

**Second Edition**

# **Inquire Within**

**IMPLEMENTING INQUIRY-BASED  
SCIENCE STANDARDS IN GRADES 3-8**

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# Preface

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*Inquiry into authentic questions generated from student experiences is the central strategy for teaching science.*

—National Research Council (1996)

## WHY INQUIRY?

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It's been just more than 10 years since the National Research Council (NRC) released its landmark publication, the *National Science Education Standards* (NRC, 1996). In that document, the NRC identified content and performance standards necessary for the United States to develop a scientifically literate society and regain a global presence in science and technology. Through committees of nationally recognized science educators, the *Standards* specifically identify what students need to know and to be able to do in the subject of science at all grade levels. Not only did the committees address the content of science, but they also stated how science should be taught, with implications for assessment, professional development, and recommendations for systemwide program reform at the local, state, and national levels. Today, the *Standards* serve as a guidepost for science teachers and curriculum developers recommending inquiry as a central strategy for teaching science. Moreover, the *Standards* encourage science teachers to plan ongoing, inquiry-based science programs for their students and to develop communities of learners who reflect the intellectual rigor of attitudes and social values conducive to scientific inquiry (NRC, 1996).

As a follow-up to the *Standards*, in 2000 the NRC published *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. That document, through case studies and vignettes, made another strong argument for inquiry and serves as an excellent primer for preservice and practicing science educators at all levels, elementary school through college, interested in becoming inquiry-based teachers.

The National Science Teachers Association (NSTA) consistently and aggressively has supported inquiry instruction. In 1998, the NSTA adopted its position statement, *The National Science Education Standards: A Vision for the Improvement of Science Teaching and Learning*. In that statement, the NSTA strongly supports the *Standards* by asserting the following:

Teachers, regardless of grade level, should promote inquiry-based instruction and provide classroom environments and experiences that facilitate students' learning in science . . . professional development activities should involve teachers in the learning of science and pedagogy through inquiry . . . [and] inquiry should be viewed as an instructional outcome (knowing and doing) for students to achieve in addition to its use as a pedagogical approach. (pp. 32–33)

In 2000, the NSTA went even further in adopting a position statement focused on Scientific Inquiry. Readers may be interested in this and other NSTA position statements relating to inquiry, such as Elementary School Science, Laboratory Science, Science Education for Middle Level Students, the Nature of Science, and Science Teacher Preparation by searching online at <http://www.nsta.org/position#list>.

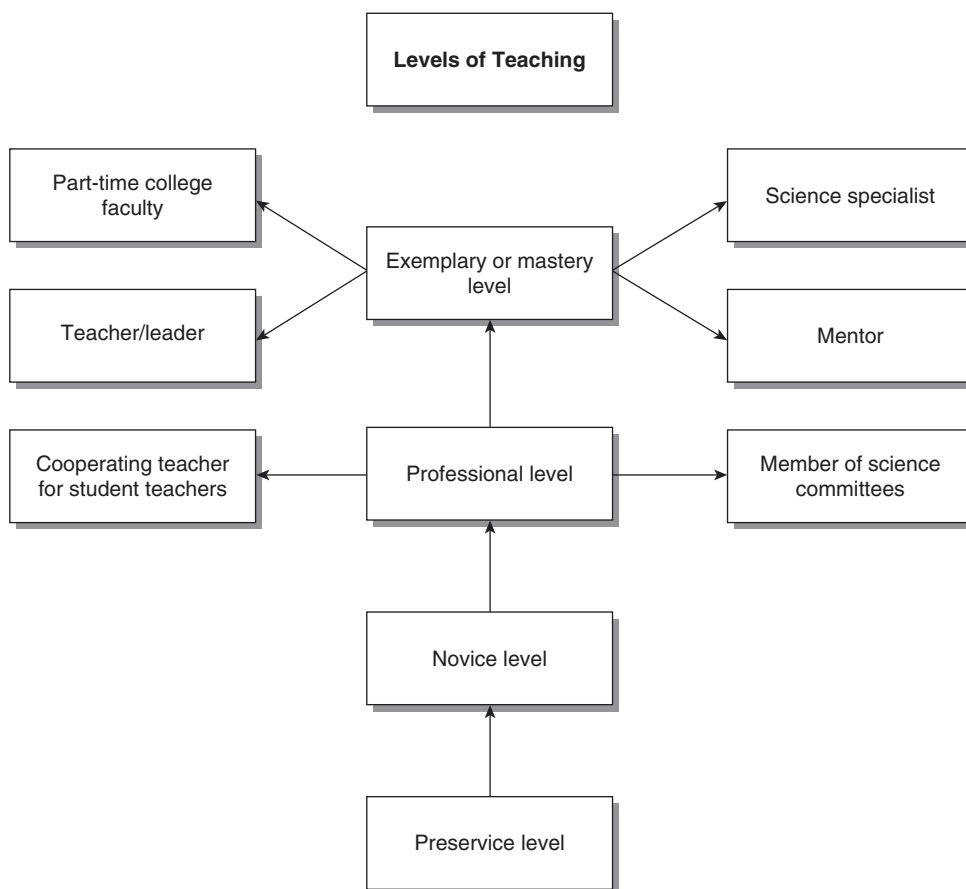
Throughout the past decade, blue-ribbon and congressional panels have advocated for education reform, especially in the areas of science. Most educators agree, however, that substantial reform will not materialize until it occurs at the school level. Today's science teachers, teacher-leaders, and supervisors need to seize an active role in implementing the national standards in every science classroom across this country (Llewellyn, 2006). This book focuses on teaching science through an inquiry-based process and implementing inquiry as called for by the *Standards*. It does not provide a plethora of inquiry activities. There are many other books that serve that purpose. *Inquire Within* will, however, challenge your values, beliefs, and biases about teaching and learning science. Although many activities and investigations are cited as examples, this book is not about doing activities; it is about raising your capacity to see questions within the activities and explorations you already provide so you can design further inquiries for your elementary or middle school students.

