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Preface

From its inception, one of the principal goals of science education has been to cultivate students' scientific habits of mind, develop their capacities to engage in scientific inquiry, and teach them how to reason in a scientific context.

—*A Framework for K–12 Science Education* by the National Research Council, 2012, p. 41

A Major Shift in Achieving Scientific Literacy

One of the primary purposes of teaching is to heighten and achieve a level of literacy. When we think of a literate person, we picture one schooled with specific knowledge, skills, and dispositions in a particular subject matter. In the case of science, when defining a scientifically literate individual, many suggest that contemporary conceptions include the foundations of scientific concepts and core ideas, scientific inquiry, and the nature of science. But recently, there has been a major shift in science education to meet the goal of scientific literacy. With the onset of the *Common Core State Standards* (Council of Chief State School Officers [CCSSO], 2010) and *A Framework for K–12 Science Education* (National Research Council [NRC], 2012), a greater emphasis is now being placed on integrating language arts competencies into the science curriculum: more specifically, having students learn the art of communication through scientific argumentation. Consequently, it is the intention throughout this book to provide an examination of the interrelationship among four topics: scientific literacy, inquiry, argumentation, and the nature of science. Through such interrelationship, we begin to appreciate the impossibility of divorcing inquiry, argumentation, and the nature of science from its underpinning—scientific literacy. Like the strands of a braided rope, the four are tightly coupled.

Before we get into this new shift in direction, let's first look back and see how science education has evolved during the past three decades. It's been almost 20 years since the National Research Council (NRC) released its landmark publication, the *National Science Education Standards* (NRC, 1996). In that document, the NRC articulated recommendations for systemwide program reform at the local, state, and national levels. Content and performance standards necessary for the United States to develop a scientifically literate society and regain a global presence in science and technology were identified. Developed by committees of nationally recognized science educators, the *Standards* specifically spelled out what students needed to know and 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 and professional development. Additionally, they recommended to science teachers and curriculum developers that inquiry serve as a central strategy for teaching science. Moreover, the

Standards encouraged science teachers to plan ongoing, inquiry-based science programs for their students and to develop communities of learners who reflected 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 still serves as an excellent primer for preservice and practicing science educators at all levels, elementary school through college, who are interested in becoming inquiry-based teachers.

In concert with the *Standards*, the National Science Teachers Association (NSTA) consistently and aggressively 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, all of which can be found online at www.nsta.org/about/positions.aspx.

On January 8, 2002, President George Bush signed into law the No Child Left Behind Act. This landmark piece of legislation was designed to ensure that no child in America is left behind through educational reforms based on accountability and additional funding for states and school districts from the federal level. Now, in the second decade of the 21st century, we once again hear the emphasis on science, technology, engineering, and mathematics (STEM) from President Barack Obama's Educate to Innovate. This program will again emphasize the importance of STEM initiatives in fostering educational reform in K–12 science. For more information on Educate to Innovate, go online to www.whitehouse.gov/issues/education/educate-innovate.

Throughout the past three decades, blue-ribbon and congressional panels have advocated 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 assume active roles in implementing the national standards in every science classroom across this country.

Now with the onset of two new standards projects, the *Core Curriculum State Standards Initiative* and *A Framework for K–12 Science Education* (adding subsequently the *Next Generation Science Standards*), elementary and middle school science teachers should be mindful of the focus on having students develop competencies and practices in both inquiry-based and argument-based instruction. According to the NRC (2012), the *Framework* provides a vision of what it means to be literate and proficient in science. Furthermore, the *Framework* proposes a vision for science education as a collective body of knowledge and as an evidence-based model that continually extends, refines, and revises knowledge. This new vision will be achieved through the teachers' ability to teach

amid scientific inquiry and scientific argumentation (which will be introduced later in Chapters 1 and 2). This direction renews the emphasis from previous standards documents, citing inquiry as a centerpiece for science instruction, and places argument-based discussions on the horizon for science curriculum and reform.

Note that in 2010, the Council of Chief State School Officers developed the *Common Core State Standards* for English/Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects. A section of the *Common Core* identifies standards for English/Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects divided by grade level junctures for K–5, 6–8, and 9–12. Of particular interest to middle school science teachers is the section on Reading Standards for Literacy in Science and Technical Subjects, Grades 6–12 (p. 62) and Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects, Grades 6–12 (pp. 64–66). For more information on the *Common Core State Standards*, see www.corestandards.org. For information on the *Framework*, see the NSTA website at www.nsta.org or the National Academies website (www.nap.edu/catalog.php?record_id=13165), where you can read or order the full document. For information on the *Next Generation Science Standards*, see www.nextgenscience.org.

