

# **BOLD VENTURES**

Volume 1

Patterns Among U.S. Innovations in  
Science and Mathematics Education

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### **Volume 2: Case Studies of U.S. Innovations in Science Education (ISBN 0-7923-4232-1)**

Building on Strength: Changing Science Teaching in California Public Schools

*J. Myron Atkin, Jenifer V. Helms, Gerald L. Rosiek, Suzanne A. Siner*

The Different Worlds of Project 2061

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*Norman L. Webb, Daniel J. Heck, William F. Tate*

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Volume 1

## **Patterns Among U.S. Innovations in Science and Mathematics Education**

edited by

**Senta A. Raizen  
Edward D. Britton**

from

**The National Center for Improving  
Science Education**

a division of  
**The NETWORK, Inc.**

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The National Center for Improving Science Education (NCISE) is a division of The NETWORK, Inc., a nonprofit organization dedicated to educational reform. The Center's mission is to promote change in state and local policies and practices in science curriculum, teaching, and assessment. To further this mission, we carry out research, evaluation, and technical assistance. Based on this work, we provide a range of products and services to educational policymakers and practitioners to help them strengthen science teaching and learning across the country.

We are dedicated to helping all stakeholders in science education reform, preschool to postsecondary, to promote better science education for all students.

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## The Editors

**Senta A. Raizen**, Director of The National Center for Improving Science Education, is principal investigator and editor of the U.S. case studies discussed in this and two companion volumes. Raizen is the primary author of a number of books, reports, and articles on science education in elementary, middle, and high school; indicators in science education; preservice education of elementary school teachers; and technology education. Her work also includes educational assessment and program evaluation, education policy, reforming education for work, and linking education research and policy with practice. She is principal investigator for NCISE research for the Third International Mathematics and Science Study (TIMSS) and serves on the TIMSS International Steering Committee. Raizen directs NCISE evaluations of several federal programs that support science education. She serves in an advisory capacity to—among others—the National Assessment of Educational Progress, the National Goals Panel, the National Institute for Science Education, and the National Research Council.

**Edward D. Britton**, Associate Director of NCISE, serves as project director for several international studies, including the work presented in this volume. He was lead editor of *Examining the Examinations: An International Comparison of Science and Mathematics Examinations for College-Bound Students*. Britton also works on several aspects of TIMSS, including the U.S. and international curriculum analyses and the international teacher and student questionnaires. In addition, he has managed development of CD-ROM disks and videotapes designed to help elementary teachers enhance their science knowledge and pedagogy. Britton has written on indicators for science education, dissemination of innovations, and evaluation.

## Senior Authors

**J. Myron Atkin** is a professor of education at Stanford University and served as dean of education from 1979 to 1986. He coedited *Changing the Subject*, the Organisation for Economic Co-operation and Development's 1996 report on member nations' case studies of innovations in science, mathematics, and technology education. His research interests and publications focus on identification of the science content to be taught in elementary and secondary schools; teacher-initiated inquiry, especially action research; practical reasoning by teachers and children; case methods in educational research; evaluation of educational programs; science education in museums; and development of policies that accord classroom teachers greater influence in determining the educational research agenda.

**Michael Huberman**, formerly a professor of education at the University of Geneva (1972-93) and now professor emeritus, is presently director of research at the Swiss Federal Institute of Professional Education and, since 1991, visiting professor of education at Harvard University. He also was a senior researcher at the National Center for Improving Science Education where he led two case studies in this project. His areas of interest are qualitative research, research use, longitudinal studies of teaching, and educational innovation. He is a coauthor, with Matthew Miles, of *Qualitative data analysis: A sourcebook of new methods*, and also recently published *The Lives of Teachers*.

**Jeremy Kilpatrick** is a Regents Professor of Mathematics Education at the University of Georgia. For the Precalculus case study, Kilpatrick was the primary researcher at the Eisenhower High School site and was one of the primary researchers at the North Carolina School of Science and Mathematics. Kilpatrick's recent professional activities include work with the International Commission on Mathematical Instruction, the Bacomet Group, the National Council of Teachers of Mathematics (NCTM), and the College Board. Kilpatrick also serves as a board member or reviewer for a number of national and international journals.

**Douglas B. McLeod** has been professor of mathematics at San Diego State University since 1972. He also served from 1979 to 1981 as a program manager at the National Science Foundation and as a professor of mathematics and education at Washington State University from 1986 to 1993. His Ph.D. is from the Department of Mathematics at the University of Wisconsin. Previous research projects have focused on mathematics teaching and learning, with a special emphasis on affective issues in mathematics education. Within the National Council of Teachers of Mathematics, he has served on several committees, including 10 years on the editorial board of the *Journal for Research in Mathematics Education*.

