BRIEF CONTENTS

Preface  • xv
Acknowledgments  • xviii

PART 1 THE ART OF TEACHING SCIENCE

CHAPTER 1 The Art of Teaching Science: A Reconnaissance  • 3
CHAPTER 2 Science for All  • 36

PART 2 THE GOALS AND THE CURRICULUM OF SCHOOL SCIENCE

CHAPTER 3 The Goals and History of Science Education  • 79
CHAPTER 4 Science in the School Curriculum  • 112

PART 3 CONNECTING THEORY AND PRACTICE IN SCIENCE TEACHING

CHAPTER 5 How Students Learn Science  • 167
CHAPTER 6 Models of Science Teaching  • 210
CHAPTER 7 Designing Science Units and Courses of Study  • 259

CHAPTER 8 Assessing Active Science Learning  • 299

PART 4 STRATEGIES OF SCIENCE TEACHING

CHAPTER 9 Strategies Fostering Thinking in the Science Classroom  • 331
CHAPTER 10 Facilitating Learning in the Science Classroom  • 369
CHAPTER 11 Science, Technology, and Society in the Science Classroom  • 399
CHAPTER 12 The Internet: Moving Toward Web-Based Learning Environments  • 440

APPENDIX A Science Curriculum Developers  • 464
APPENDIX B Professional Societies and Organizations  • 465
APPENDIX C Science Equipment and Computer Software Suppliers  • 467

Index  • 468
## CONTENTS

Preface • xv  
Acknowledgments • xviii  

### PART 1 THE ART OF TEACHING SCIENCE

#### CHAPTER 1 The Art of Teaching Science: A Reconnaissance • 3  
- Case Study: Kids Are Just Like Scientists • 3
- How to Read This Chapter • 4

#### SECTION 1: A Reconnaissance • 4  
- Invitations to Inquiry • 4
- The Artistry of Teaching • 4
- Unifying Themes of Science Teaching • 5
- Inquiry Activity 1.1: Exploring Your Initial Ideas about Science Teaching • 6
- Science Teaching: Your Career Choice • 8
- Wisdom of Practice • 9
- Science Teachers Talk • 9
- On the Nature of Science Teaching • 10
- Inquiry Activity 1.2: The Fossil and the Nature of Science Teaching • 11

#### The Nature of Science • 13  
- What Is Science? • 13
- Science and Courage • 13
- Science, Problem Solving, and the Human Mind • 14
- Science and Human Values • 15
- Science and Democracy • 17

#### The Scientific Enterprise and Teaching • 17
- Science Teaching and Inquiry • 17
- Inquiry Activity 1.3: Surveying Students' Views of Science • 18
  - Characteristics of Inquiry • 20
  - Inquiry in the Science Classroom • 21
  - Environments That Foster Inquiry • 22
- Life beyond Inquiry • 22
  - Direct/Interactive Teaching • 23
  - Cooperative Learning • 23
  - Constructivist Teaching: Learning as Meaning Making • 23
- The Scientist and the Student: Two Cultures? • 24
  - Some Differences • 24
  - Bridging the Gap • 24
- The Students We Teach: Who Are They? • 25
- Inquiry Activity 1.4: The Student Is First • 26
- The Effective Science Teacher: Who Are You? • 29
  - Effective Teachers • 29

#### SECTION 2: Science Teacher Gazette • 29  
- Volume 1: The Art of Teaching Science: A Reconnaissance • 29
  - Think Pieces • 29
  - Case Study: The Student Who Just Can’t Relate to This “Physics Stuff” • 30
  - Science-Teaching Literature: Science Is Not Words, Richard P. Feynman • 30
  - Interview a Science Teacher • 32
- Problems and Extensions • 33
CHAPTER 2  Science for All  •  36

Case Study: A New Buzz Word?  •  36
How to Read This Chapter  •  37

SECTION 1: Science for All  •  37
Invitations to Inquiry  •  37
Global Thinking  •  37
Global Events Fostering Global Thinking  •  37
Rationale for Global Thinking  •  38
Goals of Global Thinking: Implications for Science Teaching  •  39
Infusing Global Thinking into the Science Curriculum  •  40
Integrating Global Science Education Activities into Planning  •  41
Using the Internet to Globalize the Classroom  •  41
World (Global) Core Curriculum  •  42