This book is also an opportunity for you to explore the connections between how children learn and teaching science through inquiry. By providing a historical perspective on constructivism, *Inquire Within* makes a strong point to understand constructivist principles and how these principles relate as the philosophical foundation, or the mind-set for scientific inquiry. It is the opinion of this author that to become an exemplary inquiry-based teacher, one must articulate his or her understanding about how children learn and be able to express how that philosophy guides the day-to-day classroom interactions and decisions made about guiding instruction, lesson planning, answering students' questions, assessment, and a whole host of other competencies.

This book is also about raising your IQ, your Inquiry Quotient. Again, the chapters will guide you through investigations and readings to raise your capacity to seek questions in an investigation. After all, if we, as teachers, can't see the questions, why should we expect those 20 to 25 students sitting in front of us to see them?

Last, this book is also about professional growth that modifies and transforms your teaching methods. Your trek may involve giving up on prior teaching strategies and engaging in new skills and competencies. For many, professional growth initiates a self-directed journey. The journey is not developed simply by assigning inquiry lessons to students. The process is more involved than that. It is an odyssey that originates with developing an inquiry-based mind-set and reflecting on your own present beliefs, practices, and understandings. You may begin your journey by accepting an invitation to inquire within the pages of this book.

**Figure P.1** Levels of Teaching



Your excursion into inquiry may start at different levels of the teaching profession (see Figure P.1). For some, the journey commences at the preservice level, where learning the rudimentary skills and methods of teaching elementary or middle school students takes place in the college classroom. Coupled with opportunities to observe and eventually practice-teach under a master teacher, many future teachers learn to teach science through inquiry as modeled by their education professors. Probably best of all, when you begin the job interview process, being able to articulate your understanding of the national science standards and your inquiry teaching techniques with a principal or interviewing committee, you are likely to strengthen your marketability in the hiring process.

Others may embark from the novice or professional levels. As a teacher at the novice level, you may want to polish specific inquiry strategies early in your career. As a teacher at the professional level, you may use your inquiry strategies to guide preservice teachers during their practice teaching experience or incorporate inquiry into work with school committees on curriculum, assessment, or other related matters.

This book may serve its greatest purpose for those teachers already at the professional level desiring to advance to the exemplary or mastery level. Master teachers who are proficient in inquiry-based instruction can use their expertise to act



as teacher-leaders, mentors for those new to the profession, science specialists, or part-time college faculty. For many, professional growth becomes a passage ascending the steps to success.

Throughout this journey, you can expect to have gained enough confidence in inquiry-based instruction to invite your students to begin their own journeys, perhaps beginning with that same invitation; hanging a sign on the door of your classroom—"Inquire Within." The sign would communicate to students that they are about to enter a world of inquiry, where they will be invited to engage in meaningful investigations, where questions are as important as answers.

Often, we view inquiry as a set of activities that students are asked to do. During a recent teacher workshop, I asked the participating teachers to define inquiry. They responded by naming types of activities presented to students and described what students are expected to do. Their responses included descriptions that characterized student learning as "students are active learners," "students are asking questions and solving their own problems," "there is lots of activity about," or "students are encouraged to think for themselves." Although we might agree with these responses, before we can expect our students to inquire, we must raise our own understanding of how the *Standards* define scientific inquiry and the nature of science and how to carry out scientific investigations ourselves. The title's metaphor exists to stimulate our need to develop inquiring minds and strategies, and it further invites us to begin our journey by inquiring within ourselves.

