Introduction

Teaching science is an awesome responsibility. The children you teach are depending on you to model good science and to teach them the skills they need to learn about our increasingly scientific and technological world. **Learning and Assessing Science Process Skills** is designed to help you develop the knowledge and skills necessary to bring the science process skills to your students.

What are the science process skills? They are the things that scientists do when they study and investigate. Observing, inferring, measuring, and experimenting are among the thinking skills used when doing science. Much of the pleasure of both learning and teaching science is experiencing science. Mastering these process skills will help you develop the kind of science program that mirrors real science.

Features of the Fifth Edition

Although originally intended as a text for use by elementary and middle school teachers, earlier editions soon served other needs as well. For almost three decades, this book has been a source of both instructional and assessment ideas for pre-service teachers, practicing classroom teachers, and curriculum developers. Features in the 5th edition are:

- **Chapter 1**—The new chapter one contains information on:
  - **Nature of Science**—A series of activities on the nature of science, using information from the Nature of Science section of the *Benchmarks for Science Literacy* (AAAS, 1985) and from the work of Matkins and others (Matkins & Bell, in press) are included. These activities will help you understand more about how science is done and how the science process skills contribute to the nature of science.
  - **Cooperative Grouping**—cooperative learning groups are discussed as a management tool for teaching the science process skills. Appendix A contains a reproducible you can use to make job cards for your students, using the cooperative group roles discussed in this chapter.
  - **Reflections**—The first activity gives you the opportunity to reflect on your own science experiences and to write your science autobiography. The second activity is an opportunity for you to create a vision of the future; you write your vision for science teaching.

    In Chapters 2 through 7 a section at the end of each chapter is included where you will reflect on your memories of doing science and how you want to use the information in the chapter to teach your students about science.

- **Alignment to State and National Standards**—national science and mathematics standards that are met in each chapter are identified as NSES (National Science Education Standards) and NCTM (National Council of Teachers of Mathematics). Related science standards selected from states across the nation are also included. Use ***www.eduhound.com/k12staestesting.cfm*** or a search engine to access additional state science standards.

National and State Standards Connections

- Develop an understanding of properties of objects and materials. (NSES K–4)
- Describe qualitative and quantitative change. (NCTM, Pre-K–2)
- Keep records that describe observations, carefully distinguish actual observations from ideas and speculations, and are understandable weeks or months later (New Jersey Core Curriculum Content Standards. 5.2)

- **Big Science Ideas**—In each chapter the major science concepts, themes, and topics that are used for the process skills activities are identified. Teachers can use the Big Science Ideas to determine ways to adapt the process skills activities for classroom use and relate each activity to state and national science standards.
- **Self-Assessment Answers in the Appendix**—The answers to the Self-Assessment questions found in each chapter have been moved to the Appendix.
- **Technology Spotlight**—These sections in each chapter have been updated to reflect current technologies, including the QX5 digital microscope.

Technology Spotlight

Extending the Senses with a Digital Microscope

The original Intel Play QX3 and the newer Digital Blue QX5 Computer microscope perform the functions of a traditional optical microscope with the advantages of digitized images. Although originally marketed as a toy, the QX3 and QX5 have enormous instructional potential for K -12 classrooms. This versatile microscope can be used in its stand, or removed and held as a magnifying camera offering new options for student explorations. The magnifications are lOX, 60X, and 200X. Applications on the accompanying software offer numerous options not available with optical microscopes. Digital images can be stored, printed, and even assembled into a slide show. Other options include recording both real time and time-lapsed movies, and customizing images using the Print option to label and enhance images. In addition, all images and movies can be exported as jpeg images or avi movies for use in PowerPoint® presentations and on websites.

If a digital microscope is available, try looking at some common materials, such as salt, under the three magnification levels. Take slides of the salt at each magnification level. Remove the digital microscope from its stand, and use it to explore your skin, clothing texture, and even your eye! If a digital microscope is not available, explore its use on the following websites or use a search engine to locate additional sites:

QX3

www.micro.magnct.fsu.cdu/optics/intclpiaylindcx.htm I

Use the site's interactive Java tutorial- QX3 Microscope Simulator- to explore how the QX3 microscope software and hardware work together to capture images of a variety of specimens at different magnifications.