**Mary Budd Rowe** was professor of science education at Stanford University and the University of Florida. Her career-long interest in finding ways to have all students experience and understand science in part prompted her to lead the case study of ChemCom, a course seeking to bring chemistry to more students. Rowe's leading-edge work brought her many tributes, including the annual *Journal of Research in Science Teaching* award for her seminal paper that coined the term "wait time," and the National Science Teachers Association's (NSTA's) Roger Carleton Award for national leadership in science education. She later was elected president of NSTA. In her last decade, Rowe focused particularly on pressing new technologies into the service of professional development for science teachers, including videotapes, CD-ROM disks, and telecommunication networks.

**Robert E. Stake** is a professor of education and director of the Center for Instructional Research and Curriculum Evaluation at the University of Illinois. Among the evaluative studies he has directed are works in science and mathematics in elementary and secondary schools, model programs and conventional teaching of the arts in schools, development of teaching with sensitivity to gender equity, educa-

tion of teachers for the deaf and for youth in transition from school to work settings, environmental education and special programs for gifted students, and the reform of urban education. Among his writings are *Quieting Reform*, a book on Charles Murray's evaluation of Cities-in-Schools; *Custom and Cherishing*, a book with Liora Bresler and Linda Mabry on teaching the arts in ordinary elementary school classrooms in America; and *The Art of Case Study Research*, a book on research methods.

**Norman L. Webb** is a professor of mathematics at the University of Wisconsin-Madison. He served on the Urban Mathematics Collaborative Documentation Project that recorded, analyzed, and described the development of the collaboratives from their initial funding by the Ford Foundation. Webb's research focuses on mathematics and mathematics education, with a major emphasis on assessment and evaluation. He was part of the writing team of the NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989).

# Preface

This book, based on detailed studies of eight innovations in mathematics and science education, has many insights to offer on current school reform. Since each innovation studied has taken its own unique approach, the set as a whole spans the spectrum from curriculum development to systemic reform, from concentrating on particular school populations to addressing all of K-12 education. Yet these reform projects share a common context, a world view on what matters in science and mathematics for students of the 1990s and beyond, convictions about what constitutes effective instruction, and some notions about how school change can be brought about. These commonalities are drawn out in the book and illustrated with examples from the individual case studies that are reported in full in *Bold Ventures*, Volumes 2 and 3.

The eight innovations—all of them projects that are well-known, at least by name, to U.S. audiences—are briefly described in chapter 1. Each was the subject of an in-depth, three-year case study. The research teams analyzed many documents, attended numerous project meetings, visited multiple sites, conducted dozens of individual interviews. The team leaders, having spent much time with mathematics or science education over long careers, looked at these reform projects through several lenses; the teams sifted through the mountains of data they had collected in order to tell the story of each project in rich detail. We encourage the reader to peruse Volume 2 (the five science case studies) and Volume 3 (the three mathematics case studies) of *Bold Ventures* to take full advantage of the research effort invested in studying these landmark examples of science and mathematics education reform. The present volume represents a further distillation of this research—a synthesis based on the case studies themselves and on a series of exciting, if exhausting, meetings of all team members two or three times a year designed to delineate and clarify the cross-case themes as they emerged from the developing work.

The U.S. research was part of a larger international effort to study innovations in science, mathematics, and technology education undertaken by 13 member countries of the Organisation for Economic Co-operation and Development (OECD). The genesis of the international case study project was the countries' shared dissatisfaction with the state of education in these subjects; the participating countries wished to be informed about improvement efforts and their impact elsewhere in the industrialized world. The result was the largest qualitative research project ever undertaken across countries. The work has aroused much interest. In addition to the publication of a monograph based on the case studies from all the countries, two internationally sponsored conferences—one in the United States and one in Europe—have been held to disseminate key findings. In addition, several OECD countries organized their own dissemination conferences.

Just as we in the United States are learning from reform efforts in other countries, the stories and findings of the U.S. cases are proving instructive to them. Innovation in our large, decentralized, and diverse country is of particular interest for education ministries in formerly centralized systems that are now experimenting with decentralized curriculum reform and greater autonomy for teachers. Educators in other countries can compare policy priorities in the United States to issues considered important in their own countries. Also, documentation of the U.S. reform efforts in the three volumes of the *Bold Ventures* series will complement and help in interpreting—both for this country and for an international audience—the quantitative results generated on student achievement, current curriculum, and teacher and student background by the Third International Mathematics and Science Study.

