# Explorations in Elementary School Science

## Practice and Theory, K–8


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To the children in our lives:

Joshua

Olivia

Madelyne

Lilianna

Tyler

Dante

Roman

Luca

Maia

Breanna

Kaitlyn

who inspire us with their sense of wonder and delight in, and with, the world.

## A PERSONAL MESSAGE

We hope this book serves you well on your journey to becoming an elementary teacher of science, and that it nurtures your passion and enthusiasm for a subject that is exciting and relevant. Our intent is to provide support as you refine, redefine, and expand your practice and your theoretical perspectives. We invite you to imagine a science education that is student-centred, inclusive, joyous, inspiring, and filled with possibilities for transformative teaching and learning.

# Brief Contents

# Contents

# Preface

## INTRODUCTION

Elementary school science is a place where wonder, experience, and imagination come together. It is a place where children can play, investigate, and learn about the natural world they inhabit. Children's natural curiosity contributes to the magic of the elementary classroom. As a teacher of science, we hope you will nurture children's multiple perspectives, while challenging them to learn new and relevant material.

Each of you has a unique school science experience. Some of you may have fond memories of hands-on explorations, field trips, or demonstrations, while others may recall a science program dominated by reading of textbooks and answering end-of-chapter questions. Furthermore, you have different academic backgrounds in science. For some, science may have been a major in university; and for others, Grade 11 may have been the last time you thought about beakers and Bunsen burners, Newton's laws, or the Kreb's cycle. As you begin this professional journey, you have a wonderful opportunity to revisit the subject of science, develop pedagogical skills, and work collaboratively to explore the type of science program you want to create.

An elementary school teacher has the dual challenge of being both a generalist and a specialist in many areas—a feat that can be overwhelming. This textbook will support you as you become a teacher of elementary school science. We intentionally designed a book that merged practice and theory in synergistic ways. Some books on methods of teaching elementary science are collections of practical ideas and tips presented in the absence of theoretical underpinnings; others are too theoretical in nature and lack practical insights. Our aim is to strike a balance and to challenge your assumptions about what science is and how it can be taught. We hope this book will help you to feel confident and inspired as you begin your career in this important profession.

## OUR VISION

We envision this book as a guide for elementary school teacher candidates. Our goals are two-fold: to provide teacher candidates with knowledge, pedagogy, and skills to be successful in a contemporary classroom, and to equip them with strategies to critique, re-imagine, and transform the elementary science experience for their students. Additionally, in-service teachers and graduate students who are looking to refine and improve their praxis may well benefit from the book.

We have deliberately incorporated a broad range of education research perspectives and activities to support teacher candidates as they explore their beliefs, improve pedagogical knowledge, and develop judgment and decision-making skills. Furthermore, we hope that a modest immersion into the science education research literature will inspire teacher candidates in the present and inform their practice in the future.

Throughout the book we have merged practice and theory with what we consider fundamental to school science in the twenty-first century. These fundamentals include an understanding of scientific literacy as a broad concept; an appreciation of the beauty and limits of science; an understanding of the nature of science (NOS) both as a process and as a product; the integration of environmental education; and a commitment to equity, social justice, and inclusive science education that meets the needs of a diverse student population.

## UNIQUE APPROACH OF THE TEXTBOOK

In determining the specific features of this book, we drew upon our experiences as elementary, middle, and secondary teachers of science; science consultants; researchers; teacher education instructors; and graduate-level instructors. Our collective teaching experience spans Western, Central, and Atlantic Canada. Over the years we have surveyed preservice students across the country to gauge what they felt was important to include in a science methods textbook. Their thoughtful comments helped shape the direction and substance of this work.

