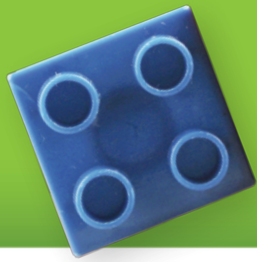
Rosalind Charlesworth

Math and Science for Young Children

Eighth Edition

MATH AND SCIENCE

FOR YOUNG CHILDREN



EIGHTH EDITION

DEDICATION

This book is dedicated to the memory of a dear friend ADA DAWSON STEPHENS.

Rosalind Charlesworth
Weber State University

Math and Science for Young Children

Eighth Edition

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***Math and Science for Young Children*, Eighth Edition**
Rosalind Charlesworth

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BRIEF CONTENTS

CONTENTS

PREFACE

Math and Science for Young Children, Eighth Edition, is designed to be used by students in training and by teachers in service in early childhood education. To the student, it introduces the excitement and extensiveness of math and science experiences in programs for young children. For teachers in the field, it presents an organized, sequential approach to creating a developmentally appropriate math and science curriculum for preschool and primary school children. Further, it is designed in line with the guidelines and standards of the major professional organizations: National Association for the Education of Young Children (NAEYC), National Council of Teachers of Mathematics (NCTM), National Science Teachers Association (NSTA), and National Research Council (NRC).

Development of the Text

The text was developed and directed by the concept that the fundamental concepts and skills that form the foundation for mathematics and science are identical. Each edition has focused on these commonalities. As changes have emerged in each area, the text has been updated. Acquaintance with child development from birth through age 8 would be a helpful prerequisite.

Organization of the Text

The text is set up in a logical progression, and students should follow the text in sequence. Applying the assessment tasks and teaching one (or more) of the sample lessons will provide the student with hands-on experience relevant to each concept and each standard.

Activities are presented in a developmental sequence designed to support young children's construction of the concepts and skills essential to a basic understanding of mathematics and science. A developmentally appropriate approach to assessment is stressed in order to have an individualized program in which each child is presented at each level with tasks that can be accomplished successfully before moving on to the next level.

A further emphasis is placed on three types of learning: naturalistic, informal, and adult guided. Much learning can take place through the child's natural exploratory activities if the environment is designed to promote such activity. The adult can reinforce and enrich this naturalistic learning by careful introduction of information through informal and adult-guided experiences.

The test-driven practices that are currently prevalent have produced a widespread use of inappropriate instructional practices with young children. Mathematics for preschoolers has been taught as "pre-math," apparently under the assumption that math learning begins only with addition and subtraction in the primary grades. It also has been taught in both preschool and primary school as rote memory material using abstract paper-and-pencil activities. Science is often presented as discrete activities if at all. This text emphasizes the recognition by the National Council of Teachers of Mathematics and the National Research Council of the inclusion of mathematics at the pre-K level in its revised mathematics standards (CCSSM, NRC, 2010). A new Science Framework (NRC, 2012) and Next Generation Common Core Standards for Science (NGSS, NRC, 2013) cover K–12 science standards and emphasize science projects as ongoing endeavors integrated with the other curriculum areas. This text is designed to bring to the attention of early childhood educators the interrelatedness of math and science and the necessity of providing young children with opportunities to explore concretely these domains of early concept learning. Further integration is stressed with language arts, social studies, art, and music; the goal is to provide a totally integrated program. With the advent of STEM, efforts are being made to emphasize the relationships among science, technology, engineering, and mathematics. Also, the national Common Core state standards for mathematics and the New Generation Science Standards support an integrated, project approach to instruction. These standards are described in the relevant chapters. Also included are the relevant NAEYC Guidelines and Professional Development standards.

Part 1 sets the theoretical and conceptual foundation. Part 2 provides chapters on fundamental concepts: one-to-one correspondence, number sense and counting, logic and classifying, comparing, shape, spatial sense, parts and wholes, and application of these concepts to science. Each chapter is introduced with the relevant Common Core State Standards, followed by assessment; naturalistic, informal, and adult-guided activities; evaluation; and summary. Every chapter includes references and further reading and resources, brain connections, a suggested related video, and a technology connection. Most of the chapters in Parts 3, 4, and 5 follow the same format. Chapter 6 (in Part 3) sums up the application of process skills and important vocabulary and provides basic ideas for integrating math and science through dramatic play and thematic units and projects. Part 5 includes the major mathematics concepts for grades 1–3. Part 6 focuses on science investigations in the primary grades. Part 7 includes three areas: materials and resources, math and science in action, and math and science in the home. The appendices contain additional assessment tasks and lists of books, periodicals, and technology resources. A glossary and index are also included.

