VOL.1

Uncovering Student Ideas in Primary Science

25 New Formative Assessment Probes for Grades K–2

By Page Keeley

NSTApress
National Science Teachers Association

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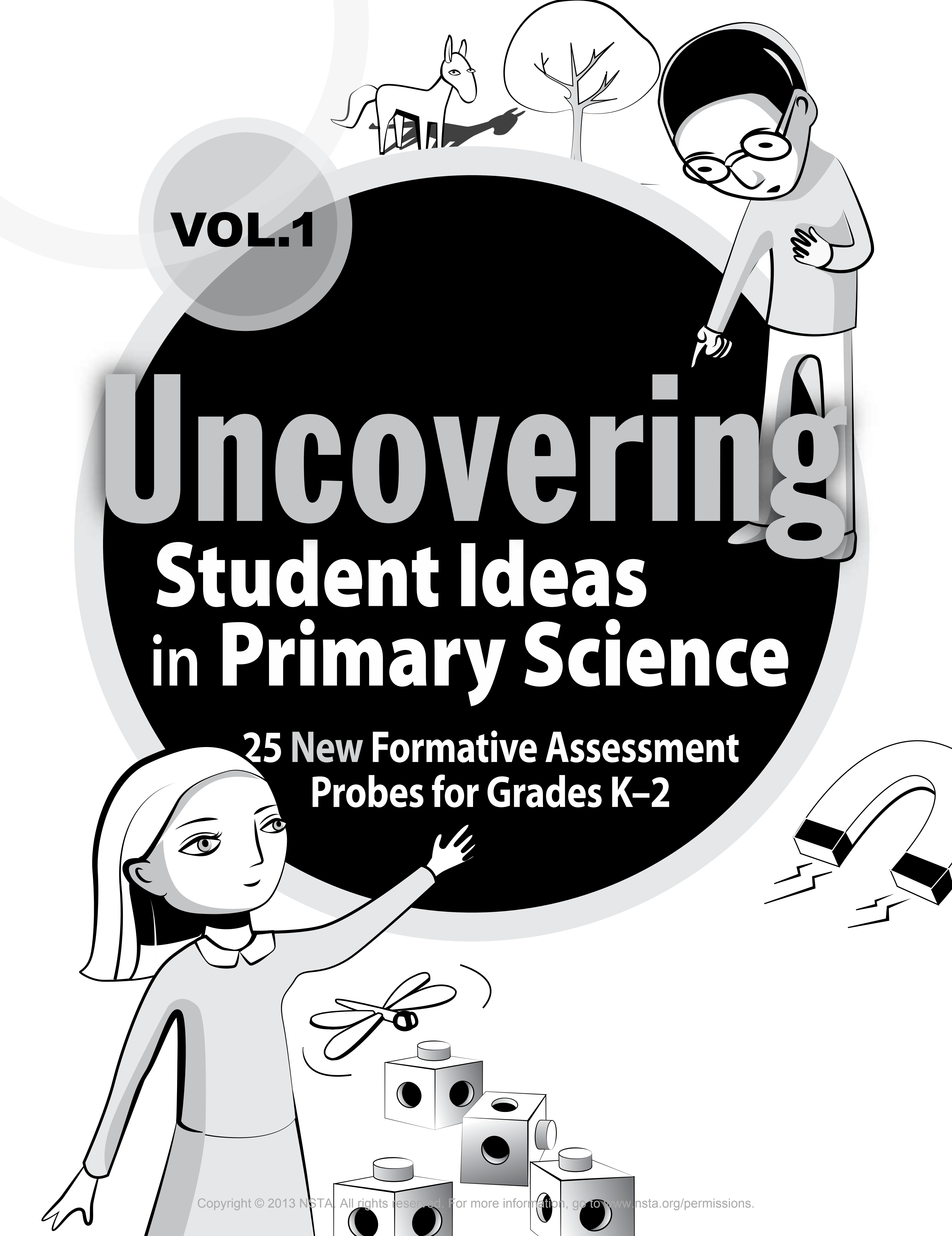

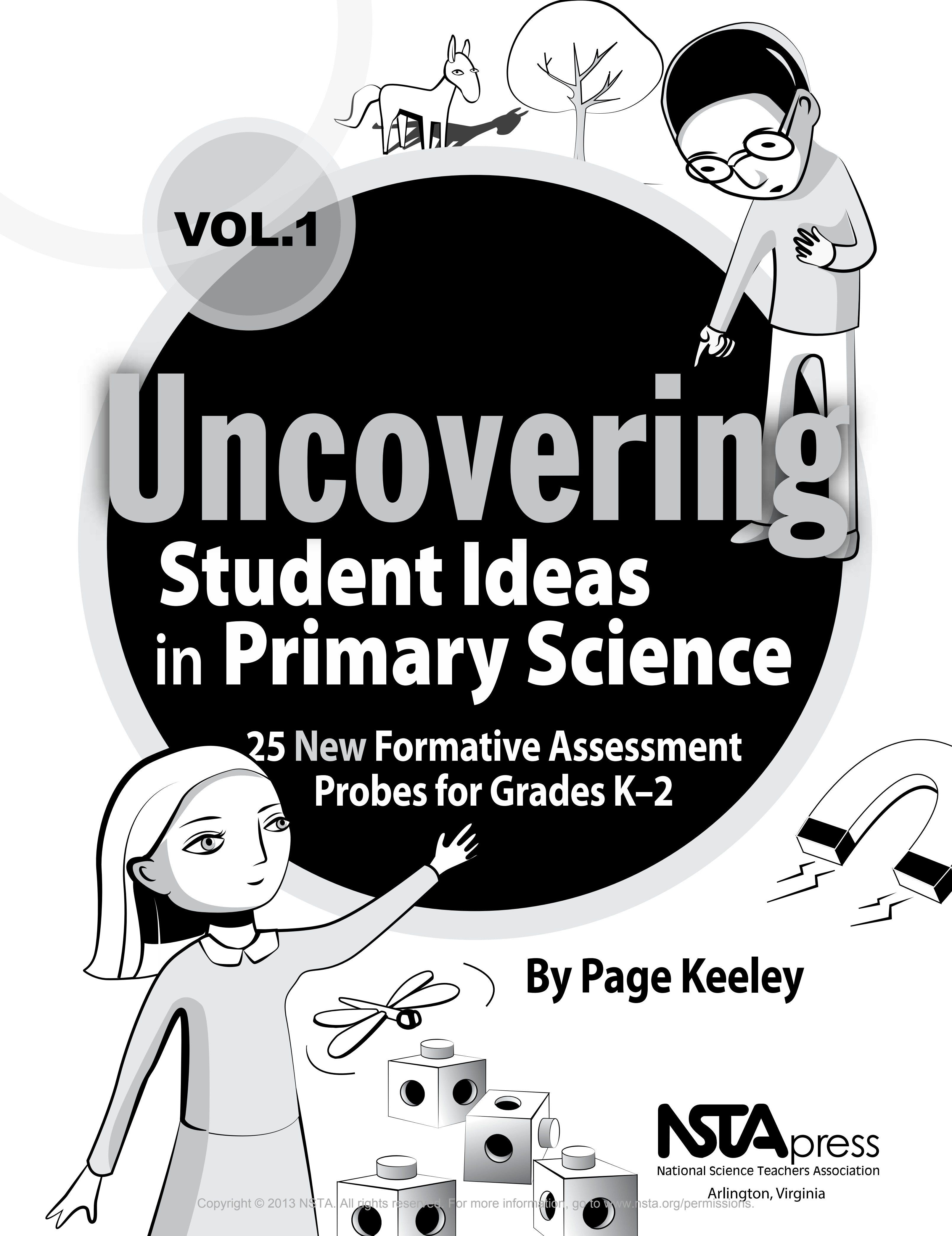

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NSTA press
National Science Teachers Association
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Contents

Section 3. Earth and Space Science

Dedication

This book is dedicated to Emma Elizabeth Keeley, Lincoln Wright DeKoster, Court Wilson Brown, Jack Anthony Morgan, Cadence Jane Friend-Gray, and Emeline Leslie Friend-Gray. May you all grow up to have wonderful ideas!

