WHAT ARE THEY THINKING?

PROMOTING ELEMENTARY LEARNING *Through* FORMATIVE ASSESSMENT

PAGE KEELEY

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Introduction

The Role of Formative Assessment in Elementary Science: An Overview

Formative assessment in science is a process that informs instruction and supports learning through a variety of tools and techniques aimed at uncovering and examining students' thinking, then using that information to drive instruction that supports students moving toward conceptual understanding of the learning target. Formative assessment in science is inextricably linked to learning. As teachers are collecting information about students' thinking related to core concepts and phenomena, students are simultaneously constructing new understandings, revising prior beliefs, and strengthening their ability to engage in the practices of science and engineering. Formative assessment is frequently referred to as assessment *for* learning rather than assessment *of* learning. One can even add a third preposition—assessment *as* learning. As you will see in each of these chapters, the formative assessment tool or technique highlighted is in essence a learning activity for students, as well as a way for the teacher to gather information about students' ideas and ways of thinking in order to determine next steps in moving their learning forward.

Elementary science teachers face an added challenge using formative assessment to move students' learning forward. Because science is a way of understanding our natural world, students arrive with ideas that have already been formulated based on their everyday experiences outside the classroom. These experiences begin in infancy, long before students enter the formal classroom. Daily experiences and interactions with "felt weight," moving objects, shapes, light and shadows, observations of living things, dropping objects, "disappearing" materials, visible changes, and other phenomena are already shaping children's ideas at an early age. Therefore, one important use of formative assessment in science is uncovering the preconceptions students bring with them to their learning, as these preconceptions will often affect the way students think about new information. Children make sense of the content they encounter in the science classroom in their own way, based on their interactions with the natural world, the words they encounter in their daily conversations and in various media, the materials they use, and the contexts in which they learn.

By taking the time to understand students' thinking at any point during an instructional cycle, instruction becomes more focused and deliberate in moving students

toward an intended learning target. It begins by helping students think about—and then verbalize or write about—their existing ideas, giving them and the teacher a springboard from which to launch into instructional experiences that will build a bridge between where students are and where they need to be. Targeted instruction then confronts students' existing ideas, providing opportunities for them to test their ideas through investigation and engage in productive science talk that incorporates scientific reasoning, construction of scientific explanations, and argumentation supported by evidence. As the teacher uses formative assessment to monitor changes in students' ideas and ways of thinking, students often resolve the conflict between their initial ideas and new ways of thinking. This process is called *conceptual change* and is strongly supported by the use of formative assessment throughout a full cycle of instruction. It begins with the elicitation of students' initial ideas and ends with reflection on new knowledge and changes in thinking.

However, to use formative assessment to promote learning in the elementary classroom, the teacher must have access to a repertoire of formative assessment classroom techniques (FACTs) and specially designed questions that link research on learning to core concepts in science (probes). But having access to these tools at your fingertips is not enough. Teachers also need to understand *how* these tools are appropriately used for formative assessment and what formative assessment looks like in the elementary classroom. That is the purpose of this book—to build and support elementary teachers' capacity to use formative assessment tools to link assessment, instruction, and learning in the science classroom.

This book will help elementary teachers deepen their understanding of their students' thinking in order to promote conceptual learning in the K–6 classroom. It moves instruction away from the pervasive practice of selecting an activity first to instead starting with an understanding of students' ideas and then selecting an appropriate activity to begin instruction. It helps teachers make adjustments to their instructional materials throughout the cycle of instruction. This is very different from following "the script" without understanding if the "script" is the right match to where students are in their thinking. The focus is on what the student is thinking and learning, not the materials or activities. This is the difference between teaching science as a series of "hands-on" activities and teaching science for conceptual understanding.

Elementary teachers are the first line of offense in addressing common misconceptions that follow students from elementary grades into middle school, into high school, and even into adulthood. This is why it is so important to build elementary teachers' capacity to continuously and seamlessly use formative assessment in science. If elementary

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students are provided with opportunities to resolve the inconsistencies between their way of thinking and the scientific way of thinking, many of the difficulties that students encounter in later grades as they progress through increasingly complex ideas and ways of thinking can be eliminated. Clearly, this is why elementary teachers are important to developing science-literate high school graduates, well prepared and interested in entering STEM fields in college or in the workplace. Elementary science teachers are critical links in a K–12 system of science learning. This book is intended to support you in that critical role!

