Science *for* English Language Learners

K–12 Classroom Strategies

Ann K. Fathman and David T. Crowther, Editors

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NSTApress
NATIONAL SCIENCE TEACHERS ASSOCIATION
Arlington, Virginia

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National Science Teachers Association
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David Beacom, Publisher

11 10 09 08 6 5 4 3

Library of Congress Cataloging-in-Publication Data

Science for English language learners : K-12 classroom strategies / Ann Fathman and David Crowther, editors.
p. cm.
Includes bibliographical references.
ISBN-13: 978-0-87355-253-0
ISBN-10: 0-87355-253-9
1. English language--Study and teaching--Foreign speakers. 2. Science--Study and teaching--English-speaking countries. I. Fathman, Ann K. II. Crowther, David (David T.)
PE1128.A2S323 2005
428'.0071'2--dc22
2005023038

eISBN 978-1-935155-36-2

To all the students and teachers
who have shown that the worlds
of science and language complement
and enhance each other

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Acknowledgments

Thanks to Carolyn Kessler and Mary Ellen Quinn for their inspiration and guidance over the years in showing me the benefits of integrating language and content area teaching and to my family for their continual encouragement and support.

Ann Fathman

A special thanks to my very patient and understanding family, Tammi, Tom, Cassi, and Chris, and to the students and staff at Veterans Memorial Elementary School and my colleagues Joaquin Vilá and John Cannon for opening my eyes and accompanying me on this wonderful journey.

David Crowther

Introduction

Science for English Language Learners is a resource for all teachers who work with linguistically and culturally diverse students. A collaborative effort between science and language educators, it provides a wealth of information on teaching science to English language learners (ELLs). We, as editors of the book, come from the very different, but complementary, fields of English language teaching and science education. Sharing ideas has given us the opportunity to better understand the academic needs of students, to develop new teaching strategies, and to integrate best practices for teaching from both fields. These are insights we hope to pass on to our readers.

Purpose and Audience

Science for English Language Learners is for teachers, prospective teachers, and teacher educators. Its purpose is to provide educators with a guide for teaching science to ELLs. We hope that, by using this book, educators will develop expertise in teaching science content and processes, in language development and literacy, and in inquiry-based teaching while getting practical ideas for teaching. We provide information from both fields by

- describing instructional practices in science and language,
- describing effective teaching strategies,
- providing models for lesson and curriculum development, and
- giving an overview of standards development and implementation.

Organization

The book is divided into four sections.

- In Section I, Parallels in Language and Science Teaching, chapters provide an overview of major themes, principles, and practices.
- In Section II, Strategies for Planning, Teaching, Assessing, and Extending Learning, chapters focus on practical suggestions for the classroom.
- In Section III, Lessons for Science and Language Learning, chapters contain design ideas from language and science educators and exemplar lessons from teachers.
- In Section IV, Contexts for Classroom Implementation, chapters contain an overview of science and English proficiency standards, of research and instructional practices, and ways to integrate science, language, and literacy.

The reader can begin at any part of the book. Readers looking for practical ideas for teaching and designing lessons may focus on sections II and III. Readers needing background in the fields of science and ESL (English as a second language) should read sections I and IV. The book as a whole provides information on theory and practice that should be useful to all educators.

Overview of the Chapters

The book is written by teachers, administrators, and teacher trainers of science and English. Each chapter is coauthored by science and language educators who have done extensive work in their fields and who realize the importance of interdisciplinary teaching. By pairing English and science educators as coauthors on chapters, we capitalize on the strengths from both fields and demonstrate the similarities in teaching methodologies that can be used to reach all students.

Section I: Parallels in Language and Science Teaching

Chapter 1

"Teaching English Through Science and Science Through English." Ann Fathman and David Crowther give an overview of central themes that can guide and improve the teaching of science to English language learners.

Chapter 2

"Learners, Programs and Teaching Practices." David Crowther, Joaquin Vilá, and Ann Fathman provide information on English language learners in our schools and the programs provided for them. They also give an overview of science and language learning principles and how these translate into best practices.

Section II: Strategies for Planning, Teaching, Assessing, and Extending Learning

Chapter 3

"Planning Science and English Instruction." Ann Baumgarten and Marie Bacher describe how to incorporate science, language arts, and ESL standards into the classroom. They offer practical suggestions on how to plan, organize, and implement activities based upon standards, teaching and learning strategies, and student background.