Inquiry Activity 2.1: Exploring Global Thinking  •  43

Multicultural Perspective  •  44
What Is Multicultural Education?  •  45
Status and Goals  •  45
Talent Development Approach  •  46
Multicultural Science Teaching  •  47
Effective Teaching Practices  •  49

Inquiry Activity 2.2: Investigating Images Portrayed in Science Teaching Materials  •  49

Gender Issues  •  51
Participation of Women in Science  •  51
Strategies to Encourage Females in Science Courses and Careers  •  53

Science for All Exceptional Students  •  55
Exceptional Students in the Regular Science Classroom  •  56
The Exceptional Student in the Science Classroom  •  57
Physically Impaired Students  •  58
Learning Disabled Students  •  60
The Gifted and Talented in Science (Advanced Learners)  •  60
At-Risk Students in Science (Struggling Learners)  •  63

Inquiry Activity 2.3: Finding Out about Science Programs for the Exceptional Student  •  64

SECTION 2: Science Teacher Gazette  •  66

Volume 2: Science for All  •  66
Think Pieces  •  66
Case Study: The Experiment  •  66
Science Teachers Talk  •  66
Science-Teaching Literature: Science for All, Peter J. Fensham  •  68
Science-Teaching Literature: Our Apartheid: The Imperative of Multiculturalism in Science Education, Randy Moore  •  69
Research Matters: Encouraging Girls in Science Courses and Careers, Jane Butler Kahle  •  70
Problems and Extensions  •  71
Notes  •  72
Readings  •  74
On the Web  •  75

PART 2  THE GOALS AND THE CURRICULUM OF SCHOOL SCIENCE

CHAPTER 3  The Goals and History of Science Education  •  79

Case Study: Divine Intervention  •  80
How to Read This Chapter  •  80

SECTION 1: Goals and Philosophy of Science  •  80
Invitations to Inquiry  •  80
The Philosophy and Goals of Science Education  •  80

Inquiry Activity 3.1: The Goals of the Science Curriculum  •  81

Science Education Reports Influencing the Future  •  82
Project 2061: Science for All Americans  •  83
The Scope, Sequence, and Coordination Project  •  87
The National Science Education Standards  •  88
Influence of Research on the Goals of Science Teaching • 88

Inquiry Activity 3.2: Icons of Science Education: How Do They Tell the Story of Science Education? • 89

Science Education: A Historical Perspective • 90

An Inquiry into the Historical Nature of Science Education • 90

Phase I: The Roots of Modern Science Education, Pre-1900–1930 • 90
Phase II: Progressive Education and Science, 1930–1950 • 92
Phase III: The Golden Age of Science Education, 1950–1977 • 93
Phase IV: Textbook Controversies and Back to Basics, 1977–1983 • 96
Phase V: A Nation at Risk, the 1980s • 98
Phase VI: The Reform Efforts of the 1990s: A Contrast with the Golden Age • 100

Inquiry Activity 3.3: How Were Course Improvement Projects of the 1960s Different from the Reform Projects of the 1990s? • 101

Phase VII: Science for All and the New Millennium • 103

SECTION 2: Science Teacher Gazette • 104

Volume 3: Goals and History of Science Teaching • 104

Think Pieces • 104

Case Study: Rehashing the Sixties • 105
Case Study: New Science Goals—Just Another Fad • 105

The Parrott Timeline • 107
Science-Teaching Literature: Back to the Future with Science Education, Larry Loeppke • 107
Problems and Extensions • 108
Notes • 108
Readings • 110
On the Web • 111

CHAPTER 4 Science in the School Curriculum • 112

Case Study: A National Science Curriculum • 112
How to Read This Chapter • 112

SECTION 1: The Science Curriculum • 113

Invitations to Inquiry • 113
The Curriculum: What Is It? • 113
The Science Standards and the School Science Curriculum • 113

Goals Underlying the Standards • 114
Organization of the Content Standards • 114

The Elementary Science Curriculum • 116
Influential Elementary Science Projects • 116
Standards for Elementary Science • 117
Exemplary Elementary Science Curriculum Projects • 117