Organization of This Book

This book is organized into 30 chapters. Each chapter features an article written for the NSTA *Science and Children* journal's monthly column, "Formative Assessment Probes: Promoting Learning Through Assessment." Each article features a formative assessment probe from one of the eight books in the NSTA Press series *Uncovering Student Ideas in Science.*

A probe is a two-tiered assessment specifically designed to reveal common misconceptions. It begins with an engaging prompt situated in a familiar context, followed by a set of selected responses. Many of the distracters in the selected responses mirror the research on children's alternative conceptions. The number of distracters used depends on the number of research-identified misconceptions. The probes avoid the use of technical terminology in order to uncover students' conceptual understanding and not their memorization of definitions. The selected response is then followed by a section in which students explain their thinking by constructing an explanation. It is this part of the probe that reveals the reasoning students use to make sense of a concept or phenomenon. It also provides insight into how a student's misconception may have developed: from their experiences in and out of the classroom, the words they encounter, their intuition, the context in which previous learning took place, or from their misinterpretation during the teaching and learning process.

Probes are often combined with a FACT (formative assessment classroom technique). FACTs are used in a variety of formats, ranging from individual formative assessment to uncovering student ideas within a small group or during a whole-class discussion. FACTs and probes are embedded throughout an instructional cycle of engagement and elicitation, exploration of ideas, formal concept development, application, and reflection. They fit easily within a 5E model of instruction or any variety of instructional models that use a learning cycle approach. FACTs serve a variety of teaching and learning purposes, including engaging and motivating students, eliciting preconceptions, activating thinking

and metacognition, providing stimuli for productive science talk, initiating investigations, determining learning transfer, improving the quality of questions and responses, providing feedback, peer and self-assessment, and post-assessment or reflection on learning.

The articles in each chapter were specifically written to illustrate how a formative assessment probe, often combined with a FACT, is used in a K–6 classroom. While each of the books in the *Uncovering Student Ideas in Science* series provides K–12 teacher notes that accompany each probe, the teacher notes in the book series do not provide extensive descriptions of how the probe is used in an elementary classroom, actual examples of student work or transcripts of students talking about their ideas, or illustrative examples of instructional decisions made by elementary teachers. The article included in each chapter provides this information specifically for elementary teachers, giving deeper insight into the formative assessment process and complementing the teacher notes. In addition, a link is provided at the end of the chapter that will take the reader to a website where they can download a copy of the probe to use with their students (Note: Only the probe is provided in each of the links in the chapters. The teacher notes for each probe are found in the referenced book in which the probe was originally published).

Each chapter also includes a Reflection and Study Guide. These guides include a set of questions designed to help the reader reflect on what they learned after reading the chapter. The questions can also be used for pre-reading. This is followed by a section on "Putting Formative Assessment Into Practice" that can be used after teachers try out the probe with their students. This section guides teachers in examining their own students' thinking and reflecting on their use of the formative assessment probe or FACT. A final set of questions in the "Going Further" section can be used to extend professional learning by suggesting other resources for individual or collaborative group learning. Many of these suggestions include links to *A Framework for K–12 Science Education* or the *Next Generation Science Standards*. Even if your state has not adopted the *NGSS*, the links provided will help you clarify the content in your own standards and provide you with a lens to focus on what effective teaching and learning in science involves when using the formative assessment probes.

Suggestions for Using This Book

The primary purpose of this book is to improve and support the teaching and learning of elementary science by embedding formative assessment into daily instruction. This purpose can be met through an individual teacher's use of this book or through collaborative structures for teacher learning. The following are suggestions for ways to use

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this book as a teacher, teacher leader, mentor, science specialist, professional development provider, or preservice instructor.

Overall Use of This Book

- Use Table 1 (pp. xvi–xvii) to match your own instructional or professional learning objective to the focus of the chapter and the probe that is highlighted. Read the chapter and use the Reflection and Study Guide questions to deepen your learning and inform your instruction before you teach a curricular unit.
- If you have not used the probe before, answer the probe yourself before reading the chapter. By experiencing the process of thinking through your own ideas, you may better understand what your students experience as they think through their ideas.
- If you have access to the *Uncovering Student Ideas in Science* books, read the teacher notes after completing the chapter. The teacher notes provide additional details on curricular considerations, related research, connections to national standards, and instructional suggestions that complement the chapter.
- After reading a chapter and using the guiding questions, note what you will do differently in your classroom as a result. Also note any information or suggestions to share with colleagues at the school or district level.
- If you are a classroom teacher or have access to students, try out the probe or FACT with children and compare what you experienced and learned through your own students with the chapter description or classroom vignette.
- Use the "Going Further" suggestions to extend your learning after reading the chapter. Search the internet or the NSTA Learning Center (*http://learningcenter.nsta.org*) for additional resources to continue your learning related to the chapter.