Preface

This is the eighth book in the *Uncovering Student Ideas in Science* series, and the first one that exclusively targets young children's ideas. Like its predecessors, this book provides a collection of formative assessment probes designed to uncover the ideas students bring to their science learning. Each probe is carefully researched to elicit commonly held ideas young children have about phenomena or scientific concepts. A best answer is provided along with distractors designed to reveal research-identified misconceptions held by young children.

A major difference between this book and others in the *Uncovering Student Ideas in Science* series lies in the format of the student pages. The probes in this book use minimal text so that they can be used with children who are just developing their reading and writing skills. Each probe provides a visual representation of the elicited idea using familiar phenomena, objects, and organisms or set in situations that can be duplicated in the classroom. For example, "Is It Living?" elicits students' ideas about living and nonliving things using pictures of familiar objects and organisms. "Big and Small Magnets" uses a concept cartoon format to elicit children's ideas about magnetism, which can then be tested in the classroom using magnets of different sizes. The visuals are designed to capture children's interest and stimulate their thinking. Each probe ends by asking, "What are you thinking?" to draw out students' reasons for their answer choices and encourage "science talk."

Other *Uncovering Student Ideas* Books That Include K–2 Probes

While this book is specifically designed for K–2 students, other books in the series include K–12 probes that can be used or modified for the primary grades. The following is a description of each of the other books in the *Uncovering Student Ideas in Science* series and selected probes that can be used as is or modified for the primary grades:

Uncovering Student Ideas in Science, Volume 1 (Keeley, Eberle, and Farrin 2005)

The first book in the series contains 25 formative assessment probes in life, physical, and Earth and space science. The introductory chapter provides an overview of what formative assessment is and how it is used. Probes from this book that can be used in grades K–2 include:

- "Making Sound"
- "Cookie Crumbles"
- "Is It Matter?" (This probe has been modified for this book.)
- "Is It an Animal?" (This probe has been modified for this book.)
- "Is It Living?" (This probe has been modified for this book.)
- "Wet Jeans"

Uncovering Student Ideas in Science, Volume 2 (Keeley, Eberle, and Tugel 2007)

The second book in the series contains 25 more formative assessment probes in life, physical, and Earth and space science. The introductory chapter of this book describes the link between formative assessment and instruction. Probes from this book that can be used in grades K–2 include:

- "Is It a Plant?" (This probe has been modified for this book.)
- "Needs of Seeds"
- "Is It a Rock?" (version 1)
- "Is It a Rock?" (version 2)
- "Objects in the Sky"

Uncovering Student Ideas in Science, Volume 3 (Keeley, Eberle, and Dorsey 2008)

The third book in the series contains 22 formative assessment probes in life, physical, and Earth and space science, as well as 3 probes about the nature of science. The introductory chapter describes ways to use the probes and student work for professional learning. Probes from this book that can be used in grades K–2 include:

- "Is It a Solid?"
- "Does It Have a Life Cycle?"
- "Me and My Shadow"

Uncovering Student Ideas in Science, Volume 4 (Keeley and Tugel 2009)

The fourth book in the series contains 23 formative assessment probes in life, physical, and Earth and space science, as well as 2 probes that target the crosscutting concepts of models and systems. The introductory chapter describes the link between formative and summative assessment. Probes from this book that can be used with grades K–2 include:

- "Magnets in Water"
- "Moonlight"

Uncovering Student Ideas in Physical Science, Volume 1 (Keeley and Harrington 2010)

The fifth book in the series, and the first in a planned four-book series of physical science probes, contains 45 force and motion formative assessment probes. The introductory chapter describes why students struggle with force and motion ideas and the implications for instruction. Probes from this book that can be used in grades K–2 include:

- "How Far Did It Go?"
- "Rolling Marbles"
- "Talking About Forces"
- "Does It Have to Touch?"
- "Balance Beam"

Uncovering Student Ideas in Life Science, Volume 1 (Keeley 2011)

The sixth book in the series, and the first in a planned three-book series of life science probes, contains 25 life science formative assessment probes. The introductory chapter describes how formative assessment probes are used in a life science context. Probes from this book that can be used in grades K–2 include:

- "Cucumber Seeds"
- "No Animals Allowed"
- "Pumpkin Seeds"
- "Rocky Soil"
- "No More Plants"
- "Chrysalis"

Uncovering Student Ideas in Astronomy (Keeley and Sneider 2011)

The seventh book in the series contains 45 formative assessment probes for astronomy. The introductory chapter describes how formative assessment probes are used to understand students' mental models in astronomy. Probes from this book that can be used in grades K–2 include:

- "Where Do People Live?"
- "Sunrise to Sunset"
- "Seeing the Moon"
- "Sizing up the Moon"
- "Crescent Moon"

Preface

Features of This Book

This book contains 25 probes for the K–2 grade range organized in three sections: Section 1, Life Science (8 probes); Section 2, Physical Science (11 probes); and Section 3, Earth and Space Science (6 probes). The format is similar to the other seven volumes, with a few changes due to the focus on the primary grades. For example, the introduction focuses on young children's ideas in science and the use of "science talk." What follows are descriptions of the features of the Teacher Notes pages that accompany each probe in this book.

Purpose

This section describes the purpose of the probe—what you will find out about your students' ideas when you use the probe. It begins with the overall concept elicited by the probe, followed by the specific idea the probe targets. Before choosing a probe, it is important to be clear about what the probe is designed to reveal. Taking time to read the purpose will help you decide if the probe fits your intended learning target.

Related Concepts

Each probe is designed to target one or more concepts that are appropriate for grades K–2 students. A concept is a one-, two-, or three-word mental construct used to organize the related ideas addressed by the probe and the related national standards. These concepts are also included on the matrix charts that precede the probes on pages 2, 44, and 92.

Explanation

A brief scientific explanation accompanies each probe and provides clarification of the scientific content that underlies the probe. The explanations are designed to help the teacher understand what the "best" or most scientifically acceptable answers are, as well as clarify any misunderstandings about the content. The explanations are not intended to provide detailed background knowledge about the content or designed to be shared with the student. The explanation is for the teacher. In writing these explanations, the author is careful not to make them too technical, as many primary-grade teachers have a limited content background in science. At the same time, the author takes great care not to oversimplify the science. The intent is to provide the information a science novice would need to understand the content related to the probe. If you have a need or desire for additional or deeper explanations of the content, refer to the NSTA resources listed for each section to build or enhance your content knowledge. For example, Bill Robertson's *Stop Faking It! Finally Understanding Science So You Can Teach It* books are excellent resources for furthering your own content understanding.

Curricular and Instructional Considerations for Grades K–2

Unlike the collections in the other books of this series, which address curricular and instructional considerations across the K–12 grade range, these probes are designed for the primary grades, and therefore the curricular and instructional considerations focus only on the K–2 grade span. (*Note:* Several probes are appropriate for the preK level as well.) This section provides a broad overview of the curricular emphasis in the primary science curriculum, the types of instructional experiences appropriate for K–2 students, and the difficulties to be aware of when teaching and learning the concepts related to the probe. This section will sometimes alert teachers to a K–2 idea from *A Framework for K–12 Science Education* (NRC 2012) that in the past has typically been addressed at the upper-elementary or middle-school level but has been moved down to the primary level. For example, static friction and waves are two concepts that typically have not been addressed at the K–2 level but are included in the grades K–2 span in *A Framework for K–12 Science Education.* These are new considerations for curriculum and instruction that teachers of primary science will need to be aware of as they use the probes and design learning experiences for their students. In some cases, the developers of the *Next Generation Science Standards* (*NGSS*) decided to move disciplinary core ideas to a later grade span. This, too, is noted in the Teacher Notes.

Administering the Probe

Suggestions are provided for administering the probe to students, including response methods and ways to use props, demonstrate the probe scenario, make modifications for different learners, or use different formative assessment classroom techniques (FACTs) to gather the assessment data. This section also suggests referring to pages xxviii–xxxiii in the introduction for techniques that can be used to guide "science talk."

