

# Teaching With Purpose

**Closing the Research – Practice Gap**



# Teaching With Purpose

**Closing the Research – Practice Gap**

**By John E. Penick and Robin Lee Harris**

**NSTA**press  
NATIONAL SCIENCE TEACHERS ASSOCIATION

Arlington, Virginia



NATIONAL SCIENCE TEACHERS ASSOCIATION

Claire Reinburg, Director  
Judy Cusick, Senior Editor  
Andrew Cocke, Associate Editor  
Betty Smith, Associate Editor  
Robin Allan, Book Acquisitions Coordinator

Linda Olliver, Cover and Inside Design

**PRINTING AND PRODUCTION** Catherine Lorrain-Hale, Director  
Nguyet Tran, Assistant Production Manager  
Jack Parker, Electronic Prepress Technician

**NATIONAL SCIENCE TEACHERS ASSOCIATION**  
Gerald F. Wheeler, Executive Director  
David Beacom, Publisher

Copyright © 2005 by the National Science Teachers Association.  
All rights reserved. Printed in the United States of America.  
07 06 05 4 3 2 1

**LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA**

Penick, John E.

Teaching with purpose : closing the research-practice gap / by John E. Penick and Robin Lee Harris.  
p. cm.

Includes bibliographical references and index.

ISBN 0-87355-241-5

1. Science--Study and teaching--Research. 2. Science teachers--Training of. I. Harris, Robin Lee. II. Title.

Q181.P3475 2005

507'.1--dc22

2005018612

*NSTA is committed to publishing material that promotes the best in inquiry-based science education. However, conditions of actual use may vary, and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors do not warrant or represent that the procedures and practices in this book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book, including any of the recommendations, instructions, or materials contained therein.*

Permission is granted in advance for photocopying brief excerpts for one-time use in a classroom or workshop. Requests involving electronic reproduction should be directed to Permissions/NSTA Press, 1840 Wilson Blvd., Arlington, VA 22201-3000; fax 703-526-9754. Permissions requests for coursepacks, textbooks, and other commercial uses should be directed to Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01923; fax 978-646-8600; [www.copyright.com](http://www.copyright.com).

# Contents

	<b>Acknowledgment and Dedication</b> .....	vii
	<b>About the Authors</b> .....	ix
	<b>Foreword</b> .....	xi
CHAPTER 1	<b>Making a Case for a Research-Based Teaching Rationale</b> .....	1
CHAPTER 2	<b>Elements of a Research-Based Rationale</b> .....	11
CHAPTER 3	<b>Developing a Research-Based Rationale</b> .....	25
	Appendix: Rating Credibility of Research Sources .....	47
CHAPTER 4	<b>Implementing Your Rationale and Becoming a Mentor</b> .....	49
	<b>Index</b> .....	61

# Acknowledgment and Dedication

**T**his book grew out of the thinking, practice, and experience of Professor Dorothy Schlitt at Florida State University between 1965 and 1975. Dorothy originated and developed the concept of a research-based teaching rationale, integrating it into her highly effective teacher education program. In subsequent years, John Penick (co-author of this book) developed the rationale concept so that it pervaded every aspect of the science teacher education program he helped develop. Many of John's 29 PhD students (including Robin Harris, his co-author) adopted the concept of a rationale, implementing it in a number of teacher education programs. Over the ensuing 30 years, with institutional constraints, changing demographics, and evolution, the original idea has grown, changed, and been studied. The central concept remains: A personal, research-based rationale can play an essential role in promoting exemplary and effective teaching and professional development.

Dorothy inspired those of us who studied under her. Her words, actions, teaching, and professional life seemed exciting, accurate, deep, purposeful, and, most importantly, successful. Her students both feared and loved her. We knew that here was a marvelous teacher—a truly professional teacher—with insights far beyond any we could conceive, much less describe. Yet, it was not intuitively obvious to us that what we noted and admired in Dorothy was actually planned, coordinated, and based on systematic research, study, and thinking. Little did we know that she changed her ideas regularly and was never content with her current level of success with students, as phenomenal as it seemed to us at the time. We did not understand that her seemingly fully developed ways of thinking and teaching were part of a work in progress. With time though, this became a significant point in our own understanding.