New to This Edition

Major revisions to the eighth edition include the following:

- **Learning Objectives** at the beginning of each chapter now correlate with main headings within the chapter and the Summary at the end of the chapter. The objectives highlight what students need to know to process and understand the information in the chapter. After completing the chapter, students should be able to demonstrate how they can use and apply their new knowledge and skills.
- **Improved integration of early childhood and primary grade professional standards** helps students make connections between what they are learning in the textbook and the standards. This edition now contains a list of standards covered at the beginning of each chapter, including NAEYC's Professional Preparation Standards (2010); Developmentally Appropriate Practice (DAP) Guidelines; Common Core Standards for Math; and Next Generation Science Standards. Throughout the text, these standards are also highlighted with icons, and a complete list of the standards addressed in this book can be found in the standards correlation chart on the inside front and back covers.
- **Digital Downloads** are downloadable and sometimes customizable practical and professional resources, which allow students to immediately implement and apply the textbook's content in the field. Students can download these tools and keep them forever, enabling preservice teachers to begin building a library of practical, professional resources. Look for the Digital Download label that identifies these items.
- **MindTap for Education** is a first-of-its kind digital solution that prepares teachers by providing them with the knowledge, skills, and competencies they must demonstrate to earn an education degree and state licensure, and to begin a successful career. Through activities based on real-life teaching situations, MindTap elevates students' thinking by giving them experiences in applying concepts, practicing skills, and evaluating decisions, guiding them to become reflective educators.
- **TeachSource Videos** feature footage from the classroom to help students relate key chapter content to real-life scenarios. Critical-thinking questions following each video provide opportunities for in-class or online discussion and reflection.
- **Brain Connection** boxes describe recent brain research related to the chapter topics.
- **Updated Technology for Young Children** boxes address the increasing role that technology tools are playing in children's education. Each box introduces resources for a particular topic or discusses related research.
- The text is streamlined for easier use, with 12 chapters rather than the 41 units that appeared in previous editions.
- Recent insights on instruction for special needs students help readers think about and determine how they will adapt their teaching style to include all children.
- Updated coverage of important topics in the field includes STEM/STEAM, with engineering now included in science and math chapters; multicultural and English Language Learner (ELL) classroom learning and strategies and multicultural integration; science performance expectations; and expanded discussion of constructivism.
- Science activities and projects are now divided into Next Generation and conventional approaches, as NGSS is just being introduced and may not be familiar to all readers.
- References have been updated throughout and are included at the end of the chapter, and the Further Readings and Resources list now includes just the most recent items and some classics.

Major Part-Specific Changes

Part 1

- Explanation and description of Science Framework and NGSS are included.
- CCSSM and new NCTM Principles and Actions are explained and described.
- Discussion of STEM and STEAM has been expanded.
- There is increased coverage of analysis of problem-solving processes.
- Chapter 1 contains content previously in Units 1, 2, 3, and 4.
- Chapter 2 includes the content from Units 5, 6, and 7.

Part 2

- Chapter 3 includes the content from Units 8–11.
- Chapter 4 includes the content from Units 12–14 and 16, and thus makes a closer connection between math and science.

Part 3

- Chapter 5 includes material from Units 17–21 and thus makes a closer connection between math and science.
- Chapter 6 includes material from Units 15 and 22, thus demonstrating how language, play, and projects can support learning across the curriculum.

Part 4

- New engineering examples are provided.
- Chapter 7 includes the material from Units 23–26 and thus provides a closer connection between math and science; in addition, it connects the more advanced concepts and skills that some children will learn by the end of kindergarten.

Part 5

- Chapter 8 includes material from Units 27–29.
- Chapter 9 includes material from Units 30–32.
- Math standards have been updated.

Part 6

- Chapter 10 includes material from Units 33–35.
- Chapter 11 includes material from Units 36–37 plus new material on engineering, technology, and science application.
- New project lesson plans based on NGSS standards are included for the primary grades.

Part 7

- Resource addresses have been updated.

Appendix A

- Tasks have been connected to new organization.
- Resources have been updated.

Appendix B

- A new section of technology resource sites has been included.
- New books have been added.

Supplement Package

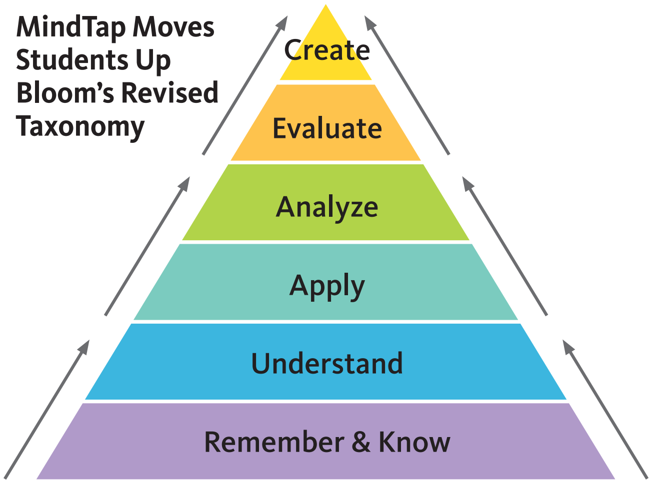
- NEW MindTap™, The Personal Learning Experience, for Charlesworth's *Math and Science for Young Children*, 8th Edition, represents a new approach to teaching and learning. A highly personalized, fully customizable learning platform, MindTap, helps students to elevate thinking by guiding them to:
  - Know, remember, and understand concepts critical to becoming a great teacher;
  - Apply concepts, create tools, and demonstrate performance and competency in key areas in the course;
  - Prepare artifacts for the portfolio and eventual state licensure, to launch a successful teaching career; and
  - Develop the habits to become a reflective practitioner.

