enable teachers to identify the ideas students bring to their learning and use that knowledge inform their teaching. A thoughtful analysis of students' ideas can help teachers make informed decisions about the instructional path needed to move them from where they are in their conceptual and procedural understandings to the destination of mathematical literacy.

Over the past several years, I have had the privilege of working with Cheryl Rose Tobey on two National Science Foundation–funded projects that developed parallel formative assessment resources for both science and mathematics. Although our work focused on different disciplines, our philosophies and approaches to formative assessment have been very similar. We both believe that if teachers are to use formative assessment results effectively, the strategies they employ must be linked to explicit learning targets. In addition, teachers need to be familiar with learning research that reveals the difficulties students may encounter in accessing content and the conceptual barriers that may impede their learning. Once teachers are grounded in the content, standards, and research on learning, they can begin the systematic cycle of collecting data, analyzing student thinking, and choosing strategies that address students' needs in the classroom. In the process, teachers come to realize that these important formative assessment tools also contribute to their ongoing professional development, deepening their pedagogical content knowledge. This book belongs in the professional library of every elementary school mathematics teacher.

As a science educator and author of several books on science formative assessment, I am thrilled to recommend this book to my science colleagues as well as to teachers of mathematics. With the emphasis on Science, Technology, Engineering, and Mathematics (STEM) education increasingly finding its way into the elementary classroom, teachers are looking for ways to meaningfully integrate mathematics and science. Many of the probes in this book address important inquiry skills students use in science such as measurement, estimation, representing and analyzing data, performing computations, choosing appropriate quantitative data, and more. As I work with K–12 science teachers throughout the United States in using assessment probes, I am frequently asked if there are similar probes in mathematics that can clarify the difficulties students encounter in applying mathematical concepts and procedures to science. And now my answer is a resounding *yes*—in this book! We now have a full suite of K–12 mathematics formative assessment probes that can be combined with their science counterparts to support and transform assessment, instruction, student learning, and teacher professional development.

In the busy day-to-day life of a classroom, we must all take the time to listen to our students and provide opportunities for them to share their thinking. Eleanor Duckworth of Harvard University said in her classic book, *The Having of Wonderful Ideas and Other Essays on Teaching and Learning*, "The having of wonderful ideas is what I consider the essence of intellectual development." (1996, p. 1) Thank you to Cheryl Rose Tobey and Leslie Minton for giving us another book designed to reveal those wonderful ideas students have that are sure to promote learning and foster a love of mathematics!

Page Keeley, Maine Mathematics and Science Alliance

Past President of the National Science Teachers Association (NSTA)