QX5

http://www.rainvdaymagazine.com/RDM2005/UM2005/QX5/RDMUMQX5FirstLook. htm

This website gives comprehensive background information and reviews about the QX5 digital microscope. For the faint at heart it also offers step by step instruction on how to set-up and use the system.

http://w\vw.playdigitalblue.com/prod llcts/ qx5linfo/

Product information is available on the company's website.

- **Websites and Search Terms**—boxes appear in every chapter. These special boxes provide suggested words and phrases you can use to search the Internet for additional information about the topics in the Chapters. Although there are many ways to refine or narrow a search, one is as simple as adding more words and phrases (in quotations) to the search words you have already used. Your new search will return a smaller, more manageable number of Web pages for you to consider. For example, a recent search resulted in the following Web pages as each new word or phrase was added:

Websites and Search Terms

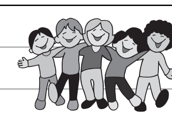
For more information about topics in this Chapter, use search words or phrases such as:
"observations"
"making observations"
"using your senses"

To find websites such as:
http://yorkcountyschools.org/pos05/science.pdf

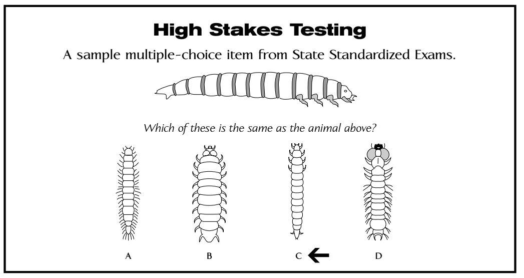
"science fair projects"	1,970,000	Web pages
add "elementary school"	69,700	
add "physical science"	725	
add "chemical change"	60	

- **Classroom Scenarios**—Illustrate how the process skills are infused into science instruction.

Classroom Scenario



- **Ideas for Your Classroom**—Takes the skills from each chapter and demonstrates how they can translate into your classroom.
- **High-Stakes Testing**—Actual questions students were given to measure their knowledge of the related science process skill. Classroom evaluation should provide students with experience in a full array of assessment procedures including multiple-choice test items.



Virginia: SOL Grade 3 Released Item.

- **A Model for Assessing Student Learning**—Included at the end of every chapter as an example of how student mastery of that process skill might be assessed. These models represent nine different strategies for assessment, from high tech optically scanned teacher checklists to authentic performance tasks.

Organization

Learning and Assessing Science Process Skills is presented in two parts, comprising 17 chapters.

Part 1

Chapter 1 provides an overview of this fifth edition and information about the nature of science, cooperative groups, assessing the process skills, meeting standards, and a goal setting activity. **Chapters 2 through 7** will take you through activities using the basic process skills. In these chapters, you will learn and practice the skills of observing, communicating, classifying, measuring, inferring, and predicting. These skills are called *the basic science process skills* because they form the foundation for later and more complex thinking skills. Instruction on the basic science process skills begins in pre-school, is emphasized in the elementary grades, and continues into middle school and beyond.

Although these chapters are primarily focused on helping you become competent in the science process skills, they are also about helping you become confident in your ability to help your students learn the same skills. An important decision-making skill for you as a teacher involves the ability to recognize opportunities in existing curricula to enhance the teaching, learning, and assessing of the science process skills. At the end of Chapter 7 you will find a section called *Decision Making* that uses typical science investigations to illustrate how existing instructional materials can be modified to better emphasize the science process skills. You will use what you have learned about the process skills to modify existing curriculum materials so that the materials will do a better job of supporting process skill development in your students.

Part 2

Chapters 8 through 17 are where you will practice the skills you and your students need to design and conduct scientific investigations in class and at home. These skills are known as *the integrated science process skills* because they are used together to do what many consider the ultimate in problem solving in science—experimenting.