As students move through each chapter's Learning Path, they engage in a scaffolded learning experience designed to move them up Bloom's Taxonomy from lower- to higher-order thinking skills. The Learning Path enables preservice students to develop these skills and gain confidence in the following ways:

- Engaging them with chapter topics and activating their prior knowledge by watching and answering questions about TeachSource videos of teachers teaching and children learning in real classrooms
- Checking their comprehension and understanding through *Did You Get It*? assessments, with varied question types that are autograded for instant feedback
- Applying concepts through mini-case scenarios in which students analyze typical teaching and learning situations and create a reasoned response to the issue(s) presented in the scenarios
- Reflecting about and justifying the choices they made within the teaching scenario problem

MindTap helps instructors facilitate better outcomes by evaluating how future teachers plan and teach lessons in ways that make content clear and help diverse students learn, assessing the effectiveness of their teaching practice, and adjusting teaching as needed. The Student Progress App makes grades visible in real time so students and instructors always have access to current standings in the class.

MindTap for *Math and Science for Young Children* helps instructors easily set their course because it integrates into the existing Learning Management System and saves instructors time by allowing them to fully customize any aspect of the learning path. Instructors can change the order of the student learning activities, hide activities they don't want for the course, and—most importantly—add any content they do want (e.g., YouTube videos, Google docs, links to state education standards). Learn more at http://www.cengage.com/mindtap.



Anderson, L. W., & Krathwohl, D. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York: Longman.

Online Instructor's Manual with Test Bank

An online Instructor's Manual accompanies this book. It contains information to assist the instructor in designing the course, including sample syllabi, discussion questions, teaching and learning activities, field experiences, learning objectives, and additional online resources. For assessment support, the updated test bank includes true/false, multiple-choice, matching, short-answer, and essay questions for each chapter.

PowerPoint Lecture Slides

These vibrant Microsoft PowerPoint lecture slides for each chapter assist you with your lecture by providing concept coverage using images, figures, and tables directly from the textbook.

Cognero

Cengage Learning Testing Powered by Cognero is a flexible online system that allows you to author, edit, and manage test bank content from multiple Cengage Learning solutions; create multiple test versions in an instant; and deliver tests from your LMS, your classroom, or wherever you want.

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The authors and Cengage Learning make every effort to ensure that all Internet resources are accurate at the time of printing. However, the fluid nature of the Internet precludes any guarantee that all URLs will remain current throughout the life of this edition.

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an introduction-to-education textbook currently in its second edition. Dr. Martin's textbooks are used widely in domestic colleges and universities and have been translated into Korean and Chinese for use in their respective countries.

- The following reviewers, who provided many valuable ideas:

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Rosalind Charlesworth is professor emerita and retired department chair in the Department of Child and Family Studies at Weber State University in Ogden, Utah. During her tenure at Weber State University, she worked with the faculty of the Department of Teacher Education to develop continuity from preprimary to primary school in the program for students in the early childhood education licensure program. She also contributed as a guest presenter in the Elementary Mathematics Methods class.

Dr. Charlesworth's career in early childhood education has included experiences with both typical and atypical young children in laboratory schools, public schools, and day care and through research in social and cognitive development and behavior. She is also known for her contributions to research on early childhood teachers' beliefs and practices. She taught courses in early education and child development at other universities before joining the faculty at Weber State University. In 1995, she was named the Outstanding Graduate of the University of Toledo College of Education and Allied Professions. In 1999, she was the co-recipient of the NAECTE/Allyn & Bacon Outstanding Early Childhood Teacher Educator award. In 2014, she received the Legacy Award from the WSU Child and Family Studies Department in recognition of her contributions to early childhood education. She is the author of the popular Wadsworth text *Understanding Child Development*, has published many articles in professional journals, and has given presentations at major professional meetings. Dr. Charlesworth has provided service to the field through active involvement in professional organizations. She has been a member of the NAEYC Early Childhood Teacher Education Panel, a consulting editor for *Early Childhood Research Quarterly*, and a member of the NAECTE (National Association of Early Childhood Teacher Educators) Public Policy and Long-Range Planning Committees. She served two terms on the NAECTE board as regional representative and one as vice president for membership. She was twice elected treasurer and was elected as newsletter editor of the Early Childhood/Child Development Special Interest Group of the American Educational Research Association (AERA); is past president of the Louisiana Early Childhood Association; and was a member of the editorial board of the Southern Early Childhood Association journal *Dimensions*. She is currently on the editorial board of the *Early Childhood Education Journal*.

PART 1
CONCEPT DEVELOPMENT IN MATHEMATICS AND SCIENCE

CHAPTER 1 Development, Acquisition, Problem Solving, and Assessment

CHAPTER 2 Basics of Science, Engineering, and Technology

CHAPTER 1

DEVELOPMENT, ACQUISITION, PROBLEM SOLVING, AND ASSESSMENT

LEARNING OBJECTIVES

After reading this chapter, you should be able to:

1-1 Define concept development, and identify the concepts children are developing in early childhood.