A key ingredient of her personal rationale included constant reflection on her teaching, her teacher education program, her students, and her own ideas and values. Focused and never idle, her reflections led her to additional reading and study, to consider alternate plans and scenarios, to rearrange elements of her teaching, and to try new things. Paradoxically, her seemingly solid and apparently immutable rationale for teaching guaranteed an ever-changing teaching strategy and environment.

The rationales for teaching and for teacher education that each of us developed stem directly from Dorothy Schlitt and have guided us in innumerable ways. We can think of no other aspect of our own professional teacher education that comes even close in terms of impact on us and the students with whom we have worked. Professor Dorothy Schlitt provided us with a strong foundation and a robust framework on which to build. We still see and feel Dorothy's impact in our work daily.

As our careers and the careers of our students have benefited enormously from Dorothy's wisdom and practice, we dedicate *Teaching With Purpose* to Professor Dorothy Schlitt.

*John E. Penick*  
*North Carolina State University*

*Robin Lee Harris*  
*Buffalo State College*

# Foreword

**E**very science teacher strives to maximize student learning. Effective science teachers promote learning by understanding and using research and practices known to work. The education literature contains considerable information about effective teachers and teaching, and researchers have documented much of what has become known as “best practice” in teaching. At the same time, the research literature on human cognition and student learning is growing both stronger and more valid. Yet, many excellent teachers have not learned how to find, evaluate, combine, and use these findings systematically to inform, guide, and ultimately improve their teaching performances. *Teaching With Purpose* is designed to close this gap between research and practice.

Written for teachers, supervisors, teacher educators, and others concerned with providing the best and most effective classroom instruction, *Teaching With Purpose* offers insight into how to develop a research-based plan to improve your work in the classroom. But, rather than attempting to compile all valid research, we describe how to combine your goals and situation with research findings to make you ever more knowledgeable and effective.

*Teaching With Purpose* requires that you bring your own personal needs, knowledge, experience, energy, taste, tolerance, and learning to bear. If you follow the recommendations and suggestions of this book, you will have a more thorough understanding of your role as a teacher and the impact of that role on student learning. Three key steps are necessary for you to succeed. First, write down your goals, thoughts, understandings, and teaching strategies to begin the process of developing your own “teaching

rationale.” Second, identify and study the most appropriate and compelling research that might help you improve your success in the classroom. Third, and most importantly, use your personal, research-based rationale in the classroom every day and see your effectiveness increase.

Throughout this book, more than a dozen teachers from across the country, ranging from second-year teachers to 20-year veterans, comment on how developing a research-based rationale has helped their students and made them better educators. Their wisdom and advice is worth heeding. Listen, learn, and apply their wisdom in your classroom, and you will see changes in yourself, your teaching, and your students.

# Making a Case for a Research-Based Teaching Rationale

*Mrs. Ramsey was an outstanding fourth-grade teacher. Everyone looked forward to being in her class—it was fun, we learned a lot, and we knew she liked us. We thought it was just her personality that made the class so enjoyable. But it was not just her personality—Mrs. Ramsey had a plan and her plan included goals for us and a clear understanding of her role in the classroom.*

*Built on years of experience, her plan grounded her, providing her with a daily image of what she wanted to achieve in the classroom. Each day she could visualize her success based on her plan. While she had little formal education research to draw on, she had a long history of continual thinking about teaching and systematic observations of students. Knowing her students, understanding her role, and developing a plan enabled her to achieve her vision.*

**R**ead and study this book, use its ideas wisely, and it will help you as a science teacher achieve the same kind of success as Mrs. Ramsey. Throughout this book we demonstrate the importance of developing a detailed plan or rationale for teaching science that will help you achieve improved results in the classroom. Although every teacher's plan or rationale will be different in some ways, we have found, based on more than 45 combined years of helping teaching candidates and teachers develop their own teaching

rationales, that most successful plans embrace ten key components. The most useful and effective plans

1. are written down and express a personal vision of success in the classroom;
2. fit the personality, goals, and experience of the teacher;
3. are flexible and subject to change;
4. are based on research, not just instinct or personal experience;
5. set specific goals and expectations, and define the desired roles for both students and the teacher;
6. identify and adopt successful strategies to use in the classroom, and build on past successes;
7. seek to create a positive environment for learning in the classroom and aim to meet the individual needs of students;
8. assess results and performance on a regular basis;
9. select content that meets standards while also encouraging creativity; and
10. are developed and shared with other teachers.