Chapter 4

"Strategies for Teaching Science to English Learners." Deborah Maatta, Fred Dobb, and Karen Ostlund discuss strategies teachers can use to help English language learners learn science while improving their speaking, listening, reading, and writing skills in English.They present ideas on how to connect with students, use collaborative learning, and develop language skills and process skills of inquiry.

Chapter 5

"Strategies for Assessing Science and Language Learning." Anne Katz and Joanne Olson give an overview of principles for assessing language learners in science. They describe how to plan assessment, to use it in the classroom, and to provide feedback and improve learning.

Chapter 6

"Science Beyond Classroom Walls." John Cannon, Judith Sweeney Lederman, Monica Colucci, and Miosotys Smith provide ideas on expanding learning beyond the classroom. They describe informal science learning experiences in museums, learning centers, and science centers. They discuss schoolwide experiences such as science fairs, festivals, and family science nights and then provide internet resources for science and language teachers.

Section III: Lessons for Science and Language Learning

Chapter 7

"Designing Lessons: Inquiry Approach to Science." Using the Sheltered Instructional Operation Protocol (SIOP) Model, Jana Eschevarria and Alan Colburn discuss science inquiry, the SIOP Model, and how to blend the two for good science instruction. They finish with a conversation between a science educator and language expert who give their different perspectives on specific science lessons.

Chapter 8

"Lessons That Work: Science Lessons for English Learners." Ann Fathman and Olga Amaral present formats for science lesson plans that incorporate inquiry and language and science objectives. Teachers from elementary, middle, and secondary levels describe successful lessons, and the benefits of these lessons for English language learners are discussed.

Section IV: Contexts for Classroom Implementation

Chapter 9

"Standards for Science and English Language Proficiency." Margo Gottlieb and Norman Lederman describe the development of the National Science Education Standards and English language proficiency standards. They then discuss new language proficiency standards that integrate science and other content area standards with language standards and give implications for teaching.

Chapter 10

"Perspectives on Teaching and Integrating English as a Second Language and Science." Deborah Short and Marlene Thier briefly review the evolution of ESL instruction and science education. They discuss current promising practices that integrate ESL, literacy, and science. Finally, they highlight innovative programs in U.S. schools that offer interventions that improve the science achievement of English language learners.

Appendixes

The chapters are followed by appendixes that include web references for resources, a glossary of science and language terms, and an overview of safety issues for the science classroom.

About the Editors

Ann K. Fathman

Ann K. Fathman is professor of English at Notre Dame de Namur University where she directs programs in English-as-a-second language teaching and English for international students. She received her PhD from Stanford University and BA in foreign language and science from University of California, Davis. Her professional experience includes elementary, secondary, and college teaching of ESL and science, as well as ESL and bilingual program administration and evaluation. She has taught in Europe and Asia and has been a Fulbright scholar in Slovakia. Her research in applied linguistics has focused on factors affecting second language acquisition, assessment, and heritage language preservation. She has had an interest in science and language teaching for many years, and her publications include coauthoring *Science for Language Learners*, published by Prentice Hall, *Elementary Science ESL Workbooks*, published by DC Heath, and *Teaching Science to English Learners*, published by the National Clearinghouse for Bilingual Education.

David T. Crowther

David T. Crowther is an associate professor of science education at the University of Nevada, Reno. He is an editor of *CESI Science*, which is the journal for the Council for Elementary Science International, and associate editor of the *Electronic Journal of Science Education*, which is the longest-running and first online journal of its kind. He is on the advisory board for the National Science Teachers Association's (NSTA) *Science and Children* and was chair of the NSTA Children's Book Council Committee. He has experience teaching at the elementary/middle level as well as biology at the high school and university levels. He has 13 years of teaching experience at the university level, nine of which have been at the University of Nevada, Reno. Previously, he taught at and received his PhD in Science Education from the University of Nebraska—Lincoln. He has published 24 articles that are both research based and practical for elementary science education and has done science education workshops and presentations in 39 states. He is the past president of CESI and a former board/council member of NSTA.

Author Biographies

Olga Amaral

Olga Amaral chairs the Division of Teacher Education at San Diego State University, Imperial Valley Campus. She is also an associate professor in the Department of Policy Studies in Language and Cross-Cultural Development. She received her EdD from the University of Massachusetts at Amherst. She serves as the director of the California Science Project in Imperial Valley and is the principal investigator for several grants that promote greater understanding and preparation for teachers of English learners. Her research and publications emphasize the instruction of English learners in the content area. Specifically, she focuses on methodology used in classrooms with English learners. Her publications have focused on improving student achievement for English learners by linking aspects of science instruction and English language development. Through her collaboration with the Valle Imperial Project in Science (VIPS) (see Chapter 10), she has helped to develop training modules for teachers that involve such techniques as lesson study and an integration of both science and English language development (ELD) standards. She has widely disseminated information about this work both nationally and internationally.