1-2 Describe three types of learning experiences, and give an example of each.

1-3 Design lessons and activities using the six steps in instruction suggested in this chapter.

1-4 Explain the reasons for development of the National Assessment Standards.

STANDARDS ADDRESSED IN THIS CHAPTER

naeyc

NAEYC Professional Preparation Standards

1a. Know and understand children's characteristics and needs (0–8).

1b. Use developmental knowledge to create healthy learning environments for young children.

2a. Understand diverse family and community characteristics.

4c. Use developmentally appropriate teaching/learning approaches.

5a. Understand content knowledge and resources in mathematics and science.

5c. Design, implement, and evaluate developmentally meaningful and challenging curriculum for each child.

3a. Understand the goals, benefits, and uses of assessment.

3b. Use a variety of appropriate assessment tools and approaches.

3c. Understand and practice responsible assessment.

DAP Guidelines

3A2. Become familiar with state standards or other mandates.

2C. Know desired program goals.

3C. Use the curriculum framework to ensure there is attention to important learning goals.

4C. Use the assessment information to guide what goes on in the classroom.

4D. Ensure methods of assessment are developmentally appropriate.

Common Core State Standards for Math

MP1 Make sense of problems and persevere in solving them.

MP4 Model with mathematics.

Next Generation Science Standards

K-PS2-1 Plan and conduct an investigation.

K-PS-3 Make observations.

K-PS3-1 Use tools and materials.

K-ESS3-1 Use a model.

K-ESS3-2 Ask questions based on observations to obtain information.

K-ESS3-3 Communicate solutions.

DAP naeyc

1-1 CONCEPT DEVELOPMENT

In early childhood, children actively engage in acquiring fundamental concepts and learning fundamental process skills. **Concepts** are the building blocks of knowledge; they allow people to organize and categorize information. Concepts can be applied to the solution of new problems in everyday experience. As we watch children in their everyday activities, we can observe them constructing and using concepts. Some examples follow:

- *One-to-one correspondence.* Passing apples, one to each child at a table; putting pegs in pegboard holes; putting a car in each garage built from blocks.
- *Counting.* Counting the pennies from a penny bank, the number of straws needed for the children at a table, or the number of rocks in a rock collection.
- *Classifying.* Placing square shapes in one pile and round shapes in another; putting cars in one garage and trucks in another.
- *Measuring.* Pouring sand, water, pebbles, or other materials from one container to another.

As you proceed through this text, you will learn how young children begin to construct many concepts during the **preprimary or preschool/kindergarten** period (the years before children enter first grade). They also develop processes that enable them to apply their newly acquired concepts and to enlarge current concepts and develop new ones.

During the preprimary period, children learn and begin to apply concepts basic to both mathematics and science. As children enter the **primary** period (grades 1–3), they apply these early basic concepts to explore more abstract inquiries in science and to help them understand the operations of addition, subtraction, multiplication, and division as well as mathematical concepts such as measurement, geometry, and algebra.

As young children grow and develop physically, socially, and mentally, their concepts also grow and develop. **Development** refers to changes that take place as a result of growth and experience. Development follows an individual timetable for each child; it is a series or sequence of steps that each child takes one at a time. Different children of the same age may be weeks, months, or even a year or two apart in reaching certain stages and still be within the normal range of development. This text examines concept development in math and science from birth through the primary grades. For an overview of this development sequence, see **Figure 1-1**.

	Concepts and Skills: Beginning Points for Understanding			
Period	**Section II Fundamental**	**Section III Applied**	**Section IV Higher Level**	**Section V Primary**
Sensorimotor (Birth to age 2)	Observation Problem solving One-to-one correspondence Number Shape Spatial sense			
Preoperational (2 to 7 years)	Sets and classifying Comparing Counting Parts and wholes	Ordering, seriation, patterning Informal measurement: Weight Length Temperature Volume Time Sequence	Number symbols Groups and symbols	
Transitional (5 to 7 years)		Graphing Language Integration	Concrete addition and subtraction	
Concrete operations (7 to 11 years)			Number and Operations in Base 10: Algebraic Thinking; Problem Solving	Whole number operations Fractions Number facts Place value Geometry Measurement with standard units

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FIGURE 1-1 The development of math and science concepts and process skills.

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PHOTO 1-1 As infants crawl and creep to explore the environment, they develop a concept of space.

Concept growth and development begin in infancy. Babies explore the world with their **senses**. They look, touch, smell, hear, and taste. Children are born curious, wanting to know all about their environment. Babies begin to learn ideas of size, weight, shape, time, and space (**Photo 1-1**). As they look about, they sense their relative smallness. They grasp things and find that some fit in their tiny hands and others do not. Infants learn about weight when items of the same size cannot always be lifted. They learn about shape. Some things stay where they put them, whereas others roll away. Children learn time sequence. When they wake up, they feel wet and hungry. They cry. The caretaker comes. They are changed and then fed. Next they play, get tired, and go to bed. As infants begin to move, they develop spatial sense. They are placed in a crib, in a playpen, or on the floor in the center of the living room. As babies first look and then move, they discover space. Some spaces are big; some are small.