The Middle School Science Curriculum • 119
Influential Middle School Projects • 120
The Middle School Movement • 122
Middle School Science Curriculum Patterns • 123
Standards for Middle School Science • 125
Exemplary Middle School Science Programs • 125

The High School Science Curriculum • 127
Contemporary High School Curriculum Patterns • 128

Inquiry Activity 4.1: Science Curriculum Patterns • 130
High School Reform Projects • 131
Standards for High School Science • 133
Exemplary High School Science Curricula • 134

Inquiry Activity 4.2: Exploring Science Curriculum Materials • 136
Science Curriculum: A Global Perspective • 140

Australia, Roger T. Cross • 140
The Example of Victoria • 141
Australian Science Education: The Case of the State of Victoria • 141

Chile, Claudia Rose • 143

China, Ronald F. Price • 146
The Scope and Sequence of the Science Curriculum • 147

Ghana, Charles Hutchison • 148
Educational Administration in Ghana • 149
The Science Curriculum and Delivery • 149
## CONTENTS

### PART 3 CONNECTING THEORY AND PRACTICE IN SCIENCE TEACHING

#### CHAPTER 5 How Students Learn Science • 167

- Case Study: A New Approach to Learning • 167
- How to Read This Chapter • 168

#### SECTION 1: How Students Learn • 168

- Invitations to Inquiry • 168
- Inquiry Activity 5.1: How Do Students Learn Science? • 168
- Students and Science Learning • 169
- Theories of How Students Learn • 170
  - From Theory to Practice, or Practice to Theory? • 170
  - The Idea of Theory • 171
- Constructivist Theories of Learning • 171

#### SECTION 2: Science Teacher Gazette • 204

- Volume 5: How Students Learn • 204
- Think Pieces • 204
- Case Study: Theory of Science Teaching • 205
- Case Study: The Student Who Thought He Failed • 205
- Science Teachers Talk • 206
- Problems and Extensions • 207
- Notes • 207
- Readings • 209
- On the Web • 209

#### CHAPTER 6 Models of Science Teaching • 210

- Case Study: Descent from Innocence • 210
- How to Read This Chapter • 212
CONTENTS

Step 8: Categorize Outcomes, Cognitions, Affects, and Skills • 269
Step 9: List Potential Activities • 273
Step 10: Develop Specific Lesson Plans • 274
Sample Lesson 7.1: Biological Attraction • 276
Sample Lesson 7.2: Drugs, Alcohol, and Tobacco • 277
Sample Lesson 7.3: Electricity—Make It Light! • 279
Step 11: Develop an Assessment Plan • 280
Step 12: Implement the Miniunit • 280
Step 13: Feedback and Reflection • 280
Models and Sample Lesson Plans • 280
Direct/Interactive Teaching Lesson Plan Guide • 281
Sample Lesson 7.4: Direct Instruction • 281
Cooperative Learning Lesson Plan Guide • 282
Sample Lesson 7.5: Mystery at the Ringgold Roadcut • 283
Inquiry/Laboratory Lesson Plan Guide • 285
Sample Lesson 7.6: Investigating Mass, Volume, and Density • 285
Constructivist Lesson Plan • 286
Sample Lesson 7.7: Electromagneticism • 287
Designing a Science Course of Study • 287
Elements of a Course of Study • 287
Sample Course Plan: Global Science: Energy, Resources, Environment • 288
Inquiry Activity 7.3: Designing a Course of Study: The Course Syllabus • 289

SECTION 2: Science Teacher Gazette • 290
Volume 7: Models of Teaching • 290
Think Pieces • 290
Science Teachers Talk • 290
Planning Activity 7.1: Earth Science: Shake, Rattle, and Quake: Earthquake Waves • 292
Planning Activity 7.2: Earth Science: Don’t Take It for Granite: Rock Classification • 293
Planning Activity 7.3: Life Science: Light On: Responses of Earthworms • 294
Planning Activity 7.4: Physical Science: Chemistry in the Bag • 295
Planning Activity 7.5: Physical Science: An Eggzact Experiment • 296
Problems and Extensions • 297
Notes • 297
Readings • 298
On the Web • 298