### **Some Research About Exemplary Teachers**

For many years educators have been studying exemplary teachers, trying to determine the nature of their excellence and, with this knowledge, to help others become equally excellent at promoting student learning. One seminal study took place 20 years ago and its results still have relevance today. Between 1982 and 1987 the National Science Teachers Association (NSTA) conducted a nationwide Search for Excellence in Science Education. Teams in every state, organized by Robert Yager of the University of Iowa, identified several hundred exemplary school science programs. As the teams studied and wrote about the programs, they also studied the teachers (at the end of this chapter, see sample titles from the Focus on Excellence series, 17 volumes published by NSTA that reported results from that study of programs and teachers).

Without fail, the teachers in this select group, those who designed and implemented wonderfully successful programs, were just like Mrs. Ramsey—each had a plan and great insight into how to make their classrooms embody the plan. Not surprisingly, their students had amazing success at learning (Bonnstetter, Penick, and Yager 1983). While many

of the Search for Excellence teachers were “naturals”—born, it seemed, to be excellent teachers—we also know that we can help others be just as successful. This book is designed to do that.

In related studies, Joseph Krajcik, a former president of the National Association for Research in Science Teaching and now at the University of Michigan, studied seven years of teacher education graduates from the University of Iowa (Krajcik 1986; Krajcik and Penick 1989). Each graduate had spent considerable time developing a written, research-based rationale for teaching and had defended it orally several times. Krajcik found that many of these new teachers demonstrated characteristics almost identical to those of expert, experienced teachers as characterized by several large, national studies (Weiss 1978, 1985). As a result, he concluded that we did not have to depend on “born” teachers; rather, teachers could be made—if their teacher education included systematic development of a well-researched plan that guided their teaching and their students’ learning.

### **Reasons for a Rationale**

While all teachers have reasons for their actions, some may base their actions more on intuition, hearsay, or even misguided experience. Many have been encouraged to develop a “philosophy of education” made up of the ideas of well-known educators combined with personal feelings about teaching and learning. In this book, we go a step further, differentiating between a “philosophy” and a “rationale.” A rationale is built on research, while a philosophy, although built on a thoughtful and intellectual base, may place little emphasis on research support for what the roles of teachers and students should be. Although research in education is not as pervasive (or persuasive) as might be desired, the purposeful teacher should use all available knowledge to inform his or her teaching.

A key to success is to put your plan in writing. Most successful teachers we have observed have written rationales that go well beyond the normal lesson plan. These plans specify their goals and expectations, what content they want to cover, their views of their own teaching roles, and their assessment strategies. The most effective teachers justify and support their ideas with research, thus creating a research-based rationale to guide teaching. Randy Smasal, a veteran high school teacher and now an administrator, recalls how he found little satisfaction in teaching until introduced to the idea of a written rationale (see sidebar, p. 8).

Teachers face a daunting task as they work with a wide array of students, with multiple needs, in physical facilities that are often far from ideal. In this environment, a research-based rationale acts as a blueprint that gives the teacher an overview while maintaining perspective and intellectual control. Having a blueprint and a sense of control reduces anxiety and builds self-confidence (Druckman and Swets 1988).

We also see the development of a personal teaching rationale as the cornerstone of personal professional development during a teacher's career. Just setting goals is not enough. You must construct a plan for growth and change. Developing a research-based rationale can be quite useful for your own success and recognition as an educator. Having reasons, justifications, for your teaching also provides survival value, helping you stay on track with your ideas, plans, and actions.

### **The Importance of Goals**

Effectiveness in teaching means having and achieving specific goals for students. (See more on goal setting in Chapter 3.) Goals are both the beginning and the end of successful teaching. Knowledge and implementation tie all the pieces together. A well-developed personal teaching rationale includes setting goals and defining objectives to reach those goals. Effective teachers do not pick goals out of a hat or have them imposed on them by administrators. They consciously develop their own.