In these chapters you will find other helpful features related to standards, technology, assessment, and connecting process skills to science content knowledge. Each chapter begins with a box containing specific references to national standards in science and mathematics and a sample state science standard related to the chapter topic. Following the standards, you will find in each chapter a materials list, a series of activities, connections to science content, classroom scenarios, self-assessments, technology applications, reflection prompts with examples, and ideas for extensions in your classroom. Because evaluation often sends a message of what is considered important, we have included throughout the book sample multiple-choice test items as well as a full array of other forms of assessment for the science process skills. All of the sections in a chapter focus on the process skill for that chapter. At the end of Chapter 17 you will find another *Decision Making* section.

The Appendix contains many helpful items, including a summary list of materials for the activities in the book, answers to the Self-Assessment for each chapter, a format for lesson planning, a sample lesson, a format for an experiment report, a reproducible for cooperative group job cards, sample activities and variables to study.

How to Use This Book

We strongly recommend that you actually *do* the activities, because mastering the science process skills can only be achieved by being actively involved. Much of what you learn from this book depends on how you use it. Begin each chapter by first reading the purpose and the objectives; knowing what is expected of you will help you learn the skills presented in the chapter. Most activities have Self-Check sections that provide you with immediate feedback on your responses. Write your responses before checking them with the answers in the Self-Check at the end of each chapter.

At the end of each chapter a Self-Assessment is provided for you to demonstrate your knowledge and skills. Compare your answers to those provided in Appendix B to evaluate your level of mastery. Your instructor may ask you to remove the Self-Assessment answers from the Appendix so that the Self-Assessments can be used as evidence of your skill development. Your experience with the chapter Self-Checks, Self-Assessments, and Assessing Student Learning examples will help you consider how you will assess your own students' abilities to use the science process skills.

Although activities in this book were designed for either individual or small group study, you are encouraged to work cooperatively with at least one other person as you progress through the chapters. Working together may help you better process information, share the tasks required, practice skills, receive feedback, and have more fun learning. When working in cooperative groups, think about how you might organize your own students into groups.

If you are using this book in a course, your instructor may suggest different materials to use in class or at home as you complete the activities in this book. Using different materials may result in some of your answers being somewhat different from ours. Those of you who are in-service teachers may wish to substitute one kind of material for another, such as paper or plastic cups for beakers. In addition you may wish to make overhead transparencies of some pages for use in your instruction and to use assessment examples from the book as part of your assessment program. You may duplicate pages that contain this notice: From *Rezba, Sprague, McDonnough & Matkins. Learning and Assessing Science Process Skills, 5th Edition. © 2007 Kendall/Hunt Publishing Co.* may be reproduced by individual teachers for classroom use only. When you use examples from other pages in the book, please give credit to the source.

The activities in this book use simple, ordinary supplies. Science can be learned with everyday materials; elaborate and costly equipment is not required. In fact, it is the very ordinary that often stimulates students to ask questions that lead them to fruitful inquiry.

A Challenge

With every adventure there lies a risk. The risk here is that the individual chapters of the text imply a separation of the process skills used to do science. In truth these thinking skills of science are interdependent. As you study the science process skills, we hope the artificial separations created here will dissolve and, by merging these skills, you become more able and confident in providing exemplary science instruction for your students.

National Science Education Standards and AAAS' Project 2061 Benchmarks

As a result of activities in grades K-4, for example, all students should develop abilities necessary to do scientific inquiry. These include:

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

K-4 Content Standard A: Science as Inquiry,
National Science Education Standards

By the end of the following grades, students should

2nd grade: Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.

5th grade: Offer reasons for their findings and consider reasons suggested by others.

8th grade: Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.

