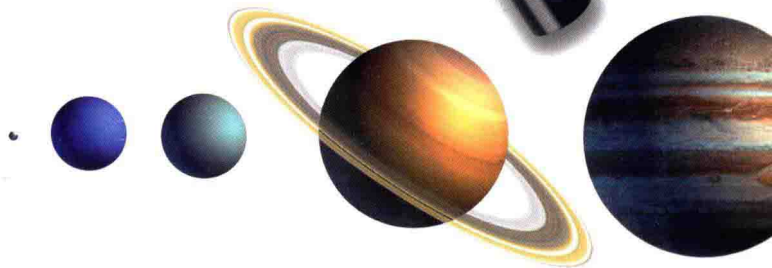


ELEMENTARY SCIENCE METHODS

A CONSTRUCTIVIST APPROACH



DAVID JERNER MARTIN

SIXTH EDITION

ELEMENTARY **SCIENCE** METHODS

A CONSTRUCTIVIST APPROACH

S I X T H E D I T I O N

David Jerner Martin

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Science Content Standards Correlation

The following correlation shows examples of where the Science Content Standards are referenced in the text and learning features: Constructing Your Ideas (CYI), In the Schools (ITS), and Constructing Science in the Classroom (CSITC).

K-12 Unifying Concepts and Processes

- Systems, Order, and Organization pp. 72, 421; CYI 3.5; ITS 3.2, 3.4, 3.5
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement ITS 4.3
- Evolution and Equilibrium
- Form and Function

K-4 & 5-8 Content Standard A: Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry pp. 81–82, 86, 88, 102, 115, 120, 125, 131, 139, 142, 146; CSITC 3.1, 3.3, 3.4, 3.5, 3.12, 3.15, 3.16, 3.17, 3.20, 3.36, 6.3; ITS 3.1, 3.6, 3.10, 3.11, 3.12, 3.14, 3.16, 3.18, 4.1; CYI 3.3, 3.7, 3.20
- Understanding About Scientific Inquiry p. 4; CYI 3.10, 4.2; ITS 4.8

K-4 Content Standard B: Physical Science

- Properties of Objects and Materials CSITC 3.22, 3.24, 3.28, 9.1, 9.2
- Position and Motion of Objects CSITC 3.43, 6.4; ITS 2.5
- Light, Heat, Electricity, and Magnetism pp. 160, 387; ITS 2.3, 2.6, 3.15, 4.6, 5.1, 10.2; CSITC 3.7, 3.18, 3.21, 3.23, 3.33, 3.34, 3.37, 3.38, 3.44, 3.45, 6.2, 9.3, 10.2, 10.3

5-8 Content Standard B: Physical Science

- Properties and Changes of Properties in Matter CSITC 3.30, 3.41, 4.1; ITS 3.19, 4.2, 4.4, 10.1, 10.4
- Motions and Forces pp. 116–117, 126, 388; CSITC 3.46, 5.2; ITS 4.5; CYI 3.14, 3.16, 3.22, 4.1
- Transfer of Energy CSITC 3.49, 3.50

K-4 Content Standard C: Life Science

- The Characteristics of Organisms CSITC 3.9, 3.11, 3.42; ITS 3.7
- Life Cycles of Organisms CSITC 3.2, 3.8, 3.31, 3.40; ITS 3.20, 10.3
- Organisms and Environments CSITC 3.25, 3.29, 9.5; ITS 3.22, 4.10, 7.4

5-8 Content Standard C: Life Science

- Structure and Function in Living Systems CSITC 3.32; ITS 7.2
- Reproduction and Heredity
- Regulation and Behavior
- Populations and Ecosystems CSITC 6.1; ITS 4.11
- Diversity and Adaptations of Organisms

K-4 Content Standard D: Earth and Space Science

- Properties of Earth Materials CSITC 3.6, 3.10, 3.13; ITS 2.1, 2.2; CYI 3.1

- Objects in the Sky p. 188; CSITC 3.35, 4.2; ITS 4.14, 10.5
- Changes in Earth and Sky pp. 64–65; CSITC 3.27, 9.4, 10.1; CYI 11.2