As children learn to crawl, stand, and walk, they are free to discover more on their own and learn to think for themselves. They hold and examine more things (**Photo 1-2**). They go over, under, and inside large objects and discover their size relative to them. Toddlers sort things. They put them in piles of the same color, the same size, the same shape, or that have the same use. Young children pour sand and water into containers of different sizes. They pile blocks into tall structures and see them fall and become small parts again. They buy food at a play store and pay with play money. As children cook imaginary food, they measure imaginary flour, salt, and milk. They set the table in their play kitchen, putting one of everything at each place, just as is done at home. The free exploring and experimentation of the first two years are the opportunity for the development of muscle coordination and the senses of taste, smell, sight, and hearing, skills children need as a basis for future learning.

As young children leave toddlerhood and enter the preschool and kindergarten levels of the preprimary period, exploration continues to be the first step in dealing with new situations; at this time, however, they also begin to apply basic concepts to collecting and organizing data to answer a

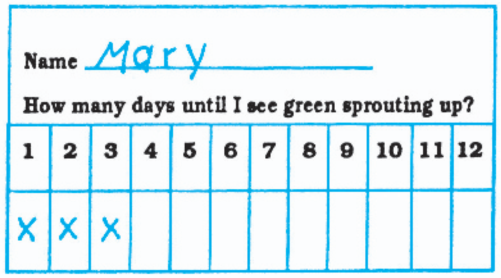

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FIGURE 1-2 Mary records each day that passes until her bean seed sprouts.

question. Collecting data requires skills in observation, counting, recording, and organizing. For example, for a science investigation, kindergartners might be interested in the process of plant growth. Supplied with lima bean seeds, wet paper towels, and glass jars, the children place the seeds so that they are held against the sides of the jars with wet paper towels. Each day they add water as needed and observe what is happening to the seeds. They dictate their observations to their teacher, who records them on a chart. Each child also plants some beans in dirt in a small container, such as a paper or plastic cup. The teacher supplies each child with a chart for his or her bean garden. The children check off each day on their charts until they see a sprout (**Figure 1-2**). Then they count how many days it took for a sprout to appear and compare this number with those of the other class members and also with the time it takes for the seeds in the glass jars to sprout. Thus, the children have used the concepts of number and counting, one-to-one correspondence, time, and the comparison of the numbers of items in two groups. Primary children might attack the same problem. But they can operate more independently and record more information, use standard measuring tools (i.e., rulers), and do background reading on their own. Development guidelines charts for mathematics and science instruction are included in CCSSM (National Governors Association, 2010), NGSS (Lead States, 2010), and in NCTM/NAEYC, 2010.

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PHOTO 1-2 Children learn though hands-on experience.

NGSS COMMON CORE STATE STANDARDS

1-1a Relationships Between Science, Technology, Engineering, Math, and Art (Stem and Steam)

The same fundamental concepts, developed in early childhood, underlie a young child's understanding of math, science, engineering, and technology. Math and science integrate with technology and engineering to form STEM (see the *Science and Children* special issue, March 2010, and *A Framework for K–12 Science Education*, National Research Council, 2012). Much of our understanding of how and when this development takes place comes from research based on Jean Piaget's and Lev Vygotsky's theories of concept development. These theories are briefly described later in the chapter. The commonalities that link science, technology, engineering, math, and the arts are also described later in the chapter.

Working with problems and tasks in the STEM and STEAM areas, and particularly math, tends to cause anxiety for many adults and children. Those learning to teach math may allay those feelings by looking through Parts 5 and 7 and Chapter 12, which provide an overview of math materials and activities for young children. Similarly, those with anxieties about teaching science should refer to Parts 6 and 7 and Chapter 12.

STEM focuses on the interrelationships of science, technology, engineering, and mathematics (Moomaw & Davis, 2013); these fundamental mathematics concepts, such as comparing, classifying, and measuring, are simply called **process skills** when applied to science and engineering problems (see Chapter 2 for a more in-depth explanation). In other words, fundamental math concepts are needed to solve problems in science and engineering. The other science process skills (observing, communicating, inferring, hypothesizing, and defining and controlling variables) are equally important for solving problems in engineering, science, and mathematics. For example, consider the principle of the ramp, a basic concept in physics (DeVries & Sales, 2011). Suppose a 2-foot-wide plywood board is leaned against a large block so that it becomes a ramp. The children are given a number of balls of different sizes and weights to roll down the ramp. Once they have the idea of the game through free exploration, the teacher might pose some questions: "What do you think would happen if two balls started to roll at exactly the same time from the top of the ramp?" "What would happen if you changed the height of the ramp or had two ramps of different heights or of different lengths?" The students could guess (predict), explore what actually happens when using ramps of varying steepnesses and lengths and balls of various types, communicate their observations, and describe commonalities and differences. They might observe differences in speed and distance traveled contingent on the size or weight of the ball, the height and length of the ramp, or other variables. In this example, children could use math concepts of speed, distance, height, length, and counting ("How many blocks are propping up each ramp?") while engaged in scientific observation.

