Teaching and Learning High School Chemistry

Stacey Lowery Bretz *is Professor of Chemistry at Miami University in Oxford, OH. Her research expertise includes assessment of student learning, applications of cognitive science and learning theory to chemistry education, and how children learn chemistry. Previous initiatives have included curriculum reform in general chemistry and the professional development of high school chemistry teachers. Dr. Bretz chaired the Gordon Research Conference on CER in 2005 and serves on the Board of Trustees for the American Chemical Society Examinations Institute. Contact information: bretzsl@muohio.edu*

by Stacey Lowery Bretz

Editor, Chemistry in the National Science Education Standards, 2nd ed.

In 1996 the National Research Council published the *National Science Education Standards*. This document was the result of a long, collaborative process intended to specify what **students** should *know* and what students should *be able to do* after graduating from high school, what **teachers** should *know* about science and *be able to do* to teach science, and what **education systems** should *know* about educating future science teachers and *be able to do* to ensure students would learn science from these teachers. In conjunction with the American Association for the Advancement of Science's *Benchmarks for Science Literacy*, the NSES catalyzed conversations in each of the 50 states about what science was being taught, what science should be taught, and how teachers would assess the quality and quantity of student learning in science.

The Standards did not delineate content for chemistry. They did not specify content for physics, geology, botany, zoology, or microbiology, either. Rather the Standards were organized across physical science, earth science, life science, inquiry, and social and personal perspectives — prompting some chemists and chemistry teachers to ask, "where's the chemistry?"

However, the *NSES* certainly included the concepts important to chemistry because the American Chemical Society's Committee on Education (SOCED) actively participated in constructing the Standards. As outreach to high school chemistry teachers, the American Chemical Society (ACS) Education Division commissioned the first edition of this book, *Chemistry in the National Science Education Standards*. Since that first edition in 1996, much has changed — many state standards have been updated to reflect the NSES and *Benchmarks,* the Internet is ubiquitous now, technology has transformed how chemists gather and interpret data, and *No Child Left Behind* (*NCLB*) is the law of the land.

This 2nd edition of *Chemistry in the National Science Education Standards* responds to the changing landscape of teaching high school chemistry by providing updated models for meaningful learning. All chapters have been thoroughly updated and several new ones on technology, English language learners, student misconceptions, and learning research have been added. Each chapter contains recommended Web sites and additional readings, as well as contact information for the authors so you can get additional information on topics of interest. A brief description of each chapter is offered below to whet your appetite.

Who should use this book? Certainly high school chemistry teachers and administrators should find this book contains valuable and thought-provoking information. ***Each chapter has been coauthored by a high school chemistry teacher,*** which means that the concrete, practical examples contained in each chapter have already been classroom tested. University chemistry and science education faculty members, both of whom teach preservice teachers, will find this a resource in designing their own courses. And as **Mickey Sarquis** and **Lynn Hogue** discuss in chapter 10, the 2nd edition of *Chemistry in the National Science Education Standards* also offers important guidance to professional development providers.

Henry Heikkenen and **Kelly Deters** begin this 2nd edition by illuminating tensions naturally inherent in the standards, e.g., means vs. ends — is one more important than the other, and how can a chemistry teacher bring them into balance? In chapter 2, **William Carroll** (former ACS president) and **Kristin Sherman** tackle many important questions. What is chemistry as practiced today? Why should we teach chemistry in high school? What is the power of a background in chemistry for today's student, given that not everyone will become a chemist? How can chemistry help manage our planet's finite resources? Their answers to these questions will help high school teachers engage their students in conversations about chemistry, careers, and the importance of chemistry in their everyday lives.

Leo Sorel

While making connections between chemistry and everyday life may be natural for chemistry teachers, it can be more difficult to identify connections between chemistry and the other sciences. In chapter 3, **Kathy Kitzmann** and **Charlotte Otto** discuss the role of unifying themes in the Standards, such as scale and structure, and how to use them for district/building planning and curriculum alignment. Chapter 5, written by **Deborah Herrington**, **Ellen Yezierski**, and **Rebecca Caldwell**, is packed with examples of how to create connections between biology and chemistry courses in the high school. In chapter 6, **Ann Benbow** and **Cheryl Mosier** make the case that chemistry as the central science can help high school students see the role of chemistry in the geosciences. They offer suggestions on how to interweave chemistry in the study of the hydrosphere, atmosphere, geosphere, and biosphere.