5-8 Content Standard D: Earth and Space Science

- Structure of the Earth System pp. 153, 155; CSITC 3.19; CYI 3.24
- Earth's History CSITC 3.26; ITS 4.7, 4.12, 4.13
- Earth in the Solar System p. 388; CSITC 3.47, 3.48; ITS 3.17, 3.21, 3.23; CYI 3.17, 11.3

K-4 Content Standard E: Science and Technology

- Abilities of Technological Design
- Understanding about Science and Technology pp. 48–49
- Abilities to Distinguish Between Natural Objects and Objects Made by Humans

5-8 Content Standard E: Science and Technology

- Abilities of Technological Design
- Understanding about Science and Technology

K-4 Content Standard F: Science in Personal and Social Perspectives

- Personal Health p. 21
- Characteristics and Changes in Populations
- Types of Resources
- Changes in Environments
- Science and Technology in Local Challenges pp. 15, 265–266; CSITC 5.1; ITS 7.1

5-8 Content Standard F: Science in Personal and Social Perspectives

- Personal Health CSITC 3.14, 3.39; ITS 2.4
- Populations, Resources, and Environments CSITC 3.51
- Natural Hazards
- Risks and Benefits
- Science and Technology in Society

K-4 Content Standard G: History and Nature of Science

- Science as a Human Endeavor

5-8 Content Standard G: History and Nature of Science

- Science as a Human Endeavor
- Nature of Science pp. 5, 18, 20, 36, 37, 39, 40, 142–143, 265
- History of Science

Elementary Science Methods





Teaching Children How to *Do* Science

Children learn science by doing science ... by asking their own questions about things that interest them, exploring answers to their questions through applying the processes of science in open-ended inquiries, and combining new experiences with information they already possess as they form personally constructed meanings. This is the essence of constructivism—building personal knowledge from one's own experience and thought.

Yet, despite children's natural fascination with exploring on their own, for many years the teaching of science has consisted of the skillful impartation of scientific knowledge to students. Textbooks have contained information for children to learn, and it has been the job of the teacher to interpret the textbook and augment it as necessary to ensure that every child learns the material presented.

Science education of the 21st century moves from this teacher-focused approach to one that is radically different. It encourages children to construct information in ways that are meaningful to them. It comprises experiences for children to undertake themselves. The focus of science education today is on doing rather than acquiring.

Children do science by using the processes of science in personally constructed inquiries. *Therefore, this book is about constructing the process-oriented inquiry method of science teaching.* It emphasizes process skills and hands-on experiences through which children develop their own questions about phenomena that interest them and seek their own answers to those questions through activities that they themselves devise. It uses a constructivist approach to teach students in a constructivist manner—the same manner as the children in their classrooms will learn how to do science.

In over 30 years in the field of science education at all levels from kindergarten through college, it has been my experience that the only science children learn is the science they do themselves. In this practical text, I have taken the bold and uncompromising position that hands-on, process-oriented, constructivist-focused inquiry must be fostered in science education in the elementary schools. Preservice and inservice teachers who construct their science education conceptualizations and methodologies through the guidance offered in this text will find science teaching to be fun, stimulating, rewarding, and extremely successful.

When Carl Sagan received a copy of the first edition of this book, he wrote a short note to me that concluded, "I hope all goes well with your effort to change the teaching of science." I won't be the one who changes science education. You will. For it is the educators who construct their own conceptualizations of the way science can be taught most effectively who will change the teaching of science.

Target Audience

This text prepares students to teach science from a constructive perspective in preschool through grade 6 (with a few activities that range up to grade 8). It is suitable for both undergraduate and graduate work. The inexperienced undergraduate student will construct sound conceptualizations of constructivist, inquiry-oriented science teaching through the use of this text. The graduate student will consider advanced models of inquiry and interdisciplinary studies including science-technology-society, issues of content and methodology, and ways of contributing to the profession through action research.

Organization

The text is divided into two parts. In Part 1, students construct basic understandings of how they will teach science. They consider a number of concepts including the nature of science, goals and objectives of quality science education, the processes of science, the role of content in teaching the processes, the constructivist paradigm, methods of encouraging student inquiry, ways of accommodating learner differences including English language learners and multicultural dimensions, and methods of assessing authentically.