Structures for Professional Learning

- Chapters can be used within a workshop format to address content or a teaching strategy. Select chapters that match the professional learning goal of a workshop.
- Professional Learning Communities (PLCs) can select chapters for reading, discussion, and application to their professional goals as a PLC.
- Form study groups to learn about, try out, examine, and improve upon techniques for formative assessment. Choose a chapter to read, discuss, try out, and report back on its use.
- Create a classroom video of your use of a probe or FACT discussed in one of the chapters. Share and discuss the chapter with peers. Use the video to discuss and provide constructive feedback on the use of the probe or FACT.

- Combine a chapter with the use of a protocol for looking at student work (LASW). The chapter can provide the groundwork or information for next steps after teachers discuss student work.
- Create a seminar series that features a chapter for each session. Use Socratic dialogue to discuss the chapter.
- Teachers who mentor new teachers can read and discuss chapters together. The new teacher can try out the probe or FACT and reflect on his or her learning with the mentor teacher. The mentor teacher can provide useful feedback as a link between the chapter and the novice teachers' practice.
- Lesson study groups can use the chapters to inform the design of the lesson they will use. Discussions during the debriefing of the lesson can be linked back to the chapter.
- Form a book study group, face-to-face or electronically. Select chapters for the book study. Use the Reflection and Study Guide for in-person or online discussions.
- Share and discuss a chapter during a grade-level team or faculty meeting. Discuss how the example of formative assessment could be applied to other disciplines.
- Curriculum planning committees can use the chapters to consider ways to embed formative assessment into the elementary curriculum. Use the chapter to provide implementation support for the curriculum.
- Conduct collaborative action research with a colleague. Choose a chapter and design a classroom research project related to the chapter. Use the example and suggestions in Chapter 12 (Teachers as Classroom Researchers) to engage in teacher research using the probes.
- Use a formative assessment probe for teacher learning in workshops or other settings. After teachers respond to the probe, use ideas from the chapter to make formative decisions or engage teachers in practices such as argumentation.
- Select chapters that can support teachers in implementing the *NGSS* or their state standards. Use the chapter for discussions about formative assessment and learning targets.
- Consider writing your own article about the use of a formative assessment probe or FACT. Use the examples in this book to help you. Consider sharing your article with your school colleagues or submitting for publication in NSTA's *Science and Children.*
- Use the book as a whole-group jigsaw book study during teacher institutes. Assign chapters to pairs or small groups as reading assignments. Each group can prepare a short presentation to teach what they learned to others.

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- Preservice instructors can use this book as a required text in their courses or select specific chapters to integrate into their courses.
- Science curriculum coordinators can use chapters to support teachers working toward improving their practice.
- The *Science Formative Assessment* book series (Keeley 2008, 2014) has been frequently used in a variety of professional learning formats. Select chapters that highlight use of a FACT and combine with the reading from *Science Formative Assessment*.
- Select a probe that can be used across grade levels. Administer the probe, collect data on students' thinking, and engage colleagues in cross-grade-level data-driven discussion. Use the chapter to ground the group's discussion about the probe and students' ideas.
- Come up with your own idea for ways to use these chapters for professional learning that builds teachers' understanding of how to use formative assessment effectively.

Teacher Learning Outcomes

Whichever chapters you decide to use in this book or the variety of ways you decide to use them, consider the following outcomes:

1. You may learn new content about the science you teach. Everyone has misconceptions, including teachers (*all* teachers, not just elementary teachers). These chapters might surface long-held misconceptions you were not aware that you had. Working through and resolving these misconceptions is a significant part of your professional learning.
2. You will learn a lot about your own students. Although the chapters describe scenarios of students in other classrooms, it is quite likely your students will think and respond in a similar way. Furthermore, trying out the probes with your own students will give you insight into your own students' thinking and how similar their ideas are to what has been learned from research about children's ideas in science.
3. You will learn new instructional strategies that link assessment and instruction, which will help you build a rich repertoire of effective teaching practices.
4. You will increase your capacity to implement the disciplinary core ideas, the scientific and engineering practices, and the crosscutting concepts in the *NGSS*. Even if your state has not adopted the *NGSS*, your teaching and your students' learning connected to your state's standards will be enhanced through your knowledge of formative assessment practices connected to the *NGSS*.