CHAPTER 8 Assessing Active Science Learning • 299
Case Study: Mrs. Cronin’s Whirlybird Project: Assessment in Action? • 299
How to Read This Chapter • 300

SECTION 1: Assessing Active Learning • 300
Invitations to Inquiry • 300
Assessing Classroom Learning • 300
Inquiry Activity 8.1: Designing an Assessment Plan • 301
A Model for Assessment in the Classroom • 302
Multiple Methods of Classroom Assessment • 303
Informal Methods of Assessment • 303
Semiformal Methods of Assessment • 304
Formal Methods of Assessment • 305
Performance-Based Assessment • 308
Inquiry Activity 8.2: Designing Performance Assessment Tasks and Rubrics • 309
Portfolios • 311
Assessing Science Learning at the National Level • 311
Long-Term Trend Assessments • 311
Long-Term Proficiency Levels • 314
Long-Term Trends in Science Achievement • 315
Trends in Student Attitudes toward Science • 316
Inquiry Activity 8.3: Surveying Students’ Knowledge and Attitudes about Science • 317
  National NAEP Assessments • 318
  Assessing Science at the International Level • 320
    TIMSS Results • 320
    TIMSS-R Results • 321

SECTION 2: Science Teacher Gazette • 322
  Volume 8: Assessing Active Science Learning • 322
    Think Pieces • 322
  Case Study: The False Crisis in Science Education • 323
  Research Matters: Science Literacy: Lessons from the First Generation, Marlene M. Hurley • 323
  Problems and Extensions • 325
  Notes • 326
  Readings • 327
  On the Web • 327

PART 4 STRATEGIES OF SCIENCE TEACHING

CHAPTER 9 Strategies Fostering Thinking in the Science Classroom • 331
  Case Study: The Learning Log • 331
  How to Read This Chapter • 332

SECTION 1: Thinking in the Science Classroom • 332
  Invitations to Inquiry • 332
  Strategies Fostering Critical and Creative Thinking • 332
  Interactive Teaching Strategies • 333
    Advance Organizers • 333
    Creating a Stimulating Classroom Environment • 333
    The Art of Questioning • 334
    Using Examples to Help Students Understand Science Concepts • 337
    Positive Learning Environment • 338
    Closure and Making Transitions • 338
  Inquiry Activity 9.1: Microteaching: Practicing Science Teaching Skills • 339
  Establishing a Culture of Learning:
    Language and Vygotsky • 241
    Talking Science • 341
    Reading Science • 344
  Sample Lesson 8.1: Earthquakes • 348
    Writing Science • 350
  Sample Lesson 8.2: Crusty (Rock) Writing • 350
  Sample Lesson 8.3: Using the Learning Log with a Hands-On Activity • 353
  Strategies That Foster Independent and Collaborative Thinking • 354
    Problem Solving • 354
    Problem Solving in Practice: Project-Based Teaching and Science Fairs • 357

SECTION 2: Science Teacher Gazette • 360
  Volume 9: Strategies Fostering Thinking in the Science Classroom • 360
    Think Pieces • 360
  Case Study: Questioning: Inquiry or the Inquisition? • 360
  Science Teachers Talk • 360
  Research Matters: Using Questions in Science Classrooms, Patricia E. Blosser • 361
  Research Matters: When Are Science Projects Learning Opportunities? Marcia C. Linn and Helen C. Clark • 363
  Problems and Extensions • 366
  Notes • 367
  Readings • 368
  On the Web • 368

CHAPTER 10 Facilitating Learning in the Science Classroom • 369
  Case Study: Ecosystem Study • 369
  How to Read This Chapter • 370

SECTION 1: Facilitating Learning in the Classroom • 370
  Invitations to Inquiry • 370
  Leadership in the Science Classroom • 370
  Inquiry Activity 10.1: The Effective Leader Project • 370
CONTENTS