**Unique Features** We believe this book is unique in the way that it:

- includes activities that support literacy and numeracy
- addresses science subject matter content knowledge
- provides activities for elementary students
- highlights cross-curricular connections
- raises thoughtful questions for discussion
- provides appendices containing practical guidance and support for elementary teachers
- infuses information and communications technologies
- merges educational practice, theory, and research
- features a range of practical teacher development activities

**Canadian Perspectives** The book is distinctly Canadian in its perspective and focus as it:

- aligns with Canadian values such as multiculturalism and inclusiveness
- draws on critical research by renowned Canadian, as well as international, science educators
- refers to Canadian provincial and territorial curriculum frameworks
- includes environmental education practice and theory
- supports equity, diversity, and social justice teaching
- incorporates Indigenous and Aboriginal ways of knowing

**21st Century Learning** The Canadian education system is undergoing significant change in support of the twenty-first-century classroom. The focus has shifted from *what* students learn to *how* students learn, and includes skills and competencies that can be transferred and applied in new situations. Every province has its own vocabulary to describe this body of knowledge. We have chosen to focus on seven **21st Century Skills and Competencies** to respond to the challenges of the evolving classroom across the country:

1. **Communication**
2. **Critical thinking**
3. **Collaboration**
4. **Creativity**
5. **Literacy and numeracy**
6. **Media literacy**
7. **Technological literacy**

Each of the activities throughout the book indicates which of these 21st Century Skills and Competencies are called on. The list is featured near the beginning of each chapter for easy reference. We believe that focusing on these seven skills and competencies in the classroom will create innovative learning opportunities that will prepare both students and teachers for the complex environments of the twenty-first century.

## Activities

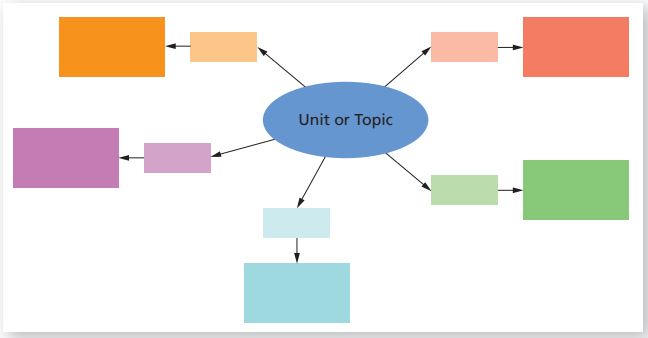
A variety of **Activities** are placed throughout each chapter to help teacher candidates explore content in context. Activities are followed by **Discussion Questions** that ask students to reflect on their experience and provide further learning. These activities and discussion questions should prompt conversations and sharing of ideas to develop rich and comprehensive views of teaching and learning science. We have provided more activities than most courses have time for, in order to give the user freedom to choose according to needs and context. Some activities are organized around the following themes:

- *Exploring Prior Knowledge and Experience*: Intended for teacher candidates to access their prior knowledge related to the focus of the chapter.
- *Working with Resources*: Designed to familiarize teacher candidates with curriculum documents, policies, and frameworks relevant to their province or territory, as well as other resources and materials.
- *Read and Reflect*: Designed to encourage teacher candidates to read and reflect on the findings of research in science education.
- *Connecting Practice and Theory*: Designed to help teacher candidates bring practice and theory together in coherent and beneficial ways.