Related Ideas in the National Standards

This section lists the learning goals stated in two national documents. One has been used extensively to develop the learning goals in states' standards and curriculum materials: The revised, online version of *Benchmarks for Science Literacy* (AAAS 2009) includes a K–2 grade span. The *National Science Education Standards* (NRC 1996) were released after the original *Benchmarks* and overlap considerably in content. However, they are not included here, as the content is similar and the learning goals target too broad a grade span (K–4). Another referenced document in the teacher notes, *A Framework for K–12 Science Education* (NRC 2012), was used to identify the disciplinary core ideas that informed the development of the K–2 performance expectations in the *NGSS*. Since the *Benchmarks* is one of the primary documents on which most state standards have been based prior to the release of the *NGSS*—which will be adopted by several states—it is still important to look at the related learning goals in this document. The third source of standards referenced is the *NGSS,* which were released shortly before the publication of this book. The Teacher Notes include the related performance expectation, which is the final assessment of student learning and is informed by the disciplinary core ideas listed under the *Framework.* The probes are not designed as summative assessments, so the listed related national standards are not intended to be considered alignments, but rather ideas that are related in some way to the probe. Some targeted probe ideas, such as the concept of living versus nonliving, are not explicitly stated as learning goals in the standards, yet they are important prerequisite ideas to understanding core ideas related to living things. In some cases, the *NGSS* performance expectation may not relate directly to the probe. Because performance expectations are designed for summative assessment purposes and not considered the curriculum or instruction, teachers need to provide experiences for students to learn the underlying ideas and concepts that will deepen the knowledge they will use to demonstrate the performance expectation. Formative assessment reveals the gaps that teachers can address in their instruction to move students toward the intended learning targets.

Related grade 3–5 learning goals, as well as some middle school learning goals, are also included in this section because it is useful to see the related idea that builds on the probe ideas at the next grade level. In other words, primary teachers can see how the foundation they are laying relates to a spiraling progression of ideas as students move from the primary grades to the intermediate elementary level. It may also be useful to teachers in grades 3–5 who may choose to use one of these probes to assess for gaps in students' understanding or misconceptions that are still tenaciously held. Sometimes the listed learning goals from upper grade spans appear to be unrelated to the probe or the K–2 learning goal. It is important to recognize that learning is a progression, and while it may seem unrelated, there is a connection. For example, when K–2 students learn about natural resources, it is in the context of objects and materials that are made from resources obtained from the Earth. The "Is a Brick a Rock?" probe is an example. However, in grade 4, the *NGSS* performance expectation shifts to energy sources and fuels obtained from the Earth. While the grade 4 *NGSS* performance expectation does not directly align with the probe, it is related to the bigger idea that humans use natural reources from the Earth.

Related Research

Each probe is informed by related research. Three comprehensive research summaries commonly available to educators—Chapter 15 in *Benchmarks for Science Literacy* (AAAS 1993), Rosalind Driver's *Making Sense of Secondary Science: Research Into Students' Ideas* (Driver, Squires, Rushworth, and Wood-Robinson 1994), and recent summaries in the *Atlas of Science Literacy, Volume 2* (AAAS 2007)—were drawn on for the research summaries. In addition, recent research is cited where available. Although many of the research citations describe studies that have been conducted in past decades and studied children not only in the United States but in other countries as well, most of the results of these studies are considered timeless and universal. Whether students develop their ideas in the United States or other countries, research indicates that many of these commonly held ideas are pervasive regardless of geographic boundaries and societal and cultural influences. Misconceptions held by students studied in past decades still exist today. Even though your students may have had different experiences and contexts for learning, the descriptions from the research can help you better understand the intent of the probe and the kinds of thinking your students will likely reveal when they respond to the probe. As you use the probes, you are encouraged to seek new and additional published research or engage in your own action research to learn more about students' thinking and share your results with other teachers to extend and build on the research summaries in the teacher notes. To learn more about conducting action research using the probes, read the *Science and Children* article "Formative Assessment Probes: Teachers as Classroom Researchers" (Keeley 2011).

Suggestions for Instruction and Assessment

Uncovering and examining the ideas children bring to their learning is considered diagnostic assessment. Diagnostic assessment becomes formative assessment when the teacher uses the assessment data to make decisions about instruction that will move students toward the intended learning target. Therefore, for the probe to be considered a formative assessment probe, the teacher needs to think about how to best design, choose, or modify a lesson or activity to best address the preconceptions students bring to their learning or misconceptions that might surface or develop during the learning process. As you carefully listen to and analyze your students' responses, the most important next step is to decide on the instructional path that would work best in your particular context based on your students' thinking, the materials you have available, and the different types of learners you have in your classroom.

The suggestions provided in this section have been gathered from the wisdom of teachers, the knowledge base on effective science teaching, and research on specific strategies used to address commonly held misconceptions. These are not lesson plans, but rather brief suggestions that may help you plan or modify your curriculum or instruction to help students learn ideas with which they may be struggling or that are incomplete. It may be as simple as realizing you need to provide an effective context, or there may be a specific strategy or activity that you could use with your students. Learning is a complex process, and most likely no single suggestion will help all students learn. But that is what formative assessment encourages: thinking carefully about the variety of instructional strategies and experiences needed to help students learn scientific ideas. As you become more familiar with the ideas your students have and the multifaceted factors that may have contributed to their misunderstandings, you will identify additional strategies that you can use to teach for deeper understanding. In addition, this section also points out other probes in the *Uncovering Student Ideas in Science* series that can be modified or used as is to further address the concepts targeted by the probe.

Related NSTA Resources

This section provides a list of additional materials that can provide further information on content, curriculum, or instruction related to the probe. For example, Bill Robertson's *Stop Faking It!* series may be helpful in clarifying content with which teachers struggle; Karen Ansberry and Emily Morgan's *Picture-Perfect Science* series may suggest trade books and classroom activities that go together; and Dick Konicek's *Everyday Science Mysteries* series may provide an engaging story context to help students start investigating ideas. Articles from NSTA's *Science and Children* journal may suggest ways to provide primary-grade students the opportunity to learn the content targeted by the probe.

References

References are provided for the standards, cited research, and some of the instructional suggestions given in the Teacher Notes. You might also wish to read the full research summary or access a copy of the research paper or resource cited in the Related Research and Suggestions for Instruction and Assessment sections of the Teacher Notes.

Formative Assessment Probes in the Elementary Classroom

Formative assessment is an essential feature of a learning-focused elementary science environment. To help teachers learn more about using formative assessment probes with elementary students to inform instruction and promote learning, NSTA's elementary science journal, *Science and Children,* publishes my monthly column "Formative Assessment Probes: Promoting Learning Through Assessment." Your NSTA membership provides you with access to all of these journal articles, which have been archived electronically by NSTA. Go to the *Science and Children* page at *www.nsta.org/elementaryschool*. Scroll down to the journal archives and type "Formative Assessment Probes" in the keyword search box. This will pull up a listing of all of my columns. These articles can be saved in your library in the NSTA Learning Center or downloaded as a PDF. The following table lists the journal issue date, title of the column, and topic of the column for the articles that have been published to date. Check back regularly as more articles are added. These articles can also be used by preservice instructors, professional developers, and facilitators of professional learning communities to engage teachers in discussions about teaching and learning related to the probes and the content they teach.