## WHAT'S NEW IN THE SECOND EDITION?

The second edition of *Inquire Within* takes several changes. First of all, with the publication of my high school book, *Teaching High School Science Through Inquiry*, which focuses on Grades 9–12, this book now exclusively targets the needs of elementary and middle school teachers at Grades 3–8. Also, more emphasis is placed on developing the prerequisite attitude and mind-set for becoming an inquiry-based teacher; balancing the *meaning* (the disposition) as well as the *mechanics* (the how-to) of inquiry. Background on self-directed learning and practice in climbing the ladder of professional improvement is an added central theme of the book.

Readers will also find many more case studies, investigations, and vignettes of inquiry-based activities. All the inquiry examples are correlated with the *National Science Education Standards* and are written in a teacher-friendly lesson format for easy implementation in your classroom. A section that ties inquiry-based instruction to scientific literacy, the nature of science, and naturalistic multiple intelligence is an added piece, as is a section on teaching inquiry to second language learners and students with special needs. A section on integrating inquiry with handheld technology rounds out the additional changes.

I trust that readers familiar with the previous edition will welcome the added information. For all readers of *Inquire Within*, I welcome your comments and suggestions, as well as your experiences and stories, as you create a culture of scientific inquiry in your own school or classroom. After all is said and done, it is you who will eventually determine whether inquiry-based instruction is a golden nugget for improving student motivation and ultimately academic achievement, or just fool's gold.

## WHO SHOULD READ THIS BOOK?

You may be interested in this book for several reasons. As a preservice elementary or middle school science teacher, you may be studying teaching methods and strategies in your undergraduate science education courses. Your college professor may be introducing inquiry as you observe elementary or middle school classrooms and eventually complete your practice teaching. As mentioned earlier, being able to describe your preservice inquiry teaching experiences in up-to-date, inquiry-based language will certainly enhance your success as a future teacher.

As an elementary or middle school teacher, you may feel you are already a good hands-on teacher, but you want to take the next step in becoming an inquiry-based teacher. Maybe you have read articles about inquiry in *Science and Children*, or *Science Scope*, and wondered, “Am I an inquiry-based teacher?” Or maybe you already feel you are an inquiry-based teacher and you want to sharpen your present skills. In either case, this book will enable you to articulate, both theoretically and practically, your understandings, skills, and dispositions regarding why this method of teaching fits your own identity as a science teacher.

This book will also provide useful information and guidance for those teachers undergoing the process of National Board Certification for Early Adolescence (ages 11–15). As you prepare your portfolio submission for area VIII, *Science Inquiry*, you will need to be well versed in scientific inquiry and demonstrate competence in designing and implementing inquiry-based lessons. For more information about the National Board for Professional Teaching Standards and the National Board Certification, see [www.NBPTS.org](http://www.NBPTS.org).

As a teacher-leader, mentor, science specialist, department head, or curriculum coordinator interested in improving science literacy in your school district, you will be provided with suggestions to facilitate professional development in inquiry-based instruction. You may also consider using *Inquire Within* for a collegial book study or supplementary reading for a summer institute on scientific inquiry.

## CONTENTS

The chapters in this book will take you through a journey in constructing an understanding of scientific inquiry, the characteristics of inquiry-based lessons, and the skills and attitudes of those who foster inquiry in their classrooms.

Chapter 1 sets the context for becoming an inquiry-based teacher, while Chapter 2, “What Is Inquiry?” explores the meaning of inquiry through a constructivist approach. After writing your definition of inquiry, you will use several statements from the *National Science Education Standards, Benchmarks for Science Literacy*, and the Exploratorium (a hands-on science museum in San Francisco) to verify and modify your understanding of scientific inquiry and the processes scientists use in developing new knowledge. Later in the chapter, several myths of inquiry-based learning are uncovered to further your understanding of what inquiry is and what it is not.

Chapter 3, “Learning Through Inquiry,” follows a fourth-grade class through a unit of study characterized by student-generated questions.