**ACTIVITY 2.9** *21st C* 1 5 6

**Planning for NOS**

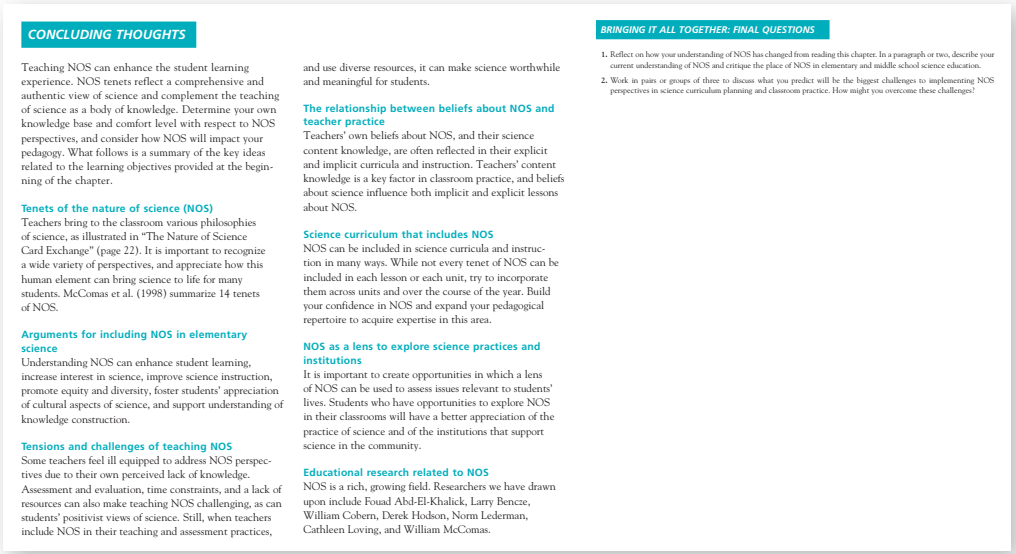
Working in small groups, choose a unit you are familiar with from your province's elementary science curriculum. Describe three ways you could integrate NOS into your chosen unit. You may wish to refer to the tenets of NOS listed on pages 24–25. Be specific and provide detail. For example, you may include the work of an innovative scientist, a theory that underwent many changes, or an aspect of science that was profoundly influenced by society and/or a historical force. Use a concept map, such as the one shown in the figure below, or another organizer to help you present your ideas. Be prepared to share your work with other groups.




Concept Map

**Appendices** The book concludes with a series of appendices that may be helpful as you prepare for your practicum and plan for teaching and learning in your future classroom. For example, you will find appendices on Strategies and Graphic Organizers, Preparing for Your Practicum, Making a Successful Beginning to the School Year, Suggested Children's Literature for Elementary Science (with over 70 annotated titles), and Planning for Field Trips.

## Other Features



**CONCLUDING THOUGHTS**

Teaching NOS can enhance the student learning experience. NOS tenets reflect a comprehensive and authentic view of science and complement the teaching of science as a body of knowledge. Determine your own knowledge base and comfort level with respect to NOS perspectives, and consider how NOS will impact your pedagogy. What follows is a summary of the key ideas related to the learning objectives provided at the beginning of the chapter.

**Tenets of the nature of science (NOS)**
Teachers bring to the classroom various philosophies of science, as illustrated in "The Nature of Science Card Exchange" (page 22). It is important to recognize a wide variety of perspectives, and appreciate how this human element can bring science to life for many students. McComas et al. (1998) summarize 14 tenets of NOS.

**Arguments for including NOS in elementary science**
Understanding NOS can enhance student learning, increase interest in science, improve science instruction, promote equity and diversity, foster students' appreciation of cultural aspects of science, and support understanding of knowledge construction.

**Tensions and challenges of teaching NOS**
Some teachers feel ill equipped to address NOS perspectives due to their own perceived lack of knowledge. Assessment and evaluation, time constraints, and a lack of resources can also make teaching NOS challenging, as can students' positivist views of science. Still, when teachers include NOS in their teaching and assessment practices, and use diverse resources, it can make science worthwhile and meaningful for students.

**The relationship between beliefs about NOS and teacher practice**
Teachers' own beliefs about NOS, and their science content knowledge, are often reflected in their explicit and implicit curricula and instruction. Teachers' content knowledge is a key factor in classroom practice, and beliefs about science influence both implicit and explicit lessons about NOS.

**Science curriculum that includes NOS**
NOS can be included in science curricula and instruction in many ways. While not every tenet of NOS can be included in each lesson or each unit, try to incorporate them across units and over the course of the year. Build your confidence in NOS and expand your pedagogical repertoire to acquire expertise in this area.