Benchmarks for Science Literacy, AAAS' Project 2061

All 50 states have embarked on education initiatives related to high standards and accountability. These efforts include the establishment of state-wide academic standards for all students and the assessments that measure student performance. Assessment is taking center stage as schools are held more accountable for what students know and are able to do. Most states now have defined consequences for unacceptable performance by students and their schools. At the federal level education legislation called *No Child Left Behind* became law in 2002. This legislation requires each state to establish its own unique set of standards for reading, math, and science. Under *No Child Left Behind* legislation each state must establish its own annual tests aligned with state standards for grades three through eight to measure how successfully students are learning what is expected by the standards. These tests must yield specific objective data. Federal funds for education will only go to states that implement standards and tests to measure student perfor-mance related to those standards.

Assessment is the process of gathering evidence of students' abilities and achievements. It is a form of communication that provides information so evaluations can be made. Assessments help teachers and parents determine what students know, are able to do, and what they still need to learn. Evidence about student performance in science is needed for a variety of purposes, such as making instructional decisions, tracking student progress, communicating judgments, and evaluating programs. For each of these purposes, data are collected from essentially three basic sources: observations, student responses to questions, and student products and performances. Science assessment should be about gathering evidence of students' achievements and then using that evidence to further the growth of science knowledge and skills for all students.

Assessment methods should allow students to demonstrate what they know and are able to do, not just what they do not know. Teachers and schools need to have a detailed level of assessment to truly understand student achievement. Because all assessments are at best estimates of what students know and are able to do there is a definite limit to the information that state tests alone can provide. Multiple forms of assessment are needed to supplement external statewide assessments because different types of assessment reveal different aspects of performance. Just as lecturing should not be the sole method of instruction, neither should multiple-choice tests be the only means of assessment. Multiple forms of assessment include open-response questions, performance tasks, portfolios, interviews, teacher rating forms, and a variety of checklists for teachers, students, parents, and peers.

One characteristic of some forms of assessment is their ability to connect assessment with instruction. Most current testing practices are only assessment tools, not teaching tools; assessment typically occurs only when instruction stops. It is interesting to note that assessment comes from the French *assidere* (Latin *sedere*) meaning to sit beside, suggesting that a much closer relationship should exist between instruction and assessment. A variety of methods is needed to bridge the gap between teaching and assessment. Assessments in science should allow students to use their science process skills and content knowledge from the science disciplines in much the same way as they do in science class. Assessment should mirror the science that is most important for students to learn.

Multiple forms of assessment are also consistent with what we know about learning. Students with differing learning styles should have varied opportunities to demonstrate what they know and are able to do in science. Assessment needs to facilitate each student's continued learning in science.

High standards, state standardized exams, and increasing accountability are among the challenges facing today's teachers. Teachers must balance these demands while providing interesting and varied instruction. Fortunately, there are superb teachers who systematically observe, challenge, and listen to students to lead the way in both teaching and assessing the performance of students. Their exemplary science classrooms are characterized by high expectations, challenging tasks, strong work ethic, mutual respect, and a belief in science for all students. Teachers are the richest sources of information about students. They have always been and will continue to be the major assessors of student achievement. Of the multiple ways to assess students, nine forms of assessment are described here and modeled in the 17 chapters of Learning and Assessing Science Process Skills (see Multiple Forms of Assessment on the following page). Also included in each chapter are sample multiple choice items selected from released standardized tests from various states. These high stakes multiple-choice items are the actual questions students were given to measure their knowledge of the related science process skill. Classroom evaluation should provide students with experience in a full array of assessment procedures including multiple-choice test items.

Multiple Forms of Assessment

Assessment	Topic	Chapter
Open Response Question	Observing Keeping Factors Constant	2 13
Performance Task	Classifying Measuring Inferring Predicting Relationships Between Variables Defining Variables	4 5 6 7 11 15
Portfolio	Identifying Variables	8
Teacher Paper and Pencil Checklist	Communicating	3
Self/Peer/Family Checklist	Tabulating Data	9
Teacher Digital Assessment	Laboratory Behaviors	12
Teacher Rating Sheet	Graphing Skills Experimenting	10 17
Individual Performance within a Group Rating Form	Designing Investigations	16
Interview	Constructing Hypotheses	14