Chapter 4, “How Do Children Learn Science?” lays the foundation for constructivist learning strategies and how constructivism complements inquiry-based learning. Although constructivism has gained much support among science educators in the last 10 years, it is not a new idea. Its theoretical foundations began with the work of cognitive psychologists such as John Dewey, Jean Piaget, and Lev Vygotsky. Chapter 4 also addresses children’s naive conceptions or misconceptions in science and how they influence the learning process. The chapter examines how children learn science through a constructivist approach and then compare them to how scientists do their work. Emphasis is placed on how science process skills such as observing, inferring, and model building enable students to construct knowledge and make meaning of science.

In Chapter 5, “Creating a Culture of Inquiry,” traditional and inquiry-based classrooms are contrasted. By looking at the differences in the students, the teachers, and the classroom environments, you will further your understanding of inquiry-based classrooms and a culture of inquiry.

In Chapter 6, “What Are the Different Levels of Inquiry?” inquiry investigations are compared with other hands-on science activities using a grid that divides instructional strategies into four areas: demonstrations, activities, teacher-initiated inquiries, and student-initiated inquiries. The grid helps define inquiry-based investigations and assists teachers in selecting and sequencing the learning opportunities for students. The grid also shows that not all hands-on activities are inquiry-based.

Chapter 7, “Designing Investigations,” compares scientific inquiry with problem solving, whereas Chapter 8 introduces the Learning Cycle, a five-step approach to designing lessons that facilitates inquiry.

Chapter 9, “Knowledge, Skills, and Attitudes of Inquiry-Based Teachers,” presents a rubric for assessing and monitoring four stages of development in becoming an inquiry-based teacher. The rubric identifies several subsets: (a) curriculum and content, (b) lesson presentation, (c) communication, (d) engagement of students, (e) classroom organization, (f) questioning skills, (g) assessment procedures, and (h) professional development (see Resources C and D). In the inquiry process. Each subset is described in relation to teacher strategies from the basic awareness level to the practicing level. This chapter also addresses teaching suggestions for second language learners and students with special needs.

Chapter 10, “Using Questioning Skills in Inquiry,” presents questioning strategies that enable inquiry-based learning. Questions are the language of inquiry; thus, competence in asking thought-provoking questions and responding to student questions is essential.

Chapter 11 provides sample inquiry lesson plans, with teachers’ notes.



## Becoming an Inquiry Teacher

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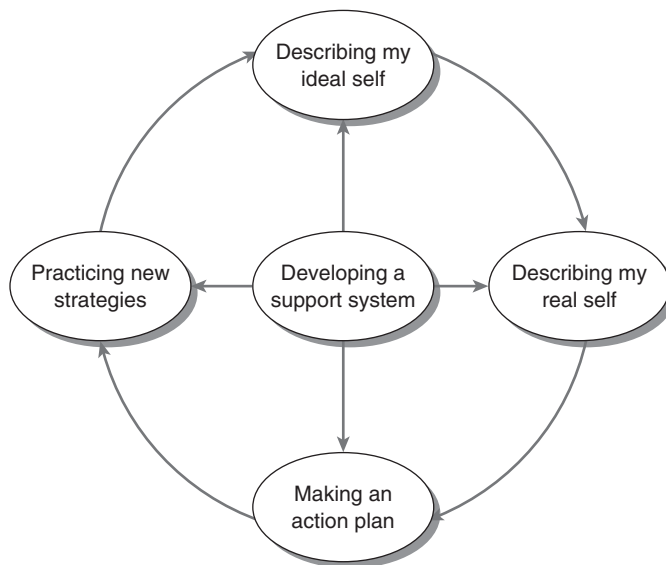
*When you inspire students to imagine beyond their expectations, to seek more questions than they will ever answer, and to persist when others concede, you are becoming an inquiry-based teacher.*

—Douglas Llewellyn

**M**any teachers acquiesce that the journey in becoming an inquiry teacher is a very personal experience. We each make the excursion in diverse ways by constructing our own paths to instructional renewal and reform. Your journey may begin by assessing your prior experiences in becoming a teacher. Some teachers may have been educated with little or no experience in testing out their own ideas. For them, the shift must seem like climbing Mt. McKinley. For others, moving toward an inquiry approach is just good teaching. Thus the paradigm shift is different for different teachers.

Becoming an inquiry teacher requires creating and sustaining reflection practices and discourse with other teachers. As Sergiovanni (1996) puts it, “Good teaching requires that teachers reflect on their practice . . . (to) analyze problems, size up situations, and make decisions” (p. 151). For that reason, teachers should establish a network to offer encouragement and support. Inquiry support groups encourage teachers to share their lessons, accomplishments, and frustrations. A local college or university science education department can be a source for developing and facilitating a teacher study and support group. The school and the administration must also demonstrate trust that teachers can make the appropriate curricular decisions to bring inquiry-based instructional strategies and change to the classroom. Lack of support from peers and administrators has discouraged many teachers from building their capacity to develop inquiry-centered classrooms.