Marie Bacher

Marie Bacher is a science resource teacher and a classroom teacher for the Santa Clara Unified School District, California. In her 15 years as an educator she has been a tutor, preschool teacher, an upper-grade multiage teacher, a science camp director, and director of environmental education. She has a masters in education with an emphasis in administration and supervision from San Jose State University. She has spent the last several years developing and implementing a hands-on science curriculum that integrates best practices in inquiry, language arts, and English language learner (ELL) strategies. She frequently does science staff development for literacy specialists, principals, environmental educators, and her fellow teacher colleagues in science inquiry. Her work focuses on strategies for English language learners in science, science notebooks, performance-based assessments, and science process skills. She started her science-teaching career in a residential outdoor science school and to this day believes the best way for everyone to learn is through hands-on experiences.

Anne Baumgarten

Anne Baumgarten is a science/literacy resource teacher with Santa Clara Unified School District, California. She is responsible for designing and delivering staff training on science instruction as well as reading and writing workshops for elementary school teachers. She works with Partnership for Student Success in Science/Bay Area Schools for Educational Excellence, a nine-district consortium of science teachers that provides training in science content and inquiry methodology. She supports the integration of the language arts and science through classroom mentoring in the Guided Language Acquisition by Design program. She has been in education for more than 15 years, teaching adults as well as young children. In addition she has worked as a science writer for the University of Southern California and as a writer of children's educational television programs for Disney Animation. She has an undergraduate degree in science writing from the University of California at Santa Cruz and is currently completing an administrative credential.

John R. Cannon

John R. Cannon is associate professor of science education at the University of Nevada, Reno. His interest in classroom technologies and their applications began in 1987. He holds a PhD in Science Education from Kansas State University, an MA in classroom teaching from Central Michigan University, and a BA in Elementary Education from the University of Montana. In 1996, he launched the first totally electronic professional journal related to science education and research: the *Electronic Journal of Science Education*. In 2000, he researched and developed *Merrill Education's Links to Science Education Resources Website*. His chapter on distance learning in science education can be found in *Evaluation of Science and Technology Education at the Dawn of a New Millennium*, Kluwer Publishers, 2002. His current research interests include second language acquisition strategies and their close relationship to learning elementary science.

Alan Colburn

Alan Colburn is an associate professor of science education at California State University Long Beach. He holds a PhD in Science Education from the University of Iowa, as well as other degrees from the University of Pennsylvania, University of Illinois, and Carnegie-Mellon University. He has taught high school chemistry, advanced placement chemistry, and physical science. He currently teaches undergraduate students, students and teachers pursuing teaching credentials, and graduate students. His interests include not only inquiry-based instruction, but also the nature of science. Recent research compared science teacher and clergy views on evolution, creationism, science, and religion. He has authored 27 publications and given 46 presentations. This is the ninth time his work has appeared in an NSTA publication.

Monica Colucci

Monica Colucci teaches math and science in Miami Dade School District, Florida, to grades three through five. She has 11 years

of teaching experience and has worked with diverse student populations, such as English language learners, students with disabilities, and gifted children. She received a BS in Elementary Education and a master's degree in educational leadership from Florida International University. She is certified in the areas of English for speakers of other languages (ESOL) and gifted education. She has served as a teacher consultant for the University of Miami's Science For All for seven years and helped develop and write the instructional units for this project, trained teachers to use the materials in their classrooms, and made presentations on this topic at professional seminars. She works closely with school administrators and teachers to develop and implement schoolwide strategies to enhance the academic performance of students, especially that of limited English-proficient students and students with disabilities.

Fred Dobb

Fred Dobb, PhD, Stanford University, has been director of the English Learner Initiative of the California Science Project (CSP) and has spent his career in language minority programs as a bilingual teacher, administrator, and staff development specialist. He has been California Department of Education director of Bilingual Education, state supervisor of International Language Programs. Before joining CSP, he was a collaborator on the California English Language Development Test. He teaches courses in linguistic and cultural diversity and second language acquisition at San Francisco State University. He is the recipient of the California Language Teachers Association President's Award. A Fulbright scholar in Brazil, he has taught at postsecondary institutions in Puerto Rico, Nicaragua, Mexico, and Spain, and has trained science teachers from Chile and Argentina at the University of California, Davis.