Table 1. List of Articles in the Column "Formative Assessment Probes: Promoting Learning Through Assessment"

Date	Title	Topic
Sept. 2010	"Doing Science"	**Probe: "Doing Science"** "Scientific method": examine how misuse of the "scientific method" influences students' ideas related to the nature of science
Oct. 2010	"'More A-More B' Rule"	**Probe: "Floating Logs"** Floating and sinking: use of intuitive rules to reason about floating and sinking
Nov. 2010	"Does It Have a Life Cycle?"	**Probe: "Does It Have a Life Cycle?"** Life cycles: addressing the limitations of context in the curriculum
Dec. 2010	"To Hypothesize or Not"	**Probe: "Is It a Hypothesis?"** Hypothesis making: reveal misconceptions teachers have about the nature of science that can be passed on to students
Jan. 2011	"How Far Did It Go?"	**Probe: "How Far Did It Go?"** Linear measurement: difficulties students have with measurement particularly with a non-zero starting point
Feb. 2011	"Needs of Seeds"	**Probe: "Needs of Seeds"** Needs of living things: engaging in evidence-based argumentation
March 2011	"The Mitten Problem"	**Probe: "The Mitten Problem"** Energy transfer; insulators: teaching for conceptual change and how children's everyday experience affects their thinking
April 2011	"Is It Living?"	**Probe: "Is It Living?"** Characteristics of living things: examine ways to uncover hidden meanings students have for some words and concepts in science
July 2011	"With a Purpose"	**Probe: various examples** A variety of probes and concepts are used to show purposeful links to various stages in an assessment, instruction, and learning cycle
Sept. 2011	"Where Are the Stars?"	**Probe: "Emmy's Moon and Stars"** Solar system, relative distances: importance of examining students' explanations even when they choose the right answer; the impact representations have on children's thinking
Oct. 2011	"Pushes and Pulls"	**Probe: "Pushes and Pulls"** Forces: examining common preconceptions and use of language to describe forces and motion

Table 1 *(continued)*

Date	Title	Topic
Nov. 2011	"Teachers as Researchers"	**Probe: "Is It an Animal?"** Biological conception of an animal: explore how formative assessment probes can be used to engage in teacher action research
Dec. 2011	"Representing Microscopic Life"	**Probe: "Pond Life"** Single-celled organisms: use of representations to examine students' ideas
Jan. 2012	"Daytime Moon"	**Probe: "Objects in the Sky"** Objects in the sky: challenges the adage "seeing is believing" with "believing is seeing"; examines reasons why children hold on to their strongly held beliefs
Feb. 2012	"Can It Reflect Light?"	**Probe: "Can It Reflect Light?"** Reflection: addressing students' preconceptions with firsthand experiences that support conceptual change
April/May 2012	"Food for Plants: A Bridging Concept"	**Probe: "Food for Plants"** Food, photosynthesis, needs of plants: using bridging concepts to address gaps in learning goals, understanding students' common sense ideas
July 2012	"Where Did the Water Go?"	**Probe: "Where Did the Water Go?"** Water cycle: using the water cycle to show how a probe can be used to link a core content idea, scientific practice, and crosscutting concept
Sept. 2012	"Confronting Common Folklore: Catching a Cold"	**Probe: "Catching a Cold"** Infectious disease, personal health: using a probe to uncover common myths and folklore related to the common cold
Oct. 2012	"Talking About Shadows"	**Probe: "Me and My Shadow"** Sun-Earth system; talk moves: using a formative assessment probe to engage students in productive science talk
Nov. 2012	"Birthday Candles: Visually Representing Ideas"	**Probe: "Birthday Candles"** Light transmission; connection between light and vision: using drawings to support explanations
Dec. 2012	"Mountain Age: Creating Classroom Formative Assessment Profiles"	**Probe: "Mountain Age"** Weathering and erosion: organizing student data using a classroom profile for instructional decisions and professional development
Jan. 2013	"Solids and Holes: A P-E-O Probe"	**Probe: "Solids and Holes"** Floating/sinking; density: using the P-E-O technique to launch into inquiry
Feb. 2013	"Labeling Versus Explaining"	**Probe: "Chrysalis"** Life cycle of a butterfly: reveals how an overemphasis on labeling diagrams with correct terminology may mask conceptual misunderstandings related to the life cycle of a butterfly

Table 1 *(continued)*

Date	Title	Topic
March 2013	"When Equipment Gets in the Way"	**Probe: "Batteries, Bulb, and Wire"** Electrical circuits; lighting a bulb with a battery and a wire: how science kit materials may make it difficult for students to examine the way a complete circuit works
Summer 2013	"Is It a Solid? Claim Cards and Argumentation"	**Probe: "Is It a Solid?"** Matter, solids: using claims and evidence to engage in argumentation

Formative Assessment Reminder

Now that you have the background on this new series, the probes, and the Teacher Notes, we should not forget the formative purpose of these probes. Reminder that a probe is not formative unless you use the information from the probe to modify, adapt, or change your instruction so students have increased opportunities to learn the important scientific ideas necessary for building a strong foundation in the primary grades. As a companion to this book and all the other volumes, NSTA has copublished the book *Science Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* (Keeley 2008). In this book, you will find a variety of strategies to use along with the probes to facilitate elicitation, support metacognition, spark inquiry, encourage discussion, monitor progress toward conceptual change, encourage feedback, and promote self-assessment and reflection. In addition, be sure to read the suggestions in the introduction before using the probes. The introduction will help you learn more about ways to facilitate productive science discussions in the primary classroom and make links to the *Common Core State Standards* in English language arts. I hope the use of these K–2 probes and the techniques used along with them will stimulate new ways of assessing your students, create environments conducive to learning, and help you discover and use new knowledge about teaching and learning.

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About the Author

Page Keeley recently retired from the Maine Mathematics and Science Alliance (MMSA), where she was the Senior Science Program Director for 16 years, directing projects and developing resources in the areas of leadership, professional development, linking standards and research on learning, formative assessment, and mentoring and coaching. She has been the PI and Project Director of three National Science Foundation–funded projects, including the Northern New England Co-Mentoring Network, PRISMS (Phenomena and Representations for Instruction of Science in Middle School), and Curriculum Topic Study: A Systematic Approach to Utilizing National Standards and Cognitive Research. In addition to NSF projects, she has directed state MSP projects, including TIES K–12: Teachers Integrating Engineering Into Science K–12 and a National Semi-Conductor Foundation grant, Linking Science, Inquiry, and Language Literacy (L-SILL). She also founded and directed the Maine Governor's Academy for Science and Mathematics Education Leadership, a replication of the National Academy for Science and Mathematics Education Leadership, of which she is a Cohort 1 Fellow.

Page is the author of 14 national best-selling books, including four books in the *Curriculum Topic Study* series, 8 volumes in the *Uncovering Student Ideas in Science* series, and both a science and mathematics version of *Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning.* Currently, she provides consulting services to school districts and organizations throughout the United States on building teachers' and school districts' capacity to use diagnostic and formative assessment. She is a frequent invited speaker on formative assessment and teaching for conceptual change.

Page taught middle and high school science for 15 years before leaving the classroom in 1996. At that time, she was an active teacher leader at the state and national levels. She served two terms as president of the Maine Science Teachers Association and was a District II NSTA Director. She received the Presidential Award for Excellence in Secondary Science Teaching in 1992, the Milken National Distinguished Educator Award in 1993, the AT&T Maine Governor's Fellow in 1994, the National Staff Development Council's (now Learning Forward) Susan Loucks-Horsley Award for Leadership in Science and Mathematics Professional Development in 2009, and the National Science Education Leadership Association's (NSELA) Outstanding Leadership in Science Education Award in 2013. She has served as an adjunct instructor at the University of Maine, was a science literacy leader for the AAAS/Project 2061 Professional Development Program, serves on several national advisory boards, and is the Region A Director for NSELA. She is a science education delegation leader for the People to People Citizen Ambassador Professional Programs,

About the Author

leading trips to South Africa in 2009, China in 2010, India in 2011, and China again in 2013.

Prior to teaching, she was a research assistant in immunology at The Jackson Laboratory of Mammalian Genetics in Bar Harbor, Maine. She received her B.S. in life sciences from the University of New Hampshire and her master's degree in science education from the University of Maine. In 2008, Page was elected the 63rd president of the National Science Teachers Association (NSTA), the world's largest professional organization of science educators.

Introduction

"The having of wonderful ideas is what I consider the essence of intellectual development." —Eleanor Duckworth

K–2 Probes as Assessments for Learning

Imagine a first-grade classroom where Miss Ortega's students are sitting in a circle on the science rug to have a science talk about living things. Miss Ortega uses the pictures from the "Is It Living?" probe to have the children share their ideas about which things are living and which things are not living. As Miss Ortega shows the pictures and names the organisms or objects, she has each student turn to his or her partner to talk about ideas. They then discuss each picture as a whole class, with students sharing the rules they used to decide if something is living or nonliving.