Part 2 extends the students' explorations of the basic science program to include literature and other interdisciplinary topics, technological applications, concept mapping, and professional aspects of science teaching.

Two appendices are designed to help students in their construction of their science education system. Appendix A contains cross-references of activities to basic scientific principles and concepts. Appendix B is a list of the children's literature cited in the text.

What's New in This Edition

There are several significant new features in this sixth edition.

- Chapter 1, *The Science Education Imperative*, has been updated to include the most recent scientific discoveries, such as the discovery of new species of animals never before seen, the decision to keep Pluto classified as something other than a planet, the search for water on Mars, and the discovery of several hundred planets outside our solar system.
- Chapter 2, *Science Education Today*, includes the latest results of national and international tests of science, the 5-E learning cycle, material on STEM (Science, Technology, Engineering, and Mathematics), and the *Blueprint for Education* which is slated to replace *No Child Left Behind*.
- Several of the activities in Chapter 3, *The Processes of Science*, are new, and several have been refined and/or expanded to include additional variations.
- The section on "Brain Research and the Construction of Knowledge" in Chapter 4, *Constructivism in Elementary Science Education*, has been rewritten to reflect current research.
- Chapter 5, *Inquiry*, has new or revised sections on problem-based learning, project-based science, differentiated instruction, personalized instruction, and the section "Does Inquiry Work?"

- The material throughout the text on teaching science to English Language Learners has been expanded and is based on increased recent attention to this field by scholars and researchers.
- Chapter 8, *Assessment*, has been revised to emphasize formative assessment.
- The entire Chapter 11, *Technology in Elementary Science Education*, has been majorly revised to reflect current advances in technology for teaching and learning, as well as coverage of the latest National Educational Technology Plan and Education Technology Standards. I hope some of the material stays valid for a little while, at least. Additionally, there is extensive new coverage of online learning in the elementary grades, a topic that is currently being pursued with vigor.
- The former Chapter 14, *A Model of Teaching by Listening* is now offered on the Education CourseMate website to serve as a supplemental chapter on this sophisticated model of teaching.
- This edition contains almost 200 suggestions for children's literature. They have been updated to include over 50 new titles, the majority of which are nonfiction, corresponding to the current trend of focusing on accurate science content.

Special Learning Features of This Text

This entire textbook is written in a constructivist manner. Each topic begins with one or more case studies or activities to help students begin to construct their conceptualizations. Topics are treated inductively, which means students explore a variety of specific situations pertaining to a phenomenon before the concept is introduced or defined. In this way, they will construct their own generalizations and conclusions as they move through a topic, rather than relying on the preconstructed conclusions of the author. Periodically, they will be asked to compare their conclusions with the author's. Hopefully there will be a degree of congruence.

Disagreement and debate are encouraged. This is the only way people can crystallize their own ideas. This is the essence of constructivism.

A wealth of open-ended inquiry activities are suggested for students to do in class to construct their own personal conceptualizations about teaching science in the elementary school. Students pursue these activities and discuss their outcomes in small groups and with the whole class—much as teachers conduct their elementary science classes. In total, over 180 process-oriented inquiry activities are suggested, each keyed to a range of grade levels, and each open-ended so teachers can encourage children to develop and perform their own investigations. The activities are placed in the text where the concepts they illustrate are discussed so students can see immediately how to apply the concepts in the classroom.

CLASSROOM APPLICATION FEATURES

- ***Constructing Your Ideas*** features appear throughout the text and are designed to help students construct their own conceptualizations of the topic under study.