**NOS as a lens to explore science practices and institutions**
It is important to create opportunities in which a lens of NOS can be used to assess issues relevant to students' lives. Students who have opportunities to explore NOS in their classrooms will have a better appreciation of the practice of science and of the institutions that support science in the community.

**Educational research related to NOS**
NOS is a rich, growing field. Researchers we have drawn upon include Fouad Abd-El-Khalick, Larry Bencze, William Cobern, Derek Hodson, Norm Lederman, Cathleen Loving, and William McComas.

**BRINGING IT ALL TOGETHER: FINAL QUESTIONS**

1. Reflect on how your understanding of NOS has changed from reading this chapter. In a paragraph or two, describe your current understanding of NOS and critique the place of NOS in elementary and middle school science education.
2. Work in pairs or groups of three to discuss what you predict will be the biggest challenges to implementing NOS perspectives in science curriculum planning and classroom practice. How might you overcome these challenges?

- Each chapter opens with a series of thought-provoking **quotations** from students, preservice teachers, in-service teachers, and notable individuals.
- A set of **Learning Objectives** is listed at the beginning of each chapter to enable the reader to see exactly where the chapter is going and guide them to a higher-level understanding of the content.
- The ***Safety* icon** alerts preservice teachers to safety issues related to the activity or investigation in question.
- Each chapter is summarized in a **Concluding Thoughts** section.
- Each chapter closes with a section entitled **Bringing it all Together**, which contains two or three synthesis questions to stimulate class discussion or assign as homework.

## ORGANIZATION OF THE BOOK

The book draws upon examples from life, physical, and Earth and space science and is organized according to the following five themes:

1. A Vision for Science Education
2. Curriculum Design
3. Scientific Inquiry and Investigations
4. Science, Technology, Society, and the Environment (STSE)
5. Knowledge

Parts 1 and 2 provide grounding in areas such as scientific literacy, the nature of science, environmental education, social justice, meeting student needs, curriculum planning and assessment, and curriculum theory. These themes reappear throughout the book. Parts 3, 4, and 5 reflect the organization of most science curriculum documents in many provinces and territories across the country, as well as the *Common Framework of Science Learning Outcomes K-12: Pan-Canadian Protocol for Collaboration on School Curriculum*. (CMEC, 1997).

Admittedly, we struggled with the order of topics; indeed, the table of contents went through a number of iterations. For example, some reviewers suggested that STSE should be at the beginning of the book, while others wanted to start with Scientific Inquiry. Some

argued that Knowledge, which is foundational to science, should appear earlier in the text. In the end, we chose an organization that reflects our way of conceptualizing a science education program, with the understanding that the chapters can be used in any order.

Each of the five parts comprises chapters that, while different in purpose and content, have commonalities. In general, each chapter attends to practice and theory, encourages the development of teacher judgment with respect to pedagogy, provides opportunities to connect literacy and numeracy to teaching science, and reflects teacher realities related to curriculum planning and implementation. Additionally, we have infused technology, assessment, and evaluation throughout. We recognize that information and communications technologies (ICT) can be powerful tools for accessing information, analyzing scientific processes, conducting scientific investigations, and supporting connections among students as they learn. We encourage teacher candidates to expand their own knowledge about the range of technologies available and to cultivate and apply a critical lens while developing sound pedagogical practices. Similarly, assessment and evaluation are interwoven throughout the book, so that teacher candidates can consider them in the context of inquiry, STSE, and knowledge, and as central to curriculum planning. In several chapters we highlight Aboriginal worldviews and learning science beyond the classroom. We also incorporate ready-to-use activities that teacher candidates may use with their own students in elementary and middle schools.

## TECHNOLOGY RESOURCES

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## SUPPLEMENTS

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- **Instructor's Manual:** This useful teaching aid provides an overview of the material within each chapter, as well as features such as Activities-at-a-Glance charts, modifiable line masters, and references.
- **PowerPoint™ Slides:** PowerPoint presentations combine graphics and text to provide premade lecture slides.

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