At one point, the class is evenly divided about whether a seed is living or nonliving. Shalika argues, "The seed is not living because it can't move. The cat moves and it is alive, so I think living things have to move." Mac disagrees: "A tree is alive, but it can't move around like a cat. I think some things can be living and not move, so maybe a seed is alive." Oscar offers a new idea: "But seeds grow into plants." Miss Ortega asks Oscar to say more about that, and he adds a clarification: "Things that are living can grow. A seed grows into a plant, so that makes it living." Cora argues that some living things stop growing: "My dad is living, but he is done growing. I think you can stop growing and still be living."

Miss Ortega lists two ideas the children have proposed so far: moving and growing. She asks the class if there are other ways to decide if something is living. Albert offers a new idea: "Living things have to eat, so if it eats, then it is alive." Kenny looks puzzled and asks a question to seek clarification: "But what about fire? It grows bigger when it eats wood." Rania responds, "Yeah, it moves around, too. Fire can move through a whole forest!"

The discussion continues for several minutes. The children are deeply involved in sharing their ideas, listening attentively to each other, seeking clarification from the teacher or other students when needed, constructing explanations to use in their arguments, and evaluating the ideas and arguments of others. Throughout the discussion, they are using and practicing speaking and listening skills.

Miss Ortega makes sure that all the children have an opportunity to make claims and express their thinking. Throughout the year, they have been working on claims and evidence during their science time. Her students know that a claim is the statement that answers the probe question, and to share their thinking, they must provide reasons, including evidence, for their claim. As the children are talking, Miss Ortega is carefully listening and making a list of the class's best ideas so far, which she will post on a chart for students to see and refer to while they visit the learning stations she will set up for the children to explore claims and ideas that support their claims. She notes the extent to which students are using scientific ideas or whether they are drawing on their own alternative conceptions or prior experiences.

By taking the time to find out what her students think about characteristics of living things, Miss Ortega collects valuable assessment data that she will use to plan lessons that will confront her students with their ideas and help them resolve some of the inconsistencies between their ideas and the scientific explanation she will guide them toward developing. By taking their ideas seriously and not correcting students' initial misconceptions, Miss Ortega is promoting learning by giving her students the opportunity to use scientific practices as they listen to each other's ideas, justify their own reasoning, and evaluate the validity of each other's arguments. This is the essence of formative assessment where good instruction and assessment are inextricably linked. Formative assessment is an approach to teaching in which students develop deeper conceptual understanding through the development of their own thinking and talking through their ideas, while simultaneously providing a window for the teacher to examine students' thinking and determine next steps based on where the learners are in their conceptual development.

Facilitating this type of approach to learning may sound demanding, and it seems it would be much simpler to just give students the information or engage in a hands-on activity. However, research shows that children learn best when they first surface their ideas before launching into investigations, activities, readings, and other opportunities to learn (Bransford, Brown, and Cocking 1999). Students have to do the thinking; the activity cannot do it for them, nor is the learning in the materials themselves. Surfacing initial ideas and recognizing when their ideas are changing as they construct new understandings is a powerful way to teach and learn. It is the explanation of the probe—not the answer selections the students choose from—that provides important assessment data and supports learning. One of the most effective ways to help students construct new understandings and simultaneously develop reasoning skills (that works particularly well with the formative assessment probes) is to provide children with the opportunity to interact in pairs, small groups, and as a whole class, where they listen to each other's ideas and have to justify their own. Communicating ideas in science is a central feature of using the formative assessment probes and one of the *Next Generation Science Standards (NGSS)* scientific practices. The probes not only provide insights for the teacher about students' understanding or misunderstanding of core ideas in science but also provide a treasure trove of data about students' use of scientific and engineering practices. For example, P-E-O (Predict-Explain-Observe) probes provide an opportunity for young children to make an initial claim (prediction), provide an explanation for their initial claim, test the claim, gather evidence (the data) from the observations, analyze the data to see if they support or refute the initial claim, and propose a new claim and explanation if the observations did not match the initial claim. See Table 2 for examples of ways the formative assessment probes support learning of the practices in the *NGSS*.

This book provides 25 highly engaging formative assessment probes that elicit preconceptions, support the development of young children's understanding of K–2 core disciplinary ideas, and encourage the use of scientific practices in the *NGSS*. However, before you skip ahead and use the probes, read through the rest of this introduction to learn more about children's ideas in science and science talk so that you can best use these probes to inform your teaching and support learning.

Table 2. Link Between K–2 Formative Assessment Probes and the *NGSS* Scientific and Engineering Practices

***NGSS* Scientific and Engineering Practice**	**K–2 Probes as Assessments for Learning**	**Examples**
Practice 1: Asking questions and defining problems	The probe begins with an interesting question. Students ask additional questions to seek understanding and determine what they already know or need to know to make a claim and construct explanations to the probe.	**Probe 16, "Do the Waves Move the Boat?"** Students may ask questions of each other and the teacher about water waves. They use the probe question to further explore the science that can provide an explanatory answer to the probe.
Practice 2: Developing and using models	Some probes involve the use of models to develop explanations of the phenomenon. As the teacher listens to children's ideas, he or she is thinking about the best model to use to help them understand the probe phenomenon.	**Probe 24, "What Lights Up the Moon?"** As the teacher listens to students, he notices several students think there is a light glowing inside the moon. He thinks about how he can have the children model the reflection of sunlight using a white ball and a flashlight.
Practice 3: Planning and carrying out investigations	Some probes (P-E-O probes) can be used to launch an investigation and require children to think about how they can best make observations and collect data to test the claims they made in response to the probe.	**Probe 19, "Big and Small Magnets"** Students test their claims using a variety of big and small magnets. They decide how they will determine strength using paper clips, make observations, and record their data.
Practice 4: Analyzing and interpreting data	To support a claim with evidence when using a P-E-O probe, students collect, analyze, and interpret the data to derive meaning.	**Probe 18, "Rubber Band Box"** Students make rubber band box guitars like the one in the probe context and test their ideas about sound. They analyze their data to determine how pitch is related to the thickness of the rubber band.
Practice 5: Using mathematics and computational thinking	Students count and use numbers to find or describe patterns related to the probe. They also use measurement and measurement instruments such as thermometers, rulers, and weighing scales to gather data.	**Probe 12, "Snap Blocks"** Students count the individual blocks and make predictions about how the weight of the blocks snapped together compares to the total weight of the individual blocks weighed together. They try this several times using different numbers of snap blocks, weigh them on a scale, record their data, and notice that the pattern shows the weight is always the same.
Practice 6: Constructing explanations and designing solutions	Every probe requires students to construct an initial explanation (their personal theory) to support their claim (answer choice) and revise their explanations as they gather new evidence and information.	**Probe 10, "Watermelon and Grape"** The initial theory proposed by the class is that large things sink and small things float. After testing a variety of objects, students revise their initial explanation to explain that size alone does not determine whether an object floats or sinks.

Table 2 *(continued)*

NGSS Scientific and Engineering Practice	K–2 Probes as Assessments for Learning	Examples
Practice 7: Engaging in argument from evidence	All the probes are used in a talk format that requires students to explain and defend their reasoning to others and promotes careful listening so that other students can build on a line of reasoning or offer alternative explanations. Together, the class searches for the best explanation from the comments and evidence offered during science talk.	**Probe 1, "Is It Living?"** As in the scenario at the beginning of this chapter, the teacher engages the students in science talk, explaining and defending their reasons for why something is or is not considered living. Later, after the teacher has provided opportunities for students to investigate their ideas, they will engage again in science talk, providing new evidence to support or revise their initial arguments.
Practice 8: Obtaining, evaluating, and communicating information	Following up the use of a probe often involves students seeking additional information that may come from trade books, videos, and other sources to provide information that supports their claims or provides new information to help them change their claim. Students must also be able to communicate information clearly to each other, which sometimes involves the use of drawings and other visual ways to share the information they obtain.	**Probe 6, "Do They Need Air?"** Many students claimed that animals that live in water do not need air, so the teacher obtained several trade books and video clips for children to learn about animals that live in water and how they meet their needs. She also brought in a goldfish that students could observe. Children revisit the probe and explain ways different animals get air and draw pictures of land and water animals, showing different structures they use to get air.