- ***In the Schools*** activities illustrate the concepts under consideration and show how they are actually used in classrooms.
- ***Constructing Science in the Classroom*** occur throughout the text near the science learning principle they can be used to teach. They are provided as suggestions for children's activities, points of departure—they are not intended to be duplicated. Grade levels are given as a suggested recommendation for the range of grade levels for the activity. Most of the activities contain suggested literature connections.
- ***TeachSource Video Activities***—*new to this edition*—bring concepts in the chapter to life. Offered on the Education CourseMate website, these short video clips illustrate the teaching and learning principles in the text, and are supported with viewing questions and other pedagogy.
- ***Safety precautions*** are highlighted with safety icons in the margins. In addition to safety notes in many of the activities, an entire section in Chapter 9 is devoted to safety in science education.
- ***Teacher Voice*** features appear in most chapters and are authentic stories supplied by the teachers of the year from several states. These pieces show how the principles addressed in the text are actually applied in classrooms of excellence. I have also included several special feature sections where I describe experiences I have had in science education.

STUDENT LEARNING AIDS

The following study aids are provided in each chapter to facilitate learning.

- **Preview Questions** appear at the beginning of each chapter to help students focus their reading.
- **National Science Education Standards [NSES]** are shown in the margins near the material they support to help students relate the reading to the key national standards of the field.
- **Summaries** are provided at the end of each chapter and have been improved to provide a complete re-cap of the main points of the chapter.
- **Key Terms** are now listed at the end of each chapter, appear in boldface in the text, and are defined in an end-of-text **Glossary** section.
- **Additional Questions for Discussion** appear at the end of each chapter to help students reflect on the important aspects of the chapter.
- **For Further Investigation** sections conclude each chapter and offer suggested websites, print material, and videos from the extensive Cengage video library (mentioned above).

Accompanying Teaching and Learning Supplements

Many supplementary materials accompany this text; they include:

- **An online Instructor's Manual with Test Bank** that contains many suggestions for teaching the course and loads of ancillary materials not provided in the text. The items in the Test Bank may be used for formative assessment of students' understandings of the principles discussed in this text.

- **The Education CourseMate Website.** Cengage Learning's Education CourseMate brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook. You can access an integrated eBook, learning tools including flashcards, quizzes, TeachSource Videos, direct links to the websites referenced in the text, two supplemental chapters (*Basic Concepts and Principles for the Elementary Science Education Program* and *A Model of Teaching by Listening*), a listing of prominent women in science, and more in your Education CourseMate, accessed through CengageBrain.com

About the Author

David Jerner Martin is author of *Elementary Science Methods: A Constructivist Approach*, *Constructing Early Childhood Science* and *Building Teachers: A Constructivist Approach to Introducing Education* (all from Wadsworth, Cengage Learning) which he co-authored with Kimberly S. Loomis. He has been educational consultant to The Weather Channel and numerous schools in the United States and abroad. *Elementary Science Methods: A Constructivist Approach* has been translated into Korean and Chinese, and has been recognized with the prestigious "Flame of Excellence" Award of the KSU Foundation of Kennesaw State University.

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College of Charleston

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David Jerner Martin

contents in brief

PART 1 Constructing the Elementary Science Program 1

- Chapter 1** The Science Education Imperative 3
- Chapter 2** Science Education Today 35
- Chapter 3** The Processes of Science 61
- Chapter 4** Constructivism in Elementary Science Education 159
- Chapter 5** Inquiry 193
- Chapter 6** Science Education for Students with Diverse Perspectives 223
- Chapter 7** Science Education for Students with Learning Differences 245
- Chapter 8** Assessment 269
- Chapter 9** The Elementary Science Classroom 303

PART 2 Beyond the Science Classroom 339

- Chapter 10** Reading, Writing, and Interdisciplinary Approaches 341
- Chapter 11** Technology in Elementary Science Education 373
- Chapter 12** Concept Mapping in Elementary Science 409
- Chapter 13** The Elementary Science Education Professional 425

- Appendix A** Activities Cross-Referenced to Basic Scientific Concepts and Principles 439
- Appendix B** Listing of Children's Literature 442
- Glossary** 444
- References** 447
- Index** 465