### **Audiences**

*Bold Ventures* is intended primarily for people working to improve science and mathematics education, though we believe it holds much of interest for audiences concerned with educational reform more generally. We include among these audiences:

- policymakers in a position to influence schools and educational systems;
- teacher educators and staff developers working with prospective or already practicing teachers;
- science, mathematics, and engineering professionals;
- school administrators;
- teachers of science and mathematics; and
- especially, those who would join the innovators and reformers of science and mathematics education.

The three volumes in the series unravel the origins, development, and implementation stories of eight of this country’s major reform initiatives. They address questions surrounding the “what” as well as the “how” of these innovations. Curriculum specialists, researchers, and teachers of science and mathematics will find the detailed case studies in the other two volumes of *Bold Ventures* of particular interest and practical utility in the teaching and learning of science and mathematics. Policymakers, administrators, and those interested in the progress and process of educational reform should find this cross-case volume informative and helpful in understanding the origins and impacts of innovation in these two critically important school subjects.



## **Organization**

While the authors of each individual chapter bear primary responsibility for its content and language, the book as a whole is a collaborative effort of the eight research teams and the editors. The book starts with brief summaries of the OECD case study project and the U.S. innovations studied and an overview, with two examples, of the methodology used by the U.S. research teams. Chapter 2 discusses the motivation for reform of mathematics and science education in the United States and the forces shaping reform initiatives in the last decade, including prominent actors and strategies, as well as the micro forces shaping individual projects. Chapters 3, 4, and 5 elaborate the main themes drawn from the eight case studies: Mike Atkin, Jeremy Kilpatrick, and their coauthors discuss changes in the fields of mathematics and science and concomitant changes in the corresponding school subjects; Norman Webb addresses the changing roles of teachers; and Senta Raizen, Douglas McLeod, and Mary Budd Rowe review the changing conceptions of educational reform as played out in the innovations. In chapter 6, Robert Stake and Senta Raizen deal with some issues we found—somewhat surprisingly—underemphasized in the U.S. case studies, including assessment of student learning, external evaluation of the projects, and equity concerns. Chapter 7, authored by Michael Huberman, takes a close look at the implementation of the eight innovations in light of their ongoing development. The book ends with some concluding thoughts about both the reform projects and our study of them. In the appendix, we provide brief summaries of the 15 case studies conducted by the other participating OECD countries.

## **Acknowledgments**

We gratefully acknowledge the many individuals who contributed to the research effort reported in this and the two companion volumes. Just counting the researchers, advisors, and support staff, over 40 U.S. professionals invested substantial amounts of their time in this effort over the last four or more years. Most of these individuals are cited on other pages of this volume: advisors are listed just before the contents page, and short biographies of senior authors are included in the section on contributors. We thank the indispensable administrative assistants to this project, especially those who spent large amounts of time organizing meetings, preparing briefing books, and working with manuscripts: Susan Callan and LaDonna Dickerson at the National Center for Improving Science Education, Sally Leshner at the University of Wisconsin, and Sunny Toy at Stanford University. Nita Congress and her colleagues toiled to help us line edit this rather large body of work; Shelley Wetzel of Marketing Options handled the manuscript layout.

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number RED-9255247. We are grateful for their funding and supportive monitoring. The content of this report does not necessarily reflect the views of the Department or NSF. Their funding extended beyond the research to support dissemination efforts including a 1993 workshop to acquaint potential audiences with the goals of the U.S. case studies; and a 1996 conference in Washington, “Getting the Word Out,” to release the U.S. and international results. We also gratefully acknowledge the support of the Mellon Foundation for the editing and production of this book.

Eve Bither, Director of the National Educational Research Policy and Priorities Board, spearheaded the Department of Education’s support of this project and has steadfastly advanced our work. Several current and former officers at NSF have generously assisted us over the years: Ken Travers, now of the University of Illinois; Daryl Chubin, director of Research, Evaluation, and Communication; David Jenness, now an independent consultant; Conrad Katzenmeyer, senior program officer; Iris Rotberg, program officer; and Larry Suter, deputy division director.

In closing, we wish to applaud and thank those who have made our work possible—the reform-minded professionals who worked in and out of the classroom to make their visions of better science and mathematics education come to life. Many people were gracious enough to let us witness their endeavors again and again and to speak with them at length. When busy educators and innovators welcome researchers into their world, it behooves these researchers to take the greatest care in depicting their efforts. We and our colleagues hope the many individuals who generously gave of themselves and their time will find *Bold Ventures* to be respectful, accurate, and helpful in advancing their important work.

Senta A. Raizen  
Edward D. Britton

*Washington, D.C.*  
*November 1996*