Block building also provides a setting for the integration of math, science, and engineering (Chalufour, Hoisington, Moriarty, Winokur, & Worth, 2004; Pollman, 2010). Pollman describes how block building is basic to developing an understanding of spatial relationships. Chalufour and colleagues identify the overlapping processes of questioning, problem solving, analyzing, reasoning, communicating, connecting, representing, and investigating as well as the common concepts of shape, pattern, measurement, and spatial relationships. For another example, suppose the teacher brings several pieces of fruit to class: one red apple, one green apple, two oranges, two grapefruit, and two bananas. The children examine the fruit to discover as much about it as possible. They observe size, shape, color, texture, taste, and composition (juicy or dry, segmented or whole, seeds or seedless, etc.). Observations may be recorded using counting and classification skills. ("How many of each fruit type? Of each color? How many are spheres? How many are juicy?") The fruit can be weighed and measured, prepared for eating, and divided equally among the students.

STEAM adds the arts to the STEM curriculum (Jones, Burr, Kaufman, & Beck, 2013). The arts provide a means for students to learn by doing. Many great scientists and mathematicians were (are) talented in the creative arts. For example, creating sculptures, paintings, architectural design, creating a song, and playing a musical instrument all apply math and science concepts (*The STEM classroom*, 2012). Geometry is integral to the visual arts when children make shape collages or draw and cut out shapes or build with blocks. Musical notes involve an understanding of fractions and recognition and discrimination of sounds.

As with these examples, it will be seen throughout the text that math and science concepts and skills can be acquired as children engage in traditional early childhood activities—such as playing with blocks, water, sand, and manipulatives during art, music, dramatic play, cooking, literacy, and outdoor activities (**Photo 1-3**).

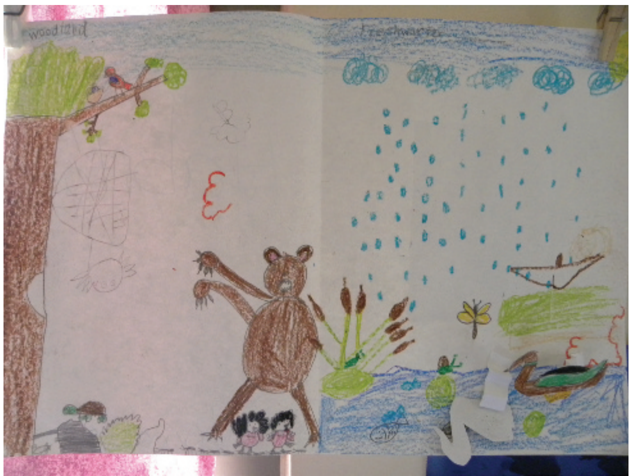

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PHOTO 1-3 Children show their views of nature through their drawings.

1-1b Rationale for Standards and Common Core Curriculum Guidelines

National professional organization members historically searched for guidelines or standards that could direct teaching in all subject areas focusing on what children should know and should be able to do at all ages and stages. The National Council of Teachers of Mathematics (NCTM) developed standards for mathematics, the National Research Council (NRC) for science, and the National Association for the Education of Young Children (NAEYC) for early childhood education. Further, using the standards as guides, educators across the country worked on the development of core curricula in each area, which provided for appropriate instructional guidelines in line with the professional standards. Although NCTM developed both standards for instruction and Core Curriculum State Standards for Math (CCSSM) for developmental placement of key concepts and skills, the National Science Teachers Association (NSTA) together with the National Academy of Sciences and the American Association for the Advancement of Science (AAAS) developed the Next Generation Science Standards (NGSS), which describe performance standards at each K–12 grade level for each primary science study area. NGSS standards development was guided by the 2012 Framework, which defined science as including the following disciplinary core ideas: Physical sciences, Life sciences, Earth and Space sciences, and Engineering, Technology, and Applications of science.

In 2002, NAEYC and NAECS/SDE (National Association of Early Childhood Specialists in State Departments of Education) published, in response to a growing standards-based movement, a joint position statement on early learning standards. Increasingly, individual states and the national Head Start were constructing lists of desired learning outcomes for young children. NAEYC and NAECS/SDE were concerned that early learning standards should be developmentally sound and applied fairly to all groups of young children. Some of the historical and current standards efforts are described next.

In 2009, NAEYC published a third edition of *Developmentally Appropriate Practice in Early Childhood Programs* (Copple & Bredekamp, 2009). In 2000, based on an evaluation and review of the previous standards' publications, NCTM published *Principles and Standards for School Mathematics* (NCTM, 2000). In 2014, NCTM moved further with the publication of *Principles to Actions: Ensuring Mathematical Success for All*, which describes eight research-supported teaching practices. In 2000, NCTM made a major change by the inclusion of preschool in its standards. In contrast, the Next Generation Science standards begin in kindergarten.