The Facilitative Science Teacher • 372
  Effective Management Behaviors • 372
  Facilitating Laboratory and Small-Group Work • 375
  Management Plan for Small-Group or Laboratory Work • 376
  Facilitating High-Level Thinking Tasks • 378
Inquiry Activity 10.2: Windows into Science Classrooms • 379
Effective Teaching for the Beginning of the Year • 380
  Room Arrangements • 380
  Establishing Rules and Procedures • 380
Inquiry Activity 10.3: Developing a Classroom Management Plan • 382
The First Day • 382
  First Lessons • 383
  Beyond Day One • 385
Inquiry Activity 10.4: Planning for Three Weeks • 386
Managing Science Classroom Materials and Facilities • 387
  Materials for Science Teaching • 387
Inquiry Activity 10.5: Preparing a Science Equipment Order • 387
Inquiry Activity 10.6: Designing a Science Tool Kit • 389
  Facilities for Science Teaching • 391
  Safety in the Science Classroom • 391
  A Safe Science Environment • 391
  Chemical Safety • 393
  Living Organisms in the Classroom • 395

SECTION 2: Science Teacher Gazette • 395
Volume 10: Facilitating Learning in the Science Classroom • 395
  Think Pieces • 395
Case Study: Misbehavior in the Lab • 395
Case Study: The Smiths Come to School • 395
Science Teachers Talk • 396
Problems and Extensions • 397
Notes • 397
Readings • 398
On the Web • 398

CHAPTER 11 Science, Technology, and Society in the Science Classroom • 399
Case Study: A Controversial Student Project • 399
How to Read This Chapter • 400

SECTION 1: STS in the Science Classroom • 400
Invitations to Inquiry • 400
The Nature of STS • 400
  Some Characteristics of STS and EE Programs • 402
Inquiry Activity 11.1: Getting Involved in STS • 407
Strategies for Teaching STS in the Classroom • 408
  Clarifying Values • 408
  The STS Module • 412
STS Themes and How to Teach Them • 414
Inquiry Activity 11.2: STS Issues in Science Textbooks • 414
Population Growth • 416
Air Quality and Atmosphere • 417
Energy • 418
Effects of Technological Development • 419
Hazardous Substances • 421
Water Resources • 422
Utilization of Natural Resources • 422
Environment • 423

Inquiry Activity 11.3: STS Module Design • 424
STS Curriculum Examples • 425
  STS Evaluation Criteria • 426
  Education for a Sustainable Future (ESF) • 426
  Science Education for Public Understanding Program (SEPUP) • 428
  ChemCom (Chemistry in the Community) • 429
  Project Learning Tree (PLT) • 429
  Other STS Materials • 429
Inquiry Activity 11.4: Evaluating an STS Module or Project • 430

SECTION 2: Science Teacher Gazette • 431
Volume 11: Science, Technology, and Society in the Science Classroom • 431
  Think Pieces • 431
CHAPTER 12  The Internet: Moving toward Web-Based Learning Environments  • 440

Case Study: Web-Based Teaching, Just Another Progressive Education Fad?  • 440

How to Read This Chapter  • 441

SECTION 1: Web-Based Learning Environments  • 441

Invitations to Inquiry  • 441
Creating a Web-Based Classroom  • 441

Inquiry Activity 12.1: Designing Web-Based Science Activities  • 442

Web-Based Tools  • 443
  Interpersonal Exchange  • 443
  Information Collections and Resource Web Tools  • 445
  Problem-Solving Web Tools  • 446

Telecommunications Projects and Science Inquiry  • 447
  Network Science Projects  • 448

Case Study: Global Lab  • 450

Inquiry Activity 12.2: Network Science—Exploring Online Projects  • 451

Web-Based Science Activities for the Online Classroom  • 453
  Establishing an Online Classroom  • 453
  Activities for the Web  • 453

Sample Lesson 12.1: Mission to the BLUE PLANET: A Terra Firm Inquiry  • 455

Inquiry Activity 12.3: Designing a Web-Based Science Activity  • 458

SECTION 2: Science Teacher Gazette  • 459

Volume 12: The Internet: Moving toward Web-Based Learning Environments  • 459
  Think Pieces  • 459
Science Teachers Talk  • 459
  Problems and Extensions  • 462
Notes  • 462
Readings  • 462
On the Web  • 463