Thus this book focuses on teaching science through an inquiry-based process and implementing inquiry through language arts as called for by the *Common Core* and the *Framework.* It does not provide a plethora of inquiry activities. There are many other books that serve that purpose. *Inquire Within* (3rd ed.) 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* (3rd ed.) emphasizes the need to understand constructivist principles and how these principles relate as they serve 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 one's understanding about how children learn and be able to express how that philosophy shapes 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?

Lastly, this book is also about professional growth that modifies and transforms your teaching methods. Your trek may involve abandoning some 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.

Given the 30-plus years of blue-ribbon commissions and committees, the overwhelming emphasis on science education suggests that elementary and middle school science teachers

follow a standards-based curriculum and develop teaching competencies and strategies that provide engaging, inquiry-based investigations for students. So what needs to happen? At the K–12 level, teachers need to hone their understandings of what it means to be scientifically literate, read books and articles on the subject, and have in-depth discussions about its impact in today's classrooms. Curriculum coordinators need to emphasize an inquiry-based approach for all students throughout all levels of a district's learning outcomes. Science supervisors need to provide teachers with effective and ongoing professional development that advances the latest standards and science literacy. School administrators need to hire teachers familiar with reform standards; teachers with the competencies to teach through inquiry, argumentation, and problem-solving modes; and teachers with the ability to create learner-centered classrooms. It is only through a multifaceted approach that school districts will achieve literacy in science for their students.

As science educators, we begin our pathway to becoming inquiry-based teachers by asking two questions: *What is the purpose of inquiry?* and *Why do we aspire to teach through inquiry?* To answer the first question, the purpose of inquiry is not to instill curiosity in students but rather to discover it: Curiosity and inquisitiveness already lie within the individual, awaiting opportunities to be uncovered and made known. To answer the second question, we teach science through inquiry because it's part of what it means to be scientifically literate: Inquiry opens the mind to questioning the natural world, allowing nature to gradually reveal its secrets. We teach through inquiry when we realize that every child is a born inquirer—coining the scientific name, *Homo sapiens inquirous*. We teach through inquiry when we realize that beyond having students memorizing the seemingly endless list of vocabulary terms, remembering the formulas for chemical equations, and recalling the laws and principles of physics, our first and foremost responsibility is to instill in students an appreciation, or even a love, for learning science. That passion for combining scientific literacy with the joy of learning commences with students exploring, discovering, and revealing the nature of science through inquiry investigations.