contents

PART 1 Constructing the Elementary Science Program 1

CHAPTER 1

The Science Education Imperative 3

How Much Science Does the Elementary Science Teacher Need to Know? 4

Amount of Science Known Today 5

Obsolescence of Scientific Knowledge 6

Changing Scientific Knowledge 6

Scientific Controversies 10

How Much Science Does the Elementary Teacher Need to Know? 10

Science Achievement Score Cards 11

Right and Wrong 14

Recognizing the Unexpected 15

Perception 16

Listening 18

The Processes of Science 18

Using the Processes of Science 19

History of the Process Approach to Science Education 20

Ownership of Knowledge and Thought 23

Mystery Box 24

Ownership 25

Valuing Children's Thinking 26

Questioning 26

Attitudes About Science and Science Teaching 29

TEACHER VOICE 31

Metaphors 32

Summary 33

Key Terms 33

Additional Questions for Discussion 33

For Further Investigation 34

Education CourseMate Resources for Chapter 1 34

CHAPTER 2

Science Education Today 35

The Nature of Science 36

Characteristics of the Scientific Enterprise 37

Teaching the Nature of Science 39

Products of Science 40

Scientific Facts 40

Scientific Concepts 42

Scientific Theories 46

Scientific Laws 47

Applications as Products of Science 48

Attitudes Toward Science 49

Interdisciplinary Nature of Science 49

Science, Technology, Engineering, and Mathematics 49

Goals of Elementary Science Education 50

National Science Teachers Association 51

American Association for the Advancement of Science 52

National Commission on Science Education

Standards and Assessment 52

No Child Left Behind 54

Blueprint for Reform 55

Goals 2000: Educate America Act 56

What Do You Think? 56

Summary 57

Key Terms 58

Additional Questions for Discussion 58

For Further Investigation 58

Education CourseMate Resources for Chapter 2 58

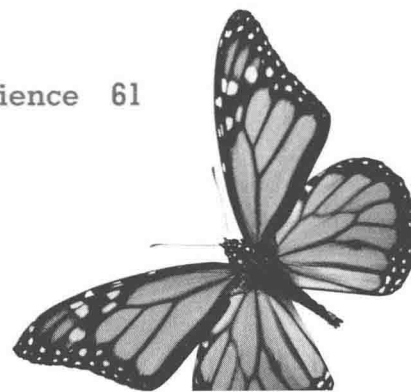
CHAPTER 3

The Processes of Science 61

Observing 62

Classifying 71

Communicating 81



Measuring	86
Length	86
Volume	88
Weight or Mass	90
Temperature	92
Time	93
Metric Versus Conventional Units	96
Predicting	101
Inferring	108
Interrelationships Among the Basic Processes	115
The Integrated Processes	115
The Pendulum	116
Identifying and Controlling Variables	120
Formulating and Testing Hypotheses	125
Interpreting Data	131
Defining Operationally	138
Experimenting	142
Constructing Models	146
The Process-Oriented Objective	156
Summary	157
Key Terms	157
Additional Questions for Discussion	157
For Further Investigation	157
Education CourseMate Resources for Chapter 3	157

CHAPTER 4

Constructivism in Elementary Science Education 159

Constructivism	161
Prior Beliefs	162
Conceptual Change	163
Cognitive Disequilibrium	164
Validity of Self-Constructed Conceptualizations	165
Constructivism and Science Learning	167
Piaget, The Constructivist	169
Mechanism of Constructing Knowledge	169

Vygotsky, The Social Constructivist	171
Characteristics of Constructivist Teaching	172
Brain Research and Construction of Knowledge	173
Stages of Cognitive Development	174
Sensorimotor Stage	175
Preoperational Stage	175
Concrete Operational Stage	176
Formal Operational Stage	182
Stage Overlapping	185
Constructivism, Dinosaurs, and the Solar System	187
Summary	191
Key Terms	192
Additional Questions for Discussion	192
For Further Investigation	192
Education CourseMate Resources for Chapter 4	192

CHAPTER 5

Inquiry 193

The Expository-Discovery Continuum	194
Expository Methodology	195
Free Discovery Methodology	196
Guided Inquiry Methodology	199
Problem-Based Learning	201
Project-Based Science	201
Differentiated Instruction	201
Personalized Instruction	202
Process-Oriented Inquiry	202
The Expository-Discovery Continuum Revisited	203
Inquiry Works	205
TEACHER VOICE	206
The Guided Inquiry Lesson Plan	208
Is Learning Taking Place?	214
Is Hands-On Minds-On?	214
Inductive Versus Deductive Teaching Styles	214
Who Owns the Knowledge?	215