Penick and Bonnstetter (1993), during a 10-year period in more than 25 states and countries, asked parents, teachers, administrators, and scientists about their goals for K–12 students in science education. Regardless of the group, all responded similarly. They wanted their students to

- become more creative,
- be effective communicators,
- use science to identify and solve problems,
- know how to learn science, and
- develop a positive attitude toward science.

Most of these goals involve processes—how you approach learning—or personal characteristics more than specific objective knowledge. Teaching only for content cannot achieve these broad goals. Effective teachers can

and do teach mandated content and skills—but they do so in a way that is consistent with their overriding goals, such as those above.

Educational goals are developed by thinking about what knowledge, abilities, and dispositions students should acquire or develop during their K–12 years. Our educational goals for students usually include not only subject matter concepts but also technological and scientific literacy, lifelong learning, inquiry, creative thinking, communication, application of science in a social context, critical thinking, nature of science, problem solving, social growth and development, appreciation of diversity and equity, and development of a worldview, among others. Each goal requires attainment of a variety of skills, knowledge, or attitudes, often in a particular sequence. Thus, our goals are built on a foundation that must be developed one stone at a time (Bransford, Brown, and Cocking 2000).

Of course, the best-laid plans often go astray. Effective teachers know this, plan for it, and are ready to follow an alternate path when needed. Like contingency plans in any critical environment, a rationale provides a vision of the desired outcome and alternative courses of action to reach that goal. With a rationale for their work, teachers are better prepared for a variety of eventualities.

Regular reflection on one's goals is a must. Daily, we think about how and what to teach tomorrow. At year's end, we reflect on the goals attained and set new goals and ideas for the following year. Reflecting is not an idle activity; it, too, must be sequenced and organized. A carefully designed rationale includes elements that provide this organization. When such reflection is done well, we are rewarded with ever increasing success in our classes.

*The cycle of research and reflection is never ending because with every question I work to answer, several others pop up. I have to maintain my focus. In order to do this, I have to apply what I learned in my undergraduate years through the research-based rationale experience. This experience allows me to focus by identifying goals and then researching and developing actions for both my students and myself. This allows me to continue to seek the “absolute truths” in what I am doing in the classroom.*

—Brandon Schauth, Second-Grade Teacher, Iowa, 2003

Ken Tangelder, a seventh-grade life science teacher in New York, saw an opportunity regarding his goal of using technology in the classroom:

*When I first started teaching, the school had just opened a new computer lab. I can remember our very first faculty meeting when our principal said, “Get those kids down there; that thing is open before school, during school, and after school. We want them down there as much as possible. We want them to be there as much as they are in the library.” I said, “Okay,” and right off the bat I started looking at one of my three goals, which was to implement technology. How can I use technology in the classroom? Well, the principal had served it to me on a platter. Not a problem; I signed up for as many times as there were available and I went from there. (2003)*

Without a reasoned set of goals, would Ken have seen the opportunity so quickly? Would he have moved as fast, becoming the first teacher to use the facility? Or would he have hesitated, perhaps so long that there was no longer room for his classes? One wonders whether, if he didn't have a rationale or that particular goal, he would have gone on to develop the successful activities that are now used by all the teachers at his level. While one cannot do controlled research about such questions, we can state that this type of success is a common story even among novice teachers with whom we have worked when they have solid, well-supported rationales for their teaching.

## **Value of Research**

Research gives us assurance of validity and reliability and guides daily practice as well, helping teachers focus on their goals rather than being sidetracked by interruptions and trivia. Research is the foundation for knowledge and reflection. Without research, actions become guesses and learning becomes a mystery.

*Effective teachers can describe eloquently and in detail how they make links between research and practice, filling in gaps with logic, experience, new knowledge, and even research of their own.*

—Jennifer Rose, Middle School Science Teacher, Minnesota, 2003

With strong research grounding (as will be discussed more fully in Chapter 3), the teacher follows a consistent pattern of seeking effective and proven avenues for goal attainment while minimizing trial and error. These teachers approach teaching as scholars—looking at the classroom as a dynamic and human system of causes and effects—rather than as technicians fixing one small problem at a time.