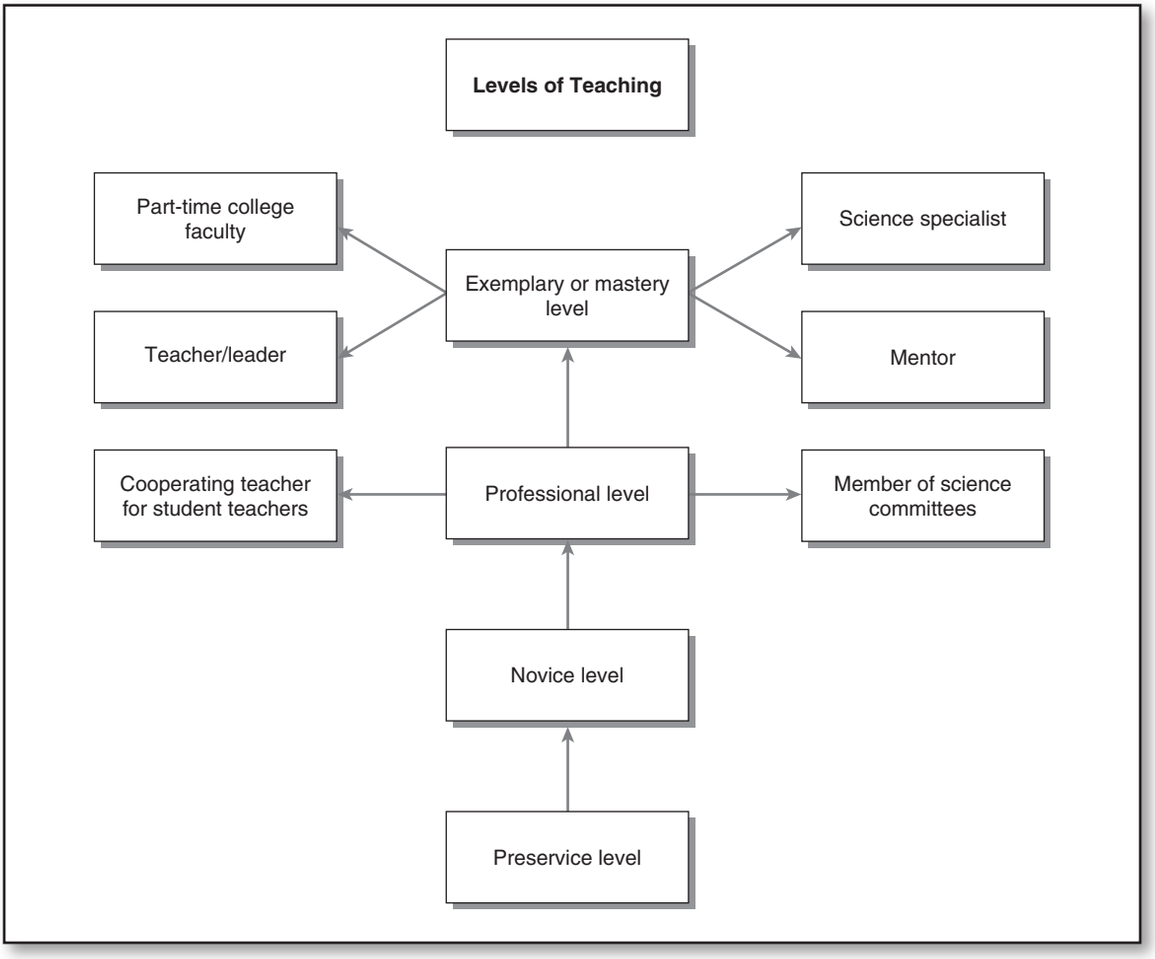
Your excursion into inquiry may start at different levels of the teaching profession (see Figure P.1). For some, the journey commences at the preservice level, where learning the rudimentary skills and methods of teaching elementary or middle school students takes place in the college classroom. Coupled 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 to a principal or interviewing committee means you are likely to strengthen your marketability in the hiring process.

Others may embark on their inquiry travels 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 who desire 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 undertake their own journeys,

Figure P.1 Levels of Teaching



perhaps beginning with the same invitation inherent to this book, 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 and 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, participating teachers were asked to define scientific 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 national standards define scientific inquiry and the nature of science and how to carry out scientific investigations ourselves. This book's title is a metaphor for stimulating our need to develop good inquiring minds and strategies, and it further invites us to begin our journey by inquiring within ourselves.

What's New in the Third Edition?

Science education has experienced several major shifts in the past few years, and the third edition of *Inquire Within* embodies these changes. First of all, with the publication of the *Common Core State Standards*, *A Framework for K–12 Science Education*, and the *Next Generation Science Standards*, readers come to understand and appreciate the practices of scientists and engineers and how their methods of investigation can be applied to elementary and middle school science classrooms. One practice in particular, making and defending scientific arguments, will join with inquiry-based teaching as a central foundation of the book. It's entirely appropriate that argumentation play a major role in the direction of this book, since it is now a primary focus of the *Common Core* and *Framework*.

Also in this edition, more emphasis is placed on developing the prerequisite attitude and mind-set for becoming an inquiry- and argument-based teacher, balancing the meaning (the disposition) as well as the mechanics (the how-to) of inquiry and argumentation. Background on self-directed learning and practice in climbing the ladder of professional improvement are two other related themes added to the book.

In this third edition, readers will also find many new vignettes of inquiry- and argument-based activities that integrate language arts with science. All the inquiry activities are correlated to the *Framework* and the *Next Generation Science Standards* and are written in a teacher-friendly lesson format for easy implementation in your classroom. New sections tie inquiry-based instruction to classroom management, language literacy, the nature of science, multiple intelligence, communication skills, and scientific argumentation. Although argumentation has been studied in select science circles for the last 10 years, it now sits on the horizon of instructional reform as the *Common Core State Standards* and the *Framework* are implemented into state and district curricula. The third edition emphasizes this new direction of the national standards and shows the harmonious marriage of scientific inquiry and argumentation. Their natural pairing is the yin and yang of scientific literacy. For that reason, the third edition has been retitled *Inquire Within: Implementing Inquiry- and Argument-Based Science Standards in Grades 3–8.*