Young Children's Ideas

Children develop ideas about their natural world well before they are taught science in school. For example, many young children think that things like hats, coats, blankets, sweaters, or mittens warm us up by generating their own heat. This makes sense to children because when they put on a sweater or wrap themselves up in a blanket, they get warmer. They have not yet learned that heat moves from warmer to cooler and that materials such as a mitten can slow down the loss of body heat. In other instances, children are novice learners in science and have not yet gained enough background knowledge or been formally introduced to scientific principles to be able to explain a concept scientifically. For example, young children may think that only organisms with fur and four legs are considered animals because they do not yet have enough knowledge about the scientific meaning of animal—such as having to acquire food from the environment—to recognize that organisms such as worms, insects, and even humans are considered animals in a scientific sense.

Some of the ideas young children have may be consistent or partially consistent with the science concepts that are taught. For example, they know when you drop an object, it falls to the ground. They are already developing ideas consistent with the idea of gravity. But often there is a significant gap between children's explanations for natural phenomena or concepts and the explanations that are developed through "school science." For example, failure to recognize that weight is conserved when a whole object is broken into individual pieces illustrates a significant gap between children's ideas about what happens to the total weight of an object when it is changed in some way and the understanding of conservation of matter with "parts and wholes" that is developed in the science class.

Many studies have been conducted of children's commonly held ideas about natural phenomena and science concepts. Most notable among the researchers of children's ideas is Dr. Rosalind Driver and her research group from the University of Leeds in England. This group has contributed extensively to our understanding of commonly held ideas children have about science that may affect their learning. The research into commonly held ideas, which is often referred to by practitioners as misconceptions, has enabled teachers to predict what their own students are likely to think about a phenomenon and how they might respond to an assessment that probes their thinking. The assessment probes in this book were developed from examining the research on children's ideas in science, particularly Driver's contributions (Driver, Squires, Rushworth, and Wood-Robinson 1994). As you use these probes, it is highly likely that your students' ideas will mirror the findings that are described in the Related Research Summaries part of the Teacher Notes that accompany each of the probes. While you may be surprised to find that your students hold many of these alternative ideas, it is important for you to realize that these are highly personal and make sense to the student. Merely correcting them does not make them go away. Students must have access to instructional experiences that will challenge their thinking and help them construct models and explanations that bridge the gap between their initial ideas and the scientific understandings that are achievable at their grade level.

Another important feature of children's ideas in science is that children learn best when knowledge is socially constructed. Much like the way science is done in the real world, children need opportunities to share their thinking, justify the reasons for their ideas, and listen to the ideas of others. Children also need to be aware of the range of ideas others have about the same phenomenon or concept and be able to evaluate them in light of their own ideas and the evidence presented. Scientific theories develop through interaction with other scientists; children's ideas develop through interaction with their classmates and the teacher. The probes provide ample opportunities for children to think through and talk about their ideas with others. Animated science talk and argumentation are the hallmarks of a formative assessment–centered learning environment in which the probes are effectively being used.

Children's Learning Experiences

Hands-on science has not always been minds-on science. The opportunity to ask questions, manipulate materials, and conduct investigations—a major emphasis of inquiry-based science—has not always resulted in deeper conceptual learning. That is because the learning is not in the materials or investigations themselves, but in the sense children make out of their experiences as they use the materials to perform investigations, make observations, and construct explanations. Perhaps the pendulum swung too far to the hands-on side in the last decade or so of elementary inquiry-based science. Inquiry without inquiry for conceptual change did little to help students give up their strongly held alternative ideas. One way to support inquiry for conceptual change is to start with uncovering children's ideas before launching into an investigation. To design probes for this book that could be used to support or enhance children's learning experiences, the following features for developing and using a probe were considered:

- Promoting curiosity and stimulating children's thinking
- Drawing out alternative ideas that could be investigated in the classroom

- Linking to previous experiences in or out of school
- Using familiar objects, phenomena, and situations
- Reducing dependency on reading text
- Improving developmental appropriateness
- Relating to core ideas in the *NGSS* or the *Benchmarks for Science Literacy*
- Supporting the use of the scientific and engineering practices such as constructing explanations and engaging in argument from evidence
- Using models and representations to develop explanations
- Encouraging sense making and reflection on how ideas have changed

Effective teaching and learning do not just happen; they are carefully planned. Using the probes to inform the design of learning experiences for children involves the recognition that children already have ideas about the natural world that they bring with them to their learning experiences. This is significant when planning instructional experiences, particularly when combined with a constructivist view of learning in which the student must take an active role in constructing meaning for himself or herself. When children's existing ideas are acknowledged as you incorporate their ideas from the probes into the lessons, learning takes place as children change their ideas through experiences that allow them to test or discuss their ideas and support them with evidence, in much the same way that scientists develop theories. This may involve supporting an initial idea, modifying an idea, or rejecting an idea in favor of an alternative explanation. Whichever it is, the student needs to "own it," which means the reasoning must be done by the student (not the teacher, although he or she can guide it).

Formative Assessment Probes and Science Talk

> When I first tried listening quietly and taking notes about what I heard students saying as they worked, my insight into their learning was phenomenal! I actually stopped talking and just listened. The data I collected showed some incorrect conceptions as well as understanding. It often opened windows into how a student had learned. The rich data I gathered helped me determine which next steps I needed to take to further learning. (Carlson, Humphrey, and Reinhardt 2003, p. 37)

This quote from an elementary teacher reveals the power of careful listening as students talk about their science ideas. The probes in this book differ from the collection of 215 other formative assessment probes in the *Uncovering Student Ideas* series because they are designed to be used in a talk format rather than having students write explanations to support their answer choice (however, they certainly can be combined with writing, especially with science notebooks). Even the formats used in this book highlight the importance of science talk. For example, you will see that several of the probes in this book use a cartoon format in which the characters share their ideas with each other and the student selects the character whose idea best matches his or her own (e.g., "Sink or Float?"). This format models what we want to encourage children to do: share their claims with one another and provide evidence that supports these claims. The author intentionally uses this format to help students recognize the importance of sharing ideas without passing judgment initially on whether they are right or wrong.

Whether you use the science workshop approach, science conferences, small-group discussions, pair talk, or other ways to involve students in science talk, the probes provide an interesting question that serves to elicit children's initial ideas and draw out their reasons for their thinking. Assessment data is gathered by carefully listening to students, and, when possible, audio-recording dialogue, taking notes, or transcribing parts of conversations as you listen will provide a treasure trove of data you can use to design instruction focused on where the learners are in their understanding.

The first step in using science talk for formative assessment is to ask questions that will capture students' interest, provoke thinking, and encourage explanations that will help you gain insight into their reasoning and understanding. Sometimes it can be challenging for teachers to know what type of question will elicit children's ideas that can provide rich information about a core concept they will be learning. This has been done for you in this book! Each probe is a question specifically designed to draw out children's ideas that will not only support their learning but also inform your teaching. Use the probe as your starting point for learning more about your students' ideas. New questions will spring from the probe and spark further conversation.

Sometimes a probe is used to develop an investigative question and launch into inquiry. Some probes provide an opportunity for students to make predictions and explain the reasons for their prediction before they make observations during their investigations. This type of probe is called a P-E-O (Predict-Explain-Observe) probe, and examples include, but are not limited to, "Snap Blocks" (p. 59), "Marble Roll" (p. 71), and "Seeds in a Bag" (p. 25) (Keeley 2008). P-E-O probes provide an opportunity for children to practice verbal communication to articulate their thoughts prior to the investigation and make their thinking visible to others. In addition, it provides an opportunity for children to discuss the best way to test their ideas and then test them, supporting the *NGSS* scientific practice of designing and carrying out investigations.