APPENDIX A  Science Curriculum Developers  • 464

APPENDIX B  Professional Societies and Organizations  • 465

APPENDIX C  Science Equipment and Computer Software Suppliers  • 467

Index  • 468
Science teachers and researchers have shown that all students are capable of learning science. *The Art of Teaching Science* is designed to help you achieve this vision and important goal of science teaching. The vision of all students learning science is highly dependent upon the beliefs we have about science, pedagogy, and students. Students learn when they are provided the opportunity to experience the richness of science through active inquiry and collaboration with peers and adults, as well as the tools to promote learning. The context of learning in this vision is humanistic through creative and imaginative encounters with teachers.

*The Art of Teaching Science* is rooted in the philosophy and structure of an earlier work, *Minds on Science*. *The Art of Teaching Science* extends this earlier work by providing a new organization of the context and focusing the preparation of science teachers on professional artistry. In this view, the *learning to teach process* involves encounters with peers, professional teachers, and science teacher educators. To help readers of this book achieve this goal, a number of pedagogical learning tools have been integrated into the text. These tools involve inquiry and experimentation and reflection through writing and discussion, as well as experiences with students, science curriculum, and pedagogy. Becoming a science teacher is a creative process. In the view espoused here, you will be encouraged to “invent” and “construct” ideas about science teaching through your interaction with your peers, teachers, and your instructors.

*The Art of Teaching Science* is a science teaching handbook/methods textbook designed for the professional development of middle and high school science teachers. The experiential tools in the book allow for its use in pre- and in-service teacher education environments. Science education in the early part of the twenty-first century will be characterized by profound changes in our understanding of the goals of science teaching, as well as the establishment of a new cadre of educators. I have written *The Art of Teaching Science* to provide meaningful learning experiences and connections with the most recent research and understanding of science teaching for this new cadre of science teachers.

*The Art of Teaching Science* is organized into four parts:

- Part 1: The Art of Teaching Science (a reconnaissance and view of science for all)
- Part 2: The Goals and Curriculum of School Science
- Part 3: Connecting Theory and Practice in Science Teaching
- Part 4: Strategies of Science Teaching
I invite you to explore the book experientially. In fact, I have included brief introductory comments in each chapter under the heading How to Read This Chapter, which I hope will help you decide how and what to read in the book.

Each chapter is divided into two sections: the first focuses on the content of the major theme of the chapter; the second is a newspaper-like feature called the *Science Teacher Gazette*, which contains a variety of strategies to help you extend your science teaching learning experience.

Throughout the book you will find a variety of what I call “pedagogical learning tools” that are based on the belief that we construct our intellectual knowledge of science teaching and that learning to teach is accelerated by:

- hands-on, experiential activity
- minds-on, high-level cognitive engagement
- socially arranged small-group learning
- reflective thinking

I have developed eleven pedagogical learning tools for the book, and you can view them in Table P.1. Perhaps one of the most important tools is the first, *inquiry activities*. I have designed forty-two inquiry activities that will give you the opportunity to creatively explore the dimensions of science teaching to help you construct and extend your professional expertise. I have begun each chapter with a *case study*, a problem-solving dilemma based on actual events about science teaching. You will also find reflective tools, including *think pieces* and *problems and extensions*. These tools should help you think, write, and share your developing ideas with others.

*The Art of Teaching Science* will bring you into contact with a worldwide community of science educators. I had the privilege of interviewing science teachers from Australia, Botswana, Canada, Chile, Ghana, Japan, Russia, and the United States. I have included some of their views and insights in chapter sections called *Science Teachers Talk*, which contain powerful insights and experiences for you to reflect upon and compare to your own views of teaching. I hope this feature will help you understand the kind of people that are your colleagues and what they think about science teaching.

Science teaching also has a very active and influential research community, and I wanted you to be able to connect with some of the research and learn how it affects the teaching of science. Much of the research about science teaching takes place in collaboration with practicing science teachers. Teams of researchers from universities and science education development centers work with colleagues in the K–12 school environment to ask questions about the nature of science teaching. I hope you find these “reports,” called *Research Matters*, interesting and informative.