A Different Kind of Bloom 216
The Pedagogical Cognitive Level 219

Summary 220

Key Terms 220

Additional Questions for Discussion 220

For Further Investigation 220

Education CourseMate Resources for
Chapter 5 221

CHAPTER 6

Science Education for Students with Diverse Perspectives 223

Some Differences in the Ways
Children Learn 224

Learning Modalities 224

Visual, Auditory, and Tactile/Kinesthetic
Learning Modalities 225

Visual Learners 225

Auditory Learners 227

Tactile/Kinesthetic Learners 229

Locus of Control 233

Field Dependence/Field Independence 235

Multiple Intelligences 238

TEACHER VOICE 241

Teachers' Learning Styles 242

Summary 242

Key Terms 243

Additional Questions for Discussion 243

For Further Investigation 243

Education CourseMate Resources for
Chapter 6 243

CHAPTER 7

Science Education for Students with Learning Differences 245

Gender Bias 246

Science Education for Children with
Disabilities 247

Strategies for Teaching Students with Disabilities 249

Materials and Equipment for Students with Disabilities 250

Science Education for Students Who
Are Gifted and Talented 252

Science Education for English
Language Learners 253

Instructional Strategies for ELL Students 255

Materials for Use with ELL Students 255

Assessment Strategies for ELL Students 258

Families 258

TEACHER VOICE 258

Multicultural Factors 260

Multicultural Attitude 261

Multicultural Instructional Methodology 262

Multicultural Curriculum 263

Summary 266

Key Terms 266

Additional Questions for Discussion 266

For Further Investigation 267

Education CourseMate Resources for
Chapter 7 267

CHAPTER 8

Assessment 269

Authentic Assessment 270

Formative and Summative Assessment 272

What Is Assessed in Elementary Science
Education? 273

Assessment of Process Skills 273

Indicators 274

Observation 276

Practical Assessments 277

Assessment of Inquiry 280

Assessment of Attitude 281

Assessment of Content 282

Additional Authentic Assessment
Techniques 283

Interviewing 283

Science Journals and Science Notebooks	285	Strategies for Successful Science Activities	310
Portfolios	286	Safety in the Elementary Science Classroom	310
Assessment Techniques that Support Learner Differences	289	Equipment and Materials	316
Report Cards	291	Animals and Plants in the Classroom	317
High-Stakes Testing and the Standardized Achievement Test	293	Family Involvement	319
National and International Standardized Science Achievement Tests	293	Classroom Organization	322
High-Stakes Testing	293	Cooperative Teaching and Cooperative Learning	323
Reauthorization of No Child Left Behind	295	Time Management	324
Assessment of the Elementary Science Teacher and Program	296	Classroom Management	325
TEACHER VOICE	298	Outdoor Classrooms	327
Summary	299	Science Outside the Classroom	329
Key Terms	300	Field Trips	330
Additional Questions for Discussion	300	Nontraditional Science Settings	334
For Further Investigation	300	Revisiting Your Metaphor	335
Education CourseMate Resources for Chapter 8	301	Summary	336
CHAPTER 9		Key Terms	336
The Elementary Science Classroom	303	Additional Questions for Discussion	336
Trust	304	For Further Investigation	336
		Education CourseMate Resources for Chapter 9	337
PART 2 Beyond the Science Classroom	339		
CHAPTER 10		Providing Vicarious Experiences	353
Reading, Writing, and Interdisciplinary Approaches	341	Providing Interdisciplinary Bridges	353
Reading, Writing, and Literature	342	Shaping Students' Perceptions About Science	353
Integrating Children's Literature and Science	344	Selecting Children's Literature	353
Introducing Lessons	344	Science Textbooks	355
Analyzing Conclusions	347	Constructivist Uses of Elementary Science Textbooks	355
Providing Factual Information	348	Commercially Available Hands-On Materials	358
Providing Supplementary Material	349	Review of Science Curriculum Materials	358
Providing Practical Examples	349	The Role of Reading and Writing in Elementary Science	359
Developing Process Skills	351		