During the preschool years, young children's natural curiosity and eagerness to learn can be exploited to develop a joy and excitement in learning and applying mathematics concepts and skills. As in the previous standards, the recommendations in the current publication are based on the belief that "students learn important mathematical skills and processes with understanding" (NCTM, 2000, p. ix). In other words, rather than simply memorizing, children should acquire a true knowledge of concepts and processes. Understanding is not present when children learn mathematics as isolated skills and procedures. Understanding develops through interaction with materials, peers, and supportive adults in settings where students have opportunities to construct their own relationships when they first meet a new topic. Exactly how this takes place will be explained further in the text.

In 2002, the NAEYC and NCTM issued a joint position statement on early childhood mathematics (NCTM & NAEYC, 2002). This statement focuses on math for 3-to 6-year-olds, elaborating on the NCTM (2000) pre-K–2 standards. The highlights for instruction are summarized in "Math Experiences That Count!" (2002). In 2009, the NRC published a review of research and recommendations for instruction for pre-K and kindergarten mathematics (Cross, Woods, & Schweingruber, 2009), which will be described later in this chapter.

Principles of School Mathematics. The *Principles and Standards of School Mathematics* makes statements reflecting basic rules that guide high-quality mathematics education. The following six **principles** describe the overarching themes of mathematics instruction (NCTM, 2000, p. 11).

- *Equity*: High expectations and strong support for all students.
- *Curriculum*: More than a collection of activities; must be coherent, focused on important mathematics, and well articulated across the grades.
- *Teaching*: Effective mathematics teaching requires an understanding of what students know and need to learn, and then challenging and supporting them to learn it well.
- *Learning*: Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.
- *Assessment*: Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.
- *Technology*: Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning (see Appendix B for a list of technology resources for children).

These principles should be used as a guide to instruction in all subjects, not just mathematics.

Standards for School Mathematics. **Standards** provide guidance as to what children should know and be able to do at different ages and stages. Ten standards are described for prekindergarten through grade 2, with examples of the expectations outlined for each standard. The first five standards are content goals for operations, algebra, geometry, measurement, and data analysis and probability. The next five standards include the processes of problem solving, reasoning and proof, connections, communication, and representation. These two sets of standards are linked, as the process standards are applied to learning the content. The standards and principles are integrated into the chapters that follow.

Standards for Science Education. In 2013, the NGSS was made public so individual states could decide whether to use the new standards, and, if so, how to use them. Each Standard has three dimensions: content; ways in which this content is used in science and engineering; and cross-cutting concepts (formerly known as interdisciplinary or multidisciplinary topics). Content is arranged into four overarching domains: the physical sciences, the life sciences, the earth and space sciences, and engineering, technology, and applications of science.

A prominent feature of the NGSS is a focus on *inquiry*. This term refers to the abilities students should develop in designing and conducting scientific investigations, as well as the understanding they should gain about the nature of scientific inquiry. Students who use inquiry to learn science engage in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge. To better understand the use of inquiry, the NRC (2000) produced a research-based report, *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*, which outlines the case for inquiry, with practical examples of engaging students in the process. Addendums to the *National Science Education Standards* include *Classroom Assessment and the National Science Education Standards* (2001) and *Selecting Instructional Materials: A Guide for K–12* (1999). These will be discussed later in the text.

A national consensus has evolved around what constitutes effective science education. This consensus is reflected in two major national reform efforts in science education that affect teaching and learning for young children: the NRC's *National Science Education Standards* (1996) and the American Association for the Advancement of Science's (AAAS) Project 2061, which has produced *Science for All Americans* (1989) and *Benchmarks for Science Literacy* (1993). With regard to philosophy, intent, and expectations, these two efforts share a commitment to the essentials of good science teaching and have many commonalities, especially regarding how children learn and what science content students should know and be able to understand within grade ranges and levels of difficulty. Although they take different approaches, both the AAAS and NRC efforts align with the 2009 NAEYC guidelines for developmentally appropriate practice and the 2010 NCTM standards for the teaching of mathematics.

These national science reform documents are based on the idea that active, hands-on conceptual learning that leads to understanding—along with the acquisition of basic skills—provides meaningful and relevant learning experiences. The reform documents also emphasize and reinforce Oakes's (1990) observation that all students, especially underrepresented groups, need to learn scientific skills (such as observation and analysis) that have been embedded in a less-is-more curriculum that starts when children are very young.

The National Science Education Standards are directed to all who have interests, concerns, or investments in improving science education and in ultimately achieving higher levels of scientific literacy for all students. The standards intend to provide support for the integrity of science in science programs by presenting and discussing criteria for the improvement of science education.

The AAAS Project 2061 initiative constitutes a long-term plan to strengthen student literacy in science, mathematics, and technology. Using a less-is-more approach to teaching, the first Project 2061 report recommends that educators use three major themes that occur repeatedly in science to weave together the science curriculum for younger children: models and scale, patterns of change, and systems and interactions.

The second AAAS Project 2061 report, *Benchmarks for Science Literacy*, categorizes the science knowledge that students need to know at all grade levels. The report is not in itself a science curriculum, but it is a useful resource for those who are developing one.