Finally, you will find discussions about science teaching written by educators from Australia, Chile, China, Ghana, Japan, and Russia (Chapter 4). Science education is a global community and the science educators from these countries have given us insight into science teaching in their nation.

Welcome to *The Art of Teaching Science*. I hope you find it an enjoyable experience as you begin or continue your professional development.
Table P.1 Pedagogical Learning Tools

<table>
<thead>
<tr>
<th>Pedagogical Learning Tool</th>
<th>Purpose</th>
<th>Location in <em>The Art of Teaching Science</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry Activities</td>
<td>Science teaching investigations that enable you to reflect on the important concepts of teaching science using hands-on and minds-on processes.</td>
<td>There are forty-two Inquiry Activities located in the first section of each chapter of <em>The Art of Teaching Science</em>.</td>
</tr>
<tr>
<td>Think Pieces</td>
<td>Short essays (generally no more than two pages) or posters (no larger than one poster board) that reflect your views on some topic or subject in science education.</td>
<td>The <em>Science Teacher Gazette</em> of each chapter contains three or more Think Pieces.</td>
</tr>
<tr>
<td>Case Studies</td>
<td>Brief case study scenarios that engage you in reflective thinking, role playing, and discussion of science teaching problems pertinent to concepts of the chapter.</td>
<td>Each chapter begins with one, and you’ll find more in the <em>Science Teacher Gazettes</em>.</td>
</tr>
<tr>
<td>Science Teachers Talk</td>
<td>Craft-talk interviews with several practicing science teachers.</td>
<td>Located in most of the <em>Science Teacher Gazettes</em>.</td>
</tr>
<tr>
<td>Research Matters</td>
<td>Consumer-type reports of research from the National Association for Research in Science Teaching (NARST) on selected topics on science teaching.</td>
<td>Located in most of the <em>Science Teacher Gazettes</em>.</td>
</tr>
<tr>
<td>Science-Teaching Literature</td>
<td>Brief essays and articles from journals of science education.</td>
<td>Located in the <em>Science Teacher Gazette</em> of most chapters.</td>
</tr>
<tr>
<td>Problems and Extensions</td>
<td>Hands-on and minds-on problems designed to engage individuals or cooperative groups in solving problems about science teaching.</td>
<td>Five to seven problems and extensions are located in each of the <em>Science Teacher Gazettes</em>.</td>
</tr>
<tr>
<td>On the Web</td>
<td>A collection of Internet resources related to the content of the chapter.</td>
<td>Located in the <em>Science Teacher Gazette</em> of each chapter.</td>
</tr>
<tr>
<td>Readings</td>
<td>Resources from the science-teaching literature pertinent to science teaching.</td>
<td>Located in the <em>Science Teacher Gazette</em> of each chapter.</td>
</tr>
<tr>
<td>Reflective Teaching</td>
<td>A laboratory encounter with teaching in which lessons are presented to develop a reflective approach to science teaching.</td>
<td>Inquiry Activity 6.1. Sample reflective teaching lessons are located in the <em>Science Teacher Gazette</em> of Chapter 6.</td>
</tr>
<tr>
<td>Microteaching</td>
<td>A scaled down version of teaching in which teachers present 5–10 minute lessons that are video-taped. Teachers practice models and strategies of teaching.</td>
<td>Inquiry Activity 9.1.</td>
</tr>
</tbody>
</table>
The Art of Teaching Science was a collaboration among many people. I could not have written this book without their help and encouragement. First I wish to thank Karita dos Santos, who when we met was the education editor of Oxford University Press and encouraged me to submit a proposal to write this book. Several science educators reviewed the initial proposal, and I wish to thank them for their critique and recommendations for The Art of Teaching Science. First, I wish to thank Mike Dias, professor of science education at the University of Georgia, Athens, for all of his contributions. He has been an active researcher and practitioner for a constructivist approach to science teacher education for many years. His feedback on the proposal and the initial draft of the entire book was extremely important because he represents a new cadre of science teacher educators, and his opinions were extremely valuable. His detailed review provided specific and powerful recommendations that I have included in the final version. I also wish to thank Elaine J. Anderson, professor of science education at Shippensburg University, Shippensburg, Pennsylvania. She was a user of my earlier text, Minds on Science, and provided valuable recommendations for changes in the proposal and final draft for this book. Julie Weisberg, formerly a professor of science education at Agnes Scott College, Decatur, Georgia, and now with the Georgia Professional Standards Commission, has continuously given me feedback about the book and provided insight into making changes for a new publication. Lynn A. Bryan, a professor of science education at the University of Georgia, provided generous suggestions for change in my original proposal, especially in the way chapters are organized. I wish to thank each of these outstanding science educators for their expertise and care in providing critiques of my work.

