Explorations in Secondary School Science
Practice and Theory, 7–12

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To Joshua and to our nieces and nephews—whose joy, wonder, and delight, in and with the natural world, inspire us.

A PERSONAL MESSAGE

We hope this book serves you well on your journey to becoming a secondary science teacher and that it nurtures your passion and enthusiasm for a discipline that is grounded in a rich tradition of research and evidence-based practices. Our intent is to help provide support as you refine, redefine, and expand both your theoretical perspectives and your practice. We invite you to imagine a science education that is student-centred, inclusive, joyous, inspiring, and filled with possibilities for transformative teaching and learning.
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INTRODUCTION

This book has existed as an idea for years—percolating through many of our conversations and informing our practice. Often, we found ourselves chatting about how to incorporate Roger Lock’s model for scientific inquiry into our teaching about laboratory work, or Derek Hodson’s framework for understanding science and technology within a broader socio-cultural context, or Glen Aikenhead’s work with Indigenous ways of knowing. At the end of every academic year, we discussed the possibility of using a textbook the next year for our secondary science methods courses. Enthusiastically, we would search for one but soon abandoned the idea, as we could not find a textbook that satisfactorily presented Canadian policies, perspectives, or initiatives or one that reflected the centrality of environment, community, culture, and worldview to schooling and science classrooms.

We wanted a book that merged theory and practice in synergistic ways. Some books were too theoretical and lacked practical perspectives, while others were a collection of practical ideas and tips without theoretical underpinnings. On many occasions we planned together for our respective classes—designing lab inquiry activities that would enable our teacher candidates to perform secondary school labs while critiquing the labs from a theoretical stance; organizing a class town hall meeting to model pedagogy appropriate for exploring science, technology, society, and environment (STSE) issues; choosing salient journal articles to create a reading package for teacher candidates to engage with a broad range of science education research literature—all the while wishing we had a textbook that reflected our vision for science education.

Consequently, over the years we continued to generate resources and materials for teaching our science methods courses within Bachelor of Education and Master of Teaching programs. It is these extensively field-tested and revised materials that form the basis of this book. In a nutshell, we set out to write the book that we wished existed.

OUR VISION

We envision this book as a guide for teacher candidates on their journey to becoming science educators. Our goals are twofold: to provide teacher candidates with knowledge, pedagogy, and skills to be successful in a contemporary classroom, and to equip them with tools to critique, re-imagine, and transform science education. Additionally, in-service teachers and graduate students who are looking to expand, 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 a) explore their beliefs, b) improve pedagogical knowledge, and c) develop judgment and decision-making skills with respect to teaching and pedagogy. Furthermore, we hope that an introduction to 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 theory and practice with what we consider fundamental to school science for the twenty-first century: an understanding of the concept of scientific literacy; an appreciation of the beauty and of the limits of science; an understanding of the nature of science, both as a process and as a product; a commitment to equity and social justice; and a commitment to inclusive science education that meets the needs of our diverse student population.
UNIQUE APPROACH OF THE TEXTBOOK

In determining the specific content, emphases, and features of this book, we drew upon our experience as secondary science teachers, science consultants, researchers, teacher education instructors, and graduate-level instructors. Our collective teaching experience spans western, central, and Atlantic Canada. Over the years we surveyed our preservice students across the country to gauge what they felt was important to include in a secondary 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:
- infuses information and communications technologies
- merges educational theory, research, and practice
- features a range of practical teacher development activities
- raises thoughtful questions for discussion
- provides appendices containing practical guidance for science teachers

**Canadian Perspective** This book is distinctly Canadian in its perspective and its 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
- 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 classroom of the twenty-first century. The focus has shifted from what students learn to how students learn—skills and competencies that can be transferred and applied in new situations. Every province has its own vocabulary for this knowledge, so 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 in this textbook indicates which of these 21st Century Skills and Competencies are called on. The list appears 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 preparing 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 a rich and comprehensive view 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:

- 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 research in science education and reflect on the findings.
- Connecting Theory and Practice: designed to help teacher candidates bring theory and practice together in coherent and beneficial ways.

Appendices
The book concludes with a series of Appendices that may be helpful as you prepare for a practicum and plan for teaching and learning the future. The appendices include Strategies and Graphic Organizers, Preparing for a Practicum, and Making a Successful Beginning to the School Year.

Other Features
- Each chapter opens with a series of thought-provoking quotations from students, pre-service teachers, in-service teachers, and famous individuals.
- A set of Learning Objectives at the beginning of each chapter enables students to see exactly where the chapter is going and guides them to a higher-level understanding of the chapter.
- The Safety icon alerts preservice teachers to safety issues related to a particular activity or lab.
- Each chapter is summarized in the Concluding Thoughts section.
- Each chapter closes with a section entitled Bringing It All Together, which contains two or three high-level questions to stimulate class discussion or assign as homework.
This book draws upon examples from biology, chemistry, physics, and earth and space science and is organized thematically into the following five parts:

1. A Vision for Science Education
2. Curriculum Design
3. Scientific Inquiry
5. Knowledge

Parts 1 and 2 provide grounding in areas such as scientific literacy, the nature of science, social justice, meeting student needs, curriculum planning and assessment, and curriculum theory. These themes re-appear throughout the book. Parts 3, 4, and 5 (Inquiry, STSE, and Knowledge) reflect the organization of science curriculum documents in many provinces and territories across the country as well as the Pan-Canadian Protocol for Collaboration on School Curriculum—Common Framework of Science Learning Outcomes (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 reflected 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 is made up of three chapters, and while the chapters are different in their purpose and content, there are commonalities. In general, each chapter attends
to theory and practice, encourages the development of teacher judgment with respect to pedagogy, and reflects teacher realities related to curriculum planning and implementation. Additionally, we have infused technology, assessment, and evaluation throughout chapters.

We recognize that information and communications technologies can be powerful tools for accessing information, analyzing scientific processes, conducting scientific inquiry, and supporting connections between students as they learn. We encourage teacher candidates to expand their own knowledge about the range of technologies available and to cultivate a critical lens while developing sound pedagogical practices. Similarly, assessment and evaluation are interwoven so 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 middle and secondary schools.

TECHNOLOGY RESOURCES

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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 pre-made lecture slides.

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