Research also can help define the benchmarks for a teaching rationale by identifying standards and best practices. National and state standards are common benchmarks frequently incorporated into teachers' rationales. Standards provide specific information for content, pedagogy, programs, systems, and assessment and are used in developing assessments for state programs. While the various state standards and frameworks and the National Science Education Standards (NRC 1996) vary considerably, all tend to focus on students learning through inquiry, on a select set of concepts to be taught, on appropriate sequencing of topics, and on valid assessments. Having a plan helps to carry out the standards. Thus, a research-based rationale aligns standards, benchmarks, and activities with goals, producing a coherent blueprint for classroom action and success.

*Developing a personal teaching rationale is an important opportunity to contemplate and continue to develop a description of the science teacher you wish to become. Developing this rationale is important because the type of teacher you want to be will strongly influence the methods and techniques of teaching that you will employ in your classroom. A rationale will encourage thinking in very specific terms about the kind of classroom you will have; the ways you will interact with your students, parents, colleagues, and administrators; and the teaching tactics you will emphasize. All these factors will shape the science teacher that you become.*

—Robert Horvat, Teacher Educator, Ohio, 1999

As teachers develop their rationales and become more versed in the skills needed for implementation, they tend to become tenacious, assertive, purposeful, and influential. They feel capable, see themselves as leaders, and feel they have much to offer their profession. They also may experience negative feedback from colleagues who see these changes as a challenge to their own way of thinking. However, other colleagues will likely look to them as leaders and sources of knowledge and skill.

*My two colleagues saw me working on my rationale; they wanted to know what I was doing and they wanted to be in there doing the same thing. I always get them coming to me for ideas and suggestions from what I have done based on some of the goals and things that I have done in my rationale. But I told them if they wanted it (my rationale), they would have to modify it on their own.*

—Ken Tangelder, Seventh-Grade Science Teacher, New York, 2003

## **How a Research-Based Rationale Influenced My Teaching**

My first real teaching experience in a science classroom was a 10th-grade biology class and I was the teacher assistant. It left me empty. I began to think of teaching as the delivery of an unending list of facts and tidbits. I thought of students as sponges whose job was to absorb knowledge. I didn't think I wanted to be a teacher anymore.

For my second teaching experience, I was assigned to student teach biology and chemistry with an enthusiastic and brilliant veteran teacher. My time in his classroom was life altering. He modeled everything that he was trying to teach me. He incorporated so much research on effective teaching into the classroom that I began to see the science of teaching in a different light. I had read articles about teachers and had seen research studies done on teaching, but I never really put that knowledge into action in the classroom the way he did. It didn't take long before my attitude toward and respect for science education research completely changed.

While observing my cooperating teacher, discussing the lessons with him, and reflecting on the research, I began to view teaching as a robust, research-based endeavor. My definitions of teaching and learning began to evolve. I started to teach in a way that was research based. After all, as a novice teacher I had a very limited background of personal experiences to draw from when making curriculum and teaching decisions. My cooperating teacher required me to write a research-based rationale for teaching science, explaining what my goals were for students, how the research supported those goals, and which specific teacher behaviors I would use to push students toward my goals. This was by far the hardest

paper I had ever written because it was so reflective of what I was doing on a daily basis. This research-based rationale began to define who I was as a teacher and became my framework for making classroom and teaching decisions.

My cooperating teacher had prepared me well, and with a research-based rationale supporting and justifying my decisions, I felt very prepared to move on and teach on my own. Teaching now seemed pretty exciting and I was anxious to try it on my own.

In my first interview, I was offered a middle school life science teaching position. I taught at that school for three and a half years before moving to a high school to teach physical science and biology. I'm now in my 11th year of teaching. Research on effective teaching has become the backbone of my educational approach. I am constantly reflecting on whether a particular assignment, project, activity, or lesson is meeting my desired student goals. In the future, I hope to work with student teachers who are committed to teaching and have an understanding of and a positive attitude toward the research on effective teaching. After all, this is a large part of what makes teaching a profession.