NAEYC DAP Guidelines for Math and Science. The NAEYC Guidelines for Developmentally Appropriate Practice in Mathematics and Science Instruction (Copple & Bredekamp, 2009) indicate that mathematics begins for 3-year-olds with the exploration of materials such as building blocks, sand, and water, and for 4- and 5-year-olds, extends to cooking, observation of environmental changes, working with tools, classifying objects with a purpose, and exploring animals, plants, machines, and so on. For children ages 5 to 8, exploration, discovery, and problem solving are appropriate. Mathematics and science are integrated with other content areas such as social studies, the arts, music, and language arts. These current standards for mathematics and science curriculum and instruction take a constructivist view based on the theories of Jean Piaget and Lev Vygotsky (described in the next section).

1-1c The Movement Toward National Core State Curriculum Standards

As of 2010, 48 states supported the establishment of common K–12 curriculum standards (Gewertz, 2010a), and as of May 2011, 43 states adopted the Common Core State Standards (CCSS, 2011). More recently, a focus on standards for birth to age 5 is gaining attention. Early childhood educators are concerned that, like the K–12 standards, early childhood birth to age 5 standards might focus on math and literacy, leaving out science, art, social/emotional development, motor development, characteristics such as problem solving, curiosity, and persistence. It is also critical that birth to age 5 standards be age appropriate and developmentally and culturally appropriate. Several states, such as Utah and New York, have or are developing core standards for early childhood that focus on the prekindergarten years.

Common Core State Standards for Mathematics (National Governors Association, 2010) are available from the Common Core State Standards Initiative website and from NCTM. The math core standards are designed to make instruction more focused and to meet the goal of mathematical understanding. They are strongly influenced by the NCTM principles, content goals, and process standards described earlier and as included in this text in each chapter. In each mathematics unit, the K–3 standards, as well as standards for birth to age 5, are included.

The Next Generation Science Standards (NGSS) (NGSS, 2013) are based on the National Academy of Sciences' *A Framework for K–12 Science Education* (National Research Council, 2012). Four overarching content topics are included: Life Science, Earth and Space Science, Physical Science, and Engineering and Technology. At each grade level K–12 performance expectations are delineated for what students who demonstrate understanding can do. In addition to content, every NGSS standard addresses scientific and engineering practices and crosscutting concepts that require exploration into the world of integration of concepts both within science and with other disciplines.

DAP naeyc

1-1d National Standards for Professional Preparation

Standards for Professional Preparation outline what teachers should know and be able to do as learned and experienced during the teacher preparation program. NAEYC is a member of the National Council for Accreditation of Teacher Education (NCATE) and is the recognized specialized professional association (SPA) for early childhood teacher education. For early childhood teacher education (birth to age 8), the major standards for preparation are those developed by NAEYC (2012). The NAEYC preparation standards fall into six areas in which early childhood professionals need to be proficient:

1. Promoting Child Development and Learning
2. Building Family and Community Relationships
3. Observing, Documenting, and Assessing to Support Young Children and Families
4. Using Developmentally Effective Approaches to Connect with Children and Families
5. Using Content Knowledge to Build Meaningful Curriculum
6. Becoming a Professional

NAEYC Standard 5, Using Content Knowledge to Build Meaningful Curriculum, provides the requirements for knowledge of content areas and ability to plan developmentally appropriate curriculum. Mathematics, science, and visual arts are specifically listed as areas of important content knowledge (5a). Candidates need to know and use the central concepts, inquiry tools, and structures of content areas or academic disciplines (5b). Candidates must be able to use their own knowledge, appropriate early learning standards, and other resources to design, implement, and evaluate developmentally meaningful and challenging curriculum for each child (5c).

1-1e Constructivism

In studying how children learn, Jean Piaget came to the conclusion that knowledge is not transmitted from one person to another; instead, people construct their own understandings by attaching new experiences to experiences they already hold in such a way that the resulting conceptualizations make sense *to them*. This notion that people build their own knowledge is termed **constructivism** (Martin, 2012).

Piagetian Periods of Concept Development and Thought. Jean Piaget contributed enormously to understanding the development of children's thought. Piaget identified four periods of cognitive, or mental, growth and development. Early childhood educators are concerned with the first two periods and the first half of the third.

The first period identified by Piaget, called the **sensorimotor period** (from birth to about age 2), is described in the first part of this chapter. It is the time when children begin to learn about the world. They use all their sensory abilities—touch, taste, sight, hearing, smell, and muscular. They also use growing motor abilities to grasp, crawl, stand, and eventually walk. Children in this first period are explorers, and they need opportunities to use their sensory and motor abilities to learn basic skills and concepts. Through these activities, the young child assimilates (takes into the mind and comprehends) a great deal of information. By the end of this period, children have developed the concept of **object permanence**; that is, they realize that objects exist even when they are out of sight. They also develop the ability of **object recognition**, learning to identify objects by using the information they have acquired about features such as color, shape, and size. As children near the end of the sensorimotor period, they reach a stage where they can engage in **representational thought**; that is, instead of acting impetuously, they can think through a solution before attacking a problem. They also enter into a time of rapid language development.