Science educators from various countries wrote responses to interview questions that I used to create the Science Teachers Talk sections of the book. These wisdom-of-practice discussions provide brief, yet candid snapshots of teaching from the practitioner’s point of view. Some of the interviews were carried over from Minds on Science and I wish to thank those educaters: Ginny Almeder, a former biology teacher from Georgia; Bob Miller, a biology teacher from Texas; Jerry Pelletier, a junior high teacher from California; John Ricciardi, a physics and astronomy teacher from Nevada; Dale Rosene, a middle school teacher from Michigan; and Mary Wilde, a middle school teacher from Georgia. To extend the Science Teachers Talk sections for this book, I interviewed two different groups of teachers, one with ten to fifteen years of teaching experience and the other comprising first-year teachers. The experienced teachers included Anita Bergman; a middle school teacher from Clayton County, Georgia; Ludmila Bolshakova, a chemistry teacher from
ACKNOWLEDGEMENTS

St. Petersburg, Russia; Ben Boza, a science teacher from Gaborone, Botswana; Tom Brown, a former high school science teacher and now professor of science education at Kennesaw State University; Virginia Cheek, a biology teacher from Cobb County, Georgia; Marina Goryunova, computer science teacher and teacher educator from St. Petersburg, Russia; Anna Morton, a middle school teacher from Fulton County, Georgia; Carol Myronuk, a science teacher from Vancouver, Canada; and Barry Plant, a science teacher from Melbourne, Australia.

The first-year teachers I interviewed graduated from a constructivist-based science teacher education program at Georgia State University (TEEMS) and were in their first year of teaching. I wish to thank Ann Gunn, a physics teacher in Fulton County, Georgia; Michael O’Brien, a physics teacher in Cobb County, Georgia; and Rachel Zgonc, a middle and high school science teacher at the Westminster School, Atlanta, Georgia.

The Art of Teaching Science includes a global perspective. Science education should be for all students in each nation. To gain insight into science education in other nations, I asked science educators from six countries if they would prepare a short description of the current state of science education in their nation. These educators provided powerful descriptions of science education in their country, and I hope you will find these valuable as you develop your view of education. I wish to thank Roger T. Cross, of Burra, for his piece on Australia; Claudia Rose for writing about science education in Chile; Charles Hutchison for writing about the art of teaching science in Ghana; Ronald F. Price of Melbourne for his discussion of science education in China; Sergei Tolstikov of Moscow for his insights into Russian science education; and Shigehiko Tsukahara for his article on Japanese science education. Each of these outstanding educators has provided us with an understanding of science teaching in another nation, thereby giving us further insight into our own.

From 1994 until 2003 I worked with the TEEMS science teacher education program at Georgia State University. During that period of time 145 men and women became middle and high school science teachers through a program based on the philosophy and pedagogy that forms the foundation for The Art of Teaching Science. Their brilliance and creativity, shown in their internship work and from reports we received of their work in school science, fostered the development of a TEEMS philosophy and provided enormous encouragement and support for the work of the faculty in the program. I wish to thank each of them for what they gave to us and for what they are now giving to their students.

I also wish to thank my colleagues in the field of science education for pursuing their passions and conducting research projects on science education that provide a knowledge base for all of us. I thank them for this work and for being able to include some of their ideas in The Art of Teaching Science.

There are several people at Oxford University Press whom I wish to thank, and they include Maura Roessner, assistant editor, Christine D’Antonio, production editor, and Terri O’Prey, copyeditor. Their contributions were professional and engaging and led to the creation of the final manuscript and book.