Productive classroom talk using a formative assessment probe before launching into an investigation also has the benefit of leading to deeper engagement in the content before and during the investigation. As students collect, analyze, and share their data, they compare their findings with their initial claims and evidence and may become aware of the discrepancies between their own or others' ideas from the evidence gathered during the investigation. For example, the probe "When Is the Next Full Moon?" provides an opportunity for students to make and test a prediction about how long it takes to see a full Moon again (length of a lunar cycle). They examine reasons for their predictions before beginning an investigation that provides the data they need to understand the repeated pattern of Moon phases, a disciplinary core idea in the *NGSS* as well as a crosscutting concept of patterns and cycles. The probe can be revisited again after students have had an opportunity to make sense of their data and use it to explain the lunar cycle. By following the probe with a scientific investigation, the students have actual data from their investigation to construct a scientific explanation to support their new or revised claim. As they engage in talk and argument again with the same probe, the context of the probe—combined with the scientific knowledge they gained through their investigation—provide an opportunity for them to build stronger, evidence-based arguments.

Talk Moves

One of the best resources I recommend that every teacher of elementary science read and become familiar with is *Ready, Set, Science! Putting Research to Work in K–8 Classrooms*

(Michaels, Shouse, and Schweingruber 2008). Since this book is published through our federal taxpayer–supported National Academies of Science, it is available for free as a PDF on the National Academies Press website (*www.nap.edu*), where you can download a copy of the book. It is also available for purchase through the NSTA bookstore. Chapter 5, "Making Thinking Visible: Talk and Argument," is an excellent read for you to deepen your understanding of the role of talk and argument in science as you use the probes in this book.

As students grapple with the ideas elicited by the probes in this book, the role of the teacher is to facilitate productive science talk in ways that will move students' thinking forward and help them clarify and expand on their reasoning. One of the ways to do this is through the use of "talk moves" (Keeley 2012). Table 3 shows six productive talk moves adapted from *Ready, Set, Science!* (Michaels, Shouse, and Schweingruber 2008) that can be used with the formative assessment probes in this book.

Table 3. Talk Moves and Examples

Talk Move (from *Ready, Set, Science!* [Michaels, Shouse, and Schweingruber 2008])	Example of Using the Talk Move with a Formative Assessment Probe
Revoicing	• "So let me see if I've got your thinking right. You're agreeing with Amy because _____?" • "Let me see if I understand. You are saying _____?"
Asking students to restate someone else's reasoning	• "Can you repeat in your own words what Latisha just said about why she agrees with Jamal?" • "Is that right, Latisha? Is that what you said?"
Asking students to apply their own reasoning to someone else's reasoning	• "Do you agree or disagree with Emma's reason for agreeing with Morrie, and why?" • "Can you tell us why you agree with what Sam said? What is your reasoning?"
Prompting students for further participation	• "Would someone like to add on to the reasons why some of you chose Fabian as the person you most agree with in the probe?" • "What about others—what would you like to add to these ideas so far?" • "What do others think about the ideas we have shared so far? Do you agree or disagree?"
Asking students to explicate their reasoning	• "Why do you agree with Penelope?" • "What evidence helped you choose Fabian as the person you most agree with in the probe?" • "Say more about that."
Using wait time	• "Take your time. We'll wait." • "I want everyone to think first, and then I will ask you to share your thinking."

Revoicing

Sometimes it is difficult to understand what the student is trying to say when they struggle to put their thoughts into words. If you, as the teacher, have difficulty understanding what the student is saying, then the students listening are apt to have even greater difficulty. Clarity in expressing ideas is often needed when encouraging young children to share their thinking. Therefore, this move not only helps the child clarify his or her thinking but also provides clarity for the listeners as well—both teacher and students. By revoicing the child's idea as a question, the teacher is giving the child more "think time" to clarify his or her ideas. It is also a strategy for making sure the student's idea is accessible to the other students who are listening and following the discussion.

Asking Students to Restate Someone Else's Reasoning

While the move above (revoicing) is used by the teacher, this move has the students reword or repeat what other students share during the probe discussion. It should then be followed up with the student whose reasoning was repeated or reworded. The benefit to using this talk move during discussions about the science probe ideas is that it gives the class more think time and opportunity to process each student's contribution to the science talk. It also provides another version of the explanation that may be an easier version for the children to understand. This talk move is especially useful with English language learners. As a formative assessment talk move, it provides the teacher with additional clarification of student ideas. Additionally, it acknowledges to the students that the teacher as well as the students in the class are listening to one another.

Asking Students to Apply Their Own Reasoning to Someone Else's Reasoning

The probes encourage students to make a claim and share their reasoning for their claim. This talk move is used with the probes to make sure students have had time to evaluate the claim based on the reasoning that was shared by a student. It helps students zero in and focus on the reasoning. Note that the teacher is not asking the other students whether they merely agree or disagree with someone's claim; they also have to explain why. This talk move helps students compare their thinking to someone else's and, in the process, helps them be more explicit in their own reasoning.

Prompting Students for Further Participation

After using revoicing to clarify the different ideas that emerge during discussion of the probe, the teacher prompts others in the class to contribute by agreeing, disagreeing, or adding on to what was already shared. This talk move encourages all students to evaluate the strength of each other's arguments. It promotes equitable and accountable discussion.

Asking Students to Explicate Their Reasoning

This talk move encourages students to go deeper with their reasoning and be more explicit in their explanations. It helps them focus on the evidence that best supports their claim and build on the reasoning of others.

Using Wait Time

This is actually a silent move, rather than a talk move. One of the hardest things for teachers to do is to refrain from not commenting immediately on children's responses. There are two types of wait time that should be used when engaging students in probe discussions. The first is for the teacher to wait at least five seconds after posing a question so the students have adequate think time. The second is for the teacher, as well as the students, to practice waiting at least five seconds before commenting on a students' response. This strategy is especially important to use with English language learners as well as students who may be shy or reluctant to contribute ideas in front of the whole class. By waiting, even though silence can be agonizing, the teacher supports students' thinking and reasoning by providing more time for them to construct an explanation or evaluate the arguments of others. This strategy provides greater inclusivity for all students in the class to participate in productive science talk by acknowledging the time they need to think through their ideas.

All of these talk moves can be used with the probes in various combinations to facilitate productive science talk in which all the students are accountable for each other's learning and the teacher is able to extract valuable formative assessment data to further plan instruction and support learning. However, to use these moves effectively, it is important to establish the conditions for a respectful learning environment. To do that, teachers should set group norms or ground rules for engaging in productive talk and equitable participation so that students will listen to and talk with one another respectfully and courteously as they use the probes. It is important for them to know that a scientific argument has a different meaning in science than in real life. In science, we argue to examine our ideas and seek understanding rather than argue to win with our point of view. Examples of norms you might establish in your classroom for science talk may include but are not limited to the following:

- Listen attentively as others talk.
- Make sure you can hear what others are saying.
- Speak so others can hear.
- Argue to learn, not to win.
- Criticize the reasoning, not the person.
- Make only respectful comments.

Communicating and listening to scientific ideas contribute to language development, an important goal of teaching in the primary grades, and is consistent with the *Common Core State Standards, ELA* (NGAC and CCSSO 2010). See Table 4 for examples of ways the formative assessment probes support the *Common Core* literacy standards for speaking and listening for primary students.

Formative assessment that supports productive scientific discussions takes time to develop and needs a lot of practice. As you incorporate these probes into your science lessons, I hope you will see the value in productive science talk that emanates from using these probes. By using these probes in talk formats with primary students, you are not only developing conceptual understanding of the life, physical, Earth, and space ideas for grades K–2 included in the *NGSS*, but also revealing and clarifying the ideas they bring to their learning, which you can use to improve and enhance your science teaching. Making students' ideas visible as you use these probes will help you build more effective lessons and support young students in using the scientific and engineering practices in sophisticated ways that show young learners are capable of far more than we often ask of them. In a nutshell, it's about teaching science well and giving your students the best possible start to be successful learners of science as they progress through school!