NSES does not mandate any particular pedagogy, which often is surprising to those who think that surely the *NSES* would recommend inquiry as a preferred pedagogy. In fact, the *Standards* make a strong case that inquiry is so important it is not just pedagogy, but rather makes the case for inquiry as *content*. Chapter 4 highlights two powerful programs to develop inquiry in high school. **Rick Moog** and **Laura Trout** describe how to use POGIL (Process-Oriented Guided Inquiry Learning) in the high school classroom while **Dawn Rickey** and **Chris Lee** make a case for MORE (Model Observe Reflect Explain) learning in the laboratory.

The chemistry laboratory has changed considerably since the first edition of this book was published. In chapter 7, **Loretta Jones** and **Seán Madden** highlight many tantalizing possibilities for integrating technology into the chemistry laboratory such as graphing calculators and probes for data collection. For teachers working with limited budgets or searching for novel ways to minimize safety hazards and waste disposal, virtual laboratories are also discussed.

Beyond the typical content standards, the *NSES* also emphasize the importance of historical and personal perspectives. **Donald Wink**, **Patrick Daubenmire**, **Sarah Brennan**, and **Stephanie Cunningham** offer their collective wisdom about incorporating these in a systematic manner, primarily with examples drawn from an implementation of the ACS textbook *ChemCom* (*Chemistry in the Community*). Chapter 8 chronicles their work in the Chicago Public Schools to connect chemistry to the daily lives of their urban students. And in a corollary to connecting

chemistry to the 21st century, **Seth Rasmussen**, **Carmen Giunta**, and **Misty Tomchuk** remind us in chapter 9 that when teaching our students about the history and nature of science, we should avoid the temptation to "sanitize" the lessons for students. Rather, they discuss the importance of students learning that science progresses through "starts" and "stops."

One very big change since the first edition of this book was published in 1996 is the enactment of No Child Left Behind. Given the realities of NCLB funding and the mandate for assessment, high school chemistry teachers will be eager to read chapter 11. **Tom Holme** and **Laura Slocum** discuss how to improve the writing of items to test students' chemistry knowledge. They also describe professional development opportunities for high school chemistry teachers through the ACS Examinations Institute, and how Institute exams are aligned with the NSES. Another change under way as this book is being published is a major reform of AP courses by the College Board. In chapter 12, **Jim Spencer** and **John Hnatow** present the rationale for changing the AP chemistry curriculum as well as the "Unifying Themes" that are guiding the AP chemistry curriculum revisions.

The 2nd edition of this book features three new chapters. **Doris Kimbrough** and **Susan Cooper** offer practical solutions in chapter 13 to the chemistry teacher who has students trying to learn English and the language of chemistry at the same time. **Dorothy Gabel** and **Karen Stucky** provide a summary of the prior knowledge that high school chemistry students bring with them from their K–8 learning; chapter 14 also includes a brief review of misconceptions common among high school chemistry students. Explaining how misconceptions develop and using research on how students learn to offer practical suggestions for chemistry teachers are topics addressed by **Diane Bunce**, **Sharon Hillery**, and **Elena Pisciotta** in chapter 15. The book ends with a forward-looking, thought-provoking discussion of the challenges chemistry teachers will face in the future. In chapter 16, **Steve Long** and **Mary Kirchhoff** share how the American Chemical Society and its Education Division stand ready with resources to empower teachers to meet these new opportunities.

Of course, a 2nd edition of *Chemistry in the National Science Education Standards* would not be possible without the authors whose contributions were responsible for the first edition. Thank you to Ronald Archer, Jerry Bell, Ann Benbow, Bonnie Brunkhorst, Diane Bunce, Dwaine Eubanks, Lucy Eubanks, Henry Heikkenen, Stanley Pine, Kathryn Scantlebury, Patricia Smith, Conrad Stanitski, Michael Tinnesand, Mary Virginia Orna, and Sylvia Ware.

In the introduction to the 1st edition of this book, Stanley Pine wrote:

> *"The standards are the cornerstone of our ongoing national efforts to improve the quality of science education for all our students. Their implementation will require a long-term effort and adequate support from educators, policy makers, and the broader public in order to accomplish the stated goals."*

It bears mention that the children born in 1996 are just today in the 5th and 6th grades. These children are just halfway through learning the science they should know and be able to do. It is our hope that this 2nd edition will empower high school chemistry teachers to meet students with knowledge of what they already know, how they learn, and the central role that chemistry can and should play in their high school education. It is also our hope that, as chemistry and chemistry teaching continue to change, a 3rd edition of this book will capture the ever-evolving nature of chemistry education. We welcome your comments regarding this edition and suggestions for future volumes.

Stacey Lowery Bretz, editor
Miami University
Department of Chemistry & Biochemistry
Oxford, OH 45056

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