Lastly, the motto at Corwin is "Helping educators do their work better." This third edition attempts to exemplify this saying in a truly unique and innovative way. I wrote *Inquire Within* (3rd ed.) to be a companion to my high school book, *Teaching High School Science Through Inquiry and Argumentation*. This means that the sequence, chapter titles, and sections generally align with each other; however, the examples and activities are geared to either Grades 3–8 or 9–12. As companion books, they share commonality in content. In fact, some wording and paragraphs can be found in both books. This can work as a definite advantage to many college professors and professional development providers in science. By having the two as companion books, a college professor who has students in a methods course preparing to teach secondary school (Grades 7–12) can now use both books simultaneously in the same course—providing the *Inquire Within: Implementing Inquiry- and Argument-Based Science Standards in Grades 3–8* (3rd ed.) for middle school-bound college students and *Teaching High School Science Through Inquiry and Argumentation* for high school-bound college students. In the same light, a summer institute director who has participants at the elementary, middle, and high school levels can now model differentiation by providing *Inquire Within* (3rd ed.) to elementary and middle school participants while providing the high school book for high school participants. I don't know of any other publisher or books that offer this kind of flexibility. This cutting-edge concept will certainly help many educators do their work better.

I trust that readers familiar with the previous editions will welcome the added relevant topics. For readers of *Inquire Within* (3rd ed.), I welcome your comments and suggestions, as well as your experiences and stories, as you create a culture of scientific inquiry and argumentation in your own classrooms.

Who Should Read This Book?

You may be interested in this book for several reasons. As a preservice or practicing elementary or middle school science teacher, you may be studying teaching methods and strategies in your undergraduate or graduate-level science education courses. Your college professor may be introducing inquiry and argumentation as you observe and study elementary or middle school classrooms. As mentioned earlier, being able to describe your inquiry-teaching experiences in coherent and eloquent language will certainly enhance your marketability in securing a teaching position and success as an exemplary teacher.

As an elementary or middle school teacher, you may feel that 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 and move on to understanding and implementing aspects of differentiation and argumentation into your lessons. 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.

As a teacher/leader, mentor, science specialist, department head, or curriculum coordinator interested in improving science literacy in your school district, you will find in these pages suggestions for facilitating professional development in inquiry- and argument-based instruction and means to integrate science with language arts. You may also consider using *Inquire Within* (3rd ed.) for a collegial book study or supplementary reading for a summer institute on teaching through inquiry and argumentation.

Whichever is your situation, best wishes on your journey, and keep inquiring!

Acknowledgments

At times, our own light goes out and is rekindled by a spark from another person. Each of us has cause to think with deep gratitude of those who have lighted the flame within us.

—Albert Schweitzer

I must admit that over the last 12 years of writing seven books on science inquiry, my creative flame has gone out far too many times to remember. I am, however, profoundly indebted to several colleagues and friends who have rekindled my flame and helped me to persist in making sense of scientific inquiry and argumentation. Through their writings, personal conversations, conference presentations, and published articles and research, they continue to illuminate my understandings of inquiry and the nature of science. I would like to especially thank Hubert Dyasi (formerly at City College of New York), Douglas Merrill at the Rochester Institute of Technology, and Michael Occhino at the Rochester City School District. Others whose writings and research have refreshed my enthusiasm include Brian Hand, Wynne Harlan, Norman Lederman, Jeff Marshall, Katherine McNeil, and Victor Sampson.

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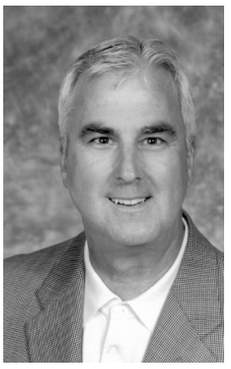
About the Author



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Llewellyn writes on science education and leadership topics for NSTA and other professional journals. He is a frequent speaker at state and national science conferences. His previous books, all by Corwin, include the following:

- *Inquire Within: Implementing Inquiry-Based Science Standards* (2002)
- *Teaching High School Science Through Inquiry: A Case Study Approach* (2005)
- *Inquire Within: Implementing Inquiry-Based Science Standards in Grades 3–8,* 2nd edition (2007)
- *Facilitator's Guide to Inquire Within: Implementing Inquiry-Based Science Standards in Grades 3–8,* 2nd edition (2009)
- *Differentiated Science Inquiry* (2011)
- *Teaching High School Science Through Inquiry and Argumentation,* 2nd edition (2013)

Doug is an avid major league baseball fan. His favorite teams are the Boston Red Sox and the Minnesota Twins. During the summer months, he is usually cruising the New York State Finger Lakes and the Erie Canal aboard his restored 1962 Lyman wooden boat. He can be reached at dllewellyn@sjfc.edu or dllewell@rochester.rr.com.