—Randy Smasal, *High School Science Teacher and Assistant Principal, Minnesota, 2003*

## References

- Bonnstetter, R. J., J. E. Penick, and R. E. Yager. 1983. *Teachers in exemplary programs: How do they compare?* Washington, DC: National Science Teachers Association.
- Bransford, J., A. Brown, and R. Cocking, eds. 2000. *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.
- Druckman, D., and J. Swets, eds. 1988. *Enhancing human performance: Issues, theories and techniques.* Washington, DC: National Academy of Sciences.
- Krajcik, J. S. 1986. An evaluation of the University of Iowa's science teacher education program, 1977–1984. Doctoral diss., University of Iowa.
- Krajcik, J. S., and J. E. Penick. 1989. Evaluation of a model science teacher education program. *Journal of Research in Science Teaching* 26 (9): 795–810.
- National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academy Press.
- Penick, J. E., and R. J. Bonnstetter. 1993. Classroom climate and instruction: New goals demand new approaches. *Journal of Science Education and Technology* 2 (2): 389–395.

Weiss, I. R. 1978. *Report of the 1977 national survey of science, mathematics, and social studies education*. Washington, DC: U.S. Government Printing Office.

Weiss, I. R. 1985. *National survey of science and mathematics education*. Research Triangle Park, NC: Research Triangle Institute.

## **Representative issues (1983–1986) of the Focus on Excellence series, published by the National Science Teachers Association**

Penick, J. E., ed. 1983. Focus on excellence: Science as inquiry 1 (1). 131 pp.

Penick, J. E., ed. 1983. Focus on excellence: Elementary science 1 (2). 157 pp.

Penick, J. E., and R. J. Bonnsetter, eds. 1983. Focus on excellence: Biology. 1 (3). 122 pp.

Penick, J. E., and V. N. Lunetta, eds. 1984. Focus on excellence: Physical science 1 (4). 74 pp.

Penick, J. E., and R. K. Meinhard-Pellens, eds. 1984. Focus on excellence: Science/technology/society 1 (5). 103 pp.

Penick, J. E., ed. 1984. Focus on excellence: Physics 2 (1). 88 pp.

Penick, J. E., and J. S. Krajcik, eds. 1985. Focus on excellence: Middle/junior high science 2 (2). 99 pp.

Penick, J. E., and J. S. Krajcik, eds. 1985. Focus on excellence: Chemistry 3 (2). 49 pp.

Penick, J. E., ed. 1986. Focus on excellence: Earth science 3 (3). 41 pp.

Yager, R. E., and J. E. Penick, eds. 1985. Focus on excellence: Non-school settings 2 (3). 109 pp.

# Index

*Page numbers in **boldface** type indicate figures or tables.*

## A

- Airasian, P. W., 41
- Amirshokoochi, Aidin, 13, 20–23, 25, 52
- Assessment, 15–19
  - of content, 18
  - domains of, 16
  - vs. evaluation, 53
  - formative, 17–19
  - of goal achievement, 16–17, **35**, 40
  - instruments for, 17
  - of program, 18–19, 52
  - self-assessment by students, 12, 17
  - self-assessment by teachers, 40–42
  - of students, 17–19, 40

## B

- Benchmarks, 7
- Best practices, 7
- Bonnstetter, R. J., 4, 27
- Brainstorming, 27–29
  - facilitator's role in, 27–29
  - for goal generation, 27
  - negative, 44–45

## C

- Career awareness, 15
- Carter, Glenda, 19, 51, 55–59
- Classroom
  - application of rationale in, 19–23
  - emotional climate of, 39
  - environment of, 14, 22, 25, **35**, 39

intellectual climate of, 39  
technology in, 6  
*Classroom Instruction That Works*, 32  
Collaborative teachers, 53–55  
Communication, 54–55  
Costa, A. L., 22  
Creativity, 30–31, 34–38, **35–37**  
Credibility of research sources, 47  
Credibility scoring guide, **48**

## D

Designing a science program, 49–51

## E

*Educating Teachers of Science, Mathematics, and Technology*, 32  
*Educational Leadership*, 22  
Emotional climate of classroom, 39  
Environment of classroom, 14, 22, 25, **35**, 39  
ERIC database, 31  
Evaluation, 53  
Exemplary teachers, 2–3

## F

Formative assessment, 17–19  
Fortney, Brian, 16

## G

Goals, 4–6, 11–12  
    assessing achievement of, 16–17, **35**, 40  
    brainstorming of, 27–29  
    content, 18  
    developing research base for, 31–33  
    developing support for, 30–31, 47  
    generation of, 27  
    justification of, 30–31  
    refining of, 29–30  
    reflection on, 5