Regardless of how you plan to increase your ability to teach through inquiry, my best advice is not to do it alone. Seek out a friend or a group of people who share

**Figure 1.1** Boyatzis' Theory of Self-Directed Learning

your values and beliefs about teaching. Ongoing conversations with colleagues will help you to develop and strengthen your skills and development.

Richard Boyatzis explains the five stages or “discoveries” in self-directed learning; that is, learning in which an individual intentionally develops and strengthens an aspect of his or her “self.” According to Goleman, Boyatzis, and McKee (2002), “The steps do not unfold in a smooth, orderly way, but rather follow a sequence, with each step demanding different amounts of time and effort” (p. 109).

The first step involves forming an image of the ideal self, where you reflect on your professional aspirations and the kind of teacher you want to become. You may start by asking yourself, “What kind of a teacher do I want to be three years from now?” In the case of becoming an inquiry-based teacher, determining this desired state motivates you to develop your inquiry skills. As you begin to understand the type of teacher you want to be, you reflect on the values and commitment that will drive you toward this goal. Goleman et al. (2002) call this the “fuel” that drives one through the difficult and often frustrating process of change.

The second step of discovery is assessing your real self—who you are right now, how you teach, and your deep-seated beliefs about how children learn. This step includes reflecting on your strengths and weaknesses as a teacher and realizing the gap between the kind of teacher you are right now and what kind of teacher you want to become. Later in the book is a rubric for becoming an inquiry-based teacher. The rubric is a starting point in assessing your present and desired states. Identifying your strengths and weaknesses is an ideal way to plan a self-directed course of action.

In the third step, consider a professional development plan that leads you from the present state to the desired state. Whether your plan becomes a formal document that you commit to writing or is planted firmly in your mind, it is essential that you formalize your action plan and determine the professional development, additional reading, college courses, online resources, professional conferences, collegial study groups, or whatever else you need that will move you closer to where you want to be. The more you commit to the plan, the more intrinsically rewarding the plan will become.

The fourth step involves gaining new strategies and improving your performance through continuous practice and reflection. This trial-and-error phase requires patience and persistence because not everything you try may work out quite as you expect. Student inquiries need constant refining. You will find yourself trying a new investigation, noting what went well and what you plan to do differently the next time you present that activity.

The final step entails finding a support system. This, however, probably will occur throughout the process. A support system may include working with an experienced inquiry teacher, mentor, or role model. It may just be another teacher in your school who is as interested in inquiry as you are. Teaming makes the learning process easier. It provides a vehicle to share your accomplishments and frustrations in a nonthreatening way. It also provokes a trusting relationship where two or more teachers can professionally share and discuss their students' work.

Much to the consternation of those new to inquiry, developing one's inquiry-based teaching techniques and strategies is more than just searching for, and then implementing, inquiry activities in your classroom. Often, when I am asked to do an inquiry presentation for teachers, the request includes something like "just give them a lot of sample activities to take back to their classrooms." Becoming an inquiry-based teacher is far more than finding an inquiry science activity to do Monday morning. Becoming a truly effective inquiry teacher involves the three R's: *Restructuring, Retooling, and Reculturing*:

- Restructuring the school's science curriculum and daily science lessons, and modifying traditional labs,
- Retooling the teacher's instructional strategies and questioning skills, and
- Reculturing the classroom's norms and relationships that foster a learner-centered environment where questions, inquisitiveness, and risk-taking are valued.

The foremost purpose of this book is to introduce teachers to the three R's of inquiry and provide concrete suggestions for the journey in becoming an inquiry-based teacher.

As you work your way through this book, a word of caution: Don't expect to become an inquiry-based teacher overnight. Honing your skills and strategies takes time. I often say, "You need a Crock-Pot to cook inquiry, not a microwave!" In most cases, teachers may need three to five years to polish their inquiry teaching techniques. There are no shortcuts to expedite the journey. Be patient, and with a smidgen of persistence, tenacity, and peer coaching, you will find yourself becoming more comfortable using the strategies and techniques to bring about instructional change in your classroom.

According to the *National Science Education Standards* (NRC, 1996), "Teachers can be effective guides for students learning science only if they have the opportunity to examine their beliefs, as well as to develop an understanding of the tenets on which the Standards are based" (p. 28). This book was written to serve that purpose. The inquiry process starts with you, the reader, by inquiring within and examining your own ability to pose and pursue authentic questions.

INQ IRY  
We can't spell inquiry without  
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