Table 4. Linking Formative Assessment Probes to the *Common Core* Speaking and Listening Standards

Common Core State Standards (Grades K, 1, and 2)	Formative Assessment Probes
◆ SL.K.1, 1.1, 2.1: Participate in collaborative conversations with diverse partners about kindergarten, grade 1, and grade 2 topics and texts with peers and adults in small and larger groups.	The probes are designed to be used in a talk format in small or large groups discussing ideas with the teacher and with each other about a science topic.
◆ SL.K.2: Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood. ◆ SL.1.2: Ask and answer questions about key details in a text read aloud or information presented orally or through other media. ◆ SL.2.2: Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.	As students talk about and share their ideas related to the probe, they ask questions about and discuss key details related to the probe context or answer choices. They may ask for clarification about the probe context or the answer choices or clarification of each other's explanations as they share their ideas through speaking and listening.
◆ SL.K.3: Ask and answer questions in order to seek help, get information, or clarify something that is not understood. ◆ SL.1.3: Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood. ◆ SL.2.3: Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.	Students ask questions about the probe task. They also ask questions of each other and seek clarification of explanations as they share their claims and provide their reasons for their claims. After students have had the opportunity to revisit the probe after the teacher has designed learning experiences, students ask and answer questions to deepen their understanding of the concepts elicited by the probe.
◆ SL.K.4: Describe familiar people, places, things, and events and, with prompting and support, provide additional detail. ◆ SL.1.4: Describe people, places, things, and events with relevant details, expressing ideas and feelings clearly. ◆ SL.2.4: Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.	The probes provide a context for discussing familiar phenomena, objects, and processes related to a science core idea. Students are encouraged to share their prior experiences connected to the probe and prompted by the teacher to provide details and further information.
◆ SL.K.5: Add drawings or other visual displays to descriptions as desired to provide additional detail. ◆ SL.1.5: Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings. ◆ SL.2.5: Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.	Students are encouraged to use drawings or other visual symbols, where appropriate, to support their ideas, clarify their responses, and communicate relevant details related to the probe.
◆ SL.K.6: Speak audibly and express thoughts, feelings, and ideas clearly. ◆ SL.1.6 and SL2.6: Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification.	Probes provide an engaging context for students to practice speaking clearly in complete sentences to support their ideas and emerging understanding of science.

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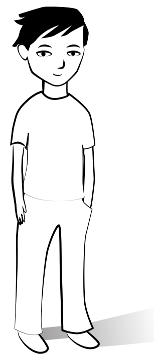
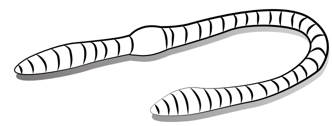
Is It Made of Parts?

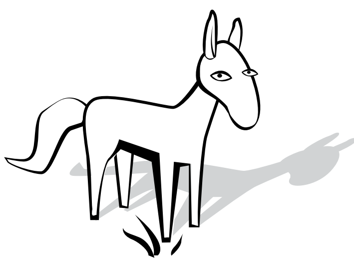
feather



person



worm



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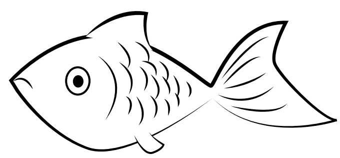

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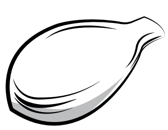
leaf



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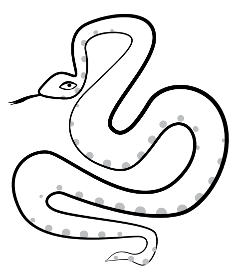

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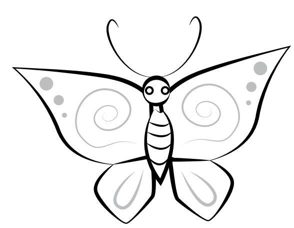

butterfly

What are you thinking?

Is It Made of Parts?

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit children's developing ideas about structure in living systems. The probe is designed to find out if students recognize that living things are made up of parts.

Related Concepts

structure, parts and wholes, systems

Explanation

All of the things listed are made up of parts. An organism's body is made up of external and internal parts. These parts are the structure of an organism and work together as a system to enable an organism to carry out its life functions. Some external parts of organisms are easy to see. Others may be so small that magnification is needed. Some internal parts may not be obvious unless students look inside the object (e.g., a seed).

Curricular and Instructional Considerations for Grades K–2

Parts and wholes is a prerequisite concept for understanding structure and function of organisms and the crosscutting concept of systems (structure and function is also a crosscutting concept). In the primary grades, children learn that things are made of parts in both living and physical systems. Primary students should first observe external parts of organisms that they can easily see (e.g., ears of a dog), as well as parts that can be seen with magnifiers (eyes on an insect). Once students develop the idea that organisms have external parts, they may begin to explore familiar internal parts and how parts work together to allow an organism to live in its environment.

Administering the Probe

Review the things on the list with students to make sure they are familiar with each thing. Name each organism or part of an organism as you associate it with the picture. This practice is especially important for English language learners. Make sure the pictures are clear to the students and that students have a sense of the relative sizes, which the pictures do not convey. If you have other pictures that illustrate each of the things listed, you might show those to the students in addition to the ones on the student page. Instruct students to circle or color the things they think are made of parts. Additionally, you may ask them to put an *X* over the ones they think are not made of parts. Have students explain the rule and the criteria they used to decide whether the things on the list are made up of parts. See pages xxviii–xxxiii in the introduction for techniques used to guide "science talk" related to the probe.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 2009)

K–2 Cells

- Magnifiers help people see things they could not see without them.

K–2 Systems

- Most things are made of parts.

3–5 Systems

- In something that consists of many parts, the parts usually influence one another.

Related Core Ideas in *A Framework for K–12 Science Education* (NRC 2012)

K–2 LS1.A: Structure and Function

- All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.

3–5 LS1.A: Structure and Function

- Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Related *Next Generation Science Standards* (Achieve Inc. 2013)

Grade 1: From Molecules to Organisms: Structures and Processes

- 1-LS1-1: Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

Grade 4: From Molecules to Organisms: Structures and Processes

- 4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Related Research

- Children recognize that the body is made up of external parts before they appear to understand internal structures (Driver, Squires, Rushworth, and Wood-Robinson 1994).

Suggestions for Instruction and Assessment

- Start with familiar organisms (such as people) and have children identify different parts and their uses. Then proceed to different types of animals and plants.
- Have students go on a "parts and wholes" walk. Have them find things that are made of parts. Challenge them to find something that is not made of parts.
- Show students a plant and ask them if the plant is made up of parts. Have them explore different parts such as the roots, stems, leaves, flowers, fruits, and seeds. Then have them look for parts that make up the parts of a plant, developing the notion that things are made up of parts that may contain even smaller parts. However, be aware that labeling the parts of a plant does not ensure that students understand these are part of a larger system.
- Give students magnifiers and ask them to find parts of organisms (e.g., insects, worms, flowers, seeds) that they could not see with just their eyes to develop the notion that some parts are too small to see with just our eyes, and tools such as magnifiers help us see very tiny things.
- Project 2061's online Resources for Science Literacy has a good example of designing instruction for K–2 around the parts and wholes concept. You can access this lesson at *www.project2061.org/publications/rsl/online/GUIDE/CH2/HLPPAR0.PDF.*
- This probe can be extended to a physical science context by providing students with a list of objects (e.g., toy, scissors, book)

and asking them to identify the things that are made of parts.

Related NSTA Resources

Ashbrook, P. 2008. The early years: Observing with magnifiers. *Science and Children* 45 (6): 18–20.

Konicek-Moran, R. 2009. *More everyday science mysteries: Stories for inquiry-based science teaching.* (See "Flowers: More Than Just Pretty," pp. 121–134.) Arlington, VA: NSTA Press.

Ritz, W. 2007. *A head start on science: Encouraging a sense of wonder.* Arlington, VA: NSTA Press.

References

Achieve Inc. 2013. *Next generation science standards. www.nextgenscience.org/next-generation-science-standards.*

American Association for the Advancement of Science (AAAS). 2009. Benchmarks for science literacy online. *www.project2061.org/publications/bsl/online*

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London: Routledge.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

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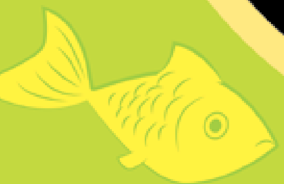
VOL.1

Uncovering Student Ideas in Primary Science

25 New Formative Assessment Probes for Grades K–2



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