Role Identification Matrix for, 33–34, **35**, 50–51  
role of students in achievement of, 12, **12**, 33–34, **35–37**  
role of teacher in achievement of, **12**, 13–14, 33, **35**, 38  
science content and, 14–15  
Goodlad, John, 11  
Gullickson, A. R., 41

## H

Horvat, Robert, 7

## I

Implementation of rationale, 49–53  
Inquiry, 14  
Instructional resources, 22, 32  
Intellectual climate of classroom, 39

## J

*Journal of College Science Teaching*, 32  
*Journal of Creative Behavior*, 32

## K

Krajcik, Joseph, 3

## L

Leadership, 23, 54  
Leager, Craig, 34, **36–37**, 51

## M

Mentoring, 53–55

## N

National Association for Research in Science Teaching, 3  
National Science Education Standards, 7, 15, 31, 56  
National Science Teachers Association, 22  
    online access to journals of, 32  
    Scope, Sequence, and Coordination project, 15  
    Search for Excellence in Science Education, 2–3  
*NEA Today*, 22

## P

- Penick, John, 4, 27, 45
- Philosophy of education, 3
- Professional development, 4, 22
- Professional publications, 22, 32
- Program assessment, 18–19, 52
- Project Synthesis, 15

## Q

- Questioning
  - HRASE strategy for, 21
  - reflection matrix on use of, 42, **43**
  - wait-time for, 13, 21–22

## R

- Reasons for rationale, 3–4
- Reflection matrix on use of questioning, 42, **43**
- Research, value of, 6–8
- Research base, 31–33
- Research sources, 32
  - rating credibility of, 47, **48**
- Resources, 22, 32
- Review of Educational Research*, 32
- Rizzo, Deanna, 19, 44, 54
- Role Identification Matrix, 33–34, **35**, 50–51
- Rose, Jennifer, 6, 18, 52, 53

## S

- Schauth, Brandon, 5, 32
- Science and Children*, 32
- Science content
  - coordination of, 15
  - goals for, 18
  - selection of, 14–15, 25
  - teaching for, 4–5, 11
- Science program design, 49–51

*Science Scope*, 32  
*Science Teacher, The*, 22, 32  
*Scientific American*, 22  
Scope, Sequence, and Coordination project, 15  
Search for Excellence in Science Education, 2–3  
Self-confidence, 4, 7  
Self-evaluation  
    by students, 12, 17  
    by teachers, 22  
Smasal, Randy, 3, 8–9  
Standards, 7, 15, 18, 31, 56  
Students  
    assessment of, 17–19, 40  
    dependence and conformity of, 14  
    goals for, 4–6, 11–12  
    role in achievement of goals, 12, **12**, 33–34, **35–37**  
    self-evaluation by, 12, 17  
    teacher’s way of responding to, 22

## T

Tangelder, Ken, 6, 8, 50  
Teacher educators, 54–59  
Teachers  
    assessment by, 15–19  
    as collaborators and mentors, 53–55  
    evaluative behaviors of, 13–14  
    exemplary, 2–3  
    peer review of, 52  
    role in achievement of goals, **12**, 13–14, 33, **35**, 38  
    self-assessment by, 40–42  
    videotaping of, 41, 52  
    visionary, 54  
Teaching  
    for content, 4–5, 11  
    goals for, 4–6, 11–12  
    influence of research-based rationale on, 8–9, 19–23  
    passion for, 32

strategies for, 13–14, 21

Teaching rationale, research-based

- benchmarks for, 7
- classroom application of, 19–23
- communication of, 54–55
- development of, 25–45
- elements of, 11–23
- goals of, 4
- implementation of, 49–53
- influence on teaching, 8–9
- key components of, 2
- vs. philosophy of education, 3
- rationale for, 1–9
- reasons for, 3–4
- written plan for, 3

Technology, 6

*Tips for the Science Teacher*, 32

Tweed, Paul, 32–33, 53, 55

## V

Value of research, 6–8

Videotaping of teacher, 41, 52

Visionary teachers, 54

## W

Wait-time, 13, 21–22

## Y

Yager, Robert, 2