Jana Echevarria

Jana Echevarria, PhD, is chair of the Department of Educational Psychology, Administration and Counseling at California State University, Long Beach, and a professor of Special Education. Her professional experience includes elementary and secondary teaching in special education, English as a second language (ESL), and bilingual programs. She has lived in Taiwan and Mexico where she taught ESL and second language acquisition courses, as well as in Spain where she conducted research on instructional programs for immigrant students. Her research and publications focus on effective instruction for English language learners, particularly those with learning disabilities. She has written numerous journal articles and book chapters, has written and produced two videotapes, and has coauthored two books: *Sheltered Content Instruction: Teaching Students with Diverse Abilities* and *Making Content Comprehensible for English Language Learners: The SIOP Model*, both published by Allyn and Bacon.

Margo Gottlieb

Margo Gottlieb is director of assessment and evaluation at the Illinois Resource Center, Des Plaines, and lead developer for

World-Class Instructional Design and Assessment (WIDA), a multistate consortium devoted to creating an assessment system for English language learners. In that capacity, she framed English language proficiency standards for 10 states. She holds a PhD in Public Policy Analysis from the University of Illinois at Chicago with a specialization in evaluation research and program design. She has authored an array of books, monographs, and articles and has constructed numerous assessment instruments. She has served as a consultant and adviser to numerous states, government agencies, organizations, universities, and publishers. In addition, she is a member of various national and state task forces and expert panels. Active in Teachers of English to Speakers of Other Languages (TESOL), she currently chairs the committee on revising its preK–12 student standards. Experienced in presenting and consulting nationally and internationally, she recently served as a Fulbright senior specialist in Chile.

Anne Katz

Anne Katz has worked for more than 20 years as a researcher and evaluator with educational projects involving linguistically and culturally diverse students. She received a PhD in Second Language Education from Stanford University. As a lecturer at the School for International Training in Brattleboro, Vermont, she teaches courses in curriculum, assessment, and evaluation. She has also worked as a teacher educator in Brazil, Egypt, and Ukraine. She led the TESOL-sponsored team that developed assessment guidelines for the preK–12 ESL Standards, and her most recent publications focus on standards-based assessment systems. She currently serves on the TESOL committee revising student standards. In her work, she promotes linkages between research and the classroom to support student learning and teacher development.

Judith Sweeney Lederman

Judith Sweeney Lederman is the director of Teacher Education in the Department of Mathematics and Science Education at Illinois Institute of Technology. Her experience with informal education includes her work as curator of education at the Museum of Natural History and Planetarium in Providence, Rhode Island. She regularly presents nationally and internationally on the teaching and learning of science in both formal and informal settings. In addition to numerous book chapters, she has recently published an elementary science teaching methods text and is currently writing a secondary methods text and two books on the nature of science. She has served on the boards of directors of NSTA and CESI and is president of CESI.

Norman G. Lederman

Norman G. Lederman is chair and professor of mathematics and science education at the Illinois Institute of Technology. He received a PhD in Science Education and has MS degrees in both biology and secondary education. Prior to his 20-plus years in science education, he was a high school teacher of biology and chemistry

for 10 years. He is internationally known for his research and scholarship on the development of students' and teachers' conceptions of the nature of science and scientific inquiry. He has been author or editor of 10 books, written 15 book chapters, published more than 150 articles in professional journals, and made more than 500 presentations at professional conferences around the world. He is a former president of the National Association for Research in Science Teaching (NARST) and the Association for the Education of Teachers in Science (AETS). He has also served as director of teacher education for NSTA and has served on the boards of directors of NSTA, AETS, NARST, and the School Science and Mathematics Association.

Deborah Maatta

Deborah Maatta is a project coordinator with the District of Columbia Public Schools Office of Bilingual Education. She began teaching English as a foreign language in West Africa where she also worked as a technical trainer for the U.S. Peace Corps. She went on to teach content-based ESL at Lincoln Multicultural Middle School in the District of Columbia. She coordinated the "Hands-On Science Program," a Title III project designed to improve science education for middle school level ESL students in the District of Columbia Public Schools. She currently manages a Title III Teachers and Personnel grant and a Refugee Children School Impact Grant. She received an MA in Education from American University.

Joanne K. Olson

Joanne K. Olson is an assistant professor in the Center for Excellence in Science and Mathematics Education at Iowa State University. She received a PhD in Science Education in 1999 from the University of Southern California. She earned a master's degree in education in 1993 from the Claremont Graduate University and received a bachelor's degree in liberal studies with a concentration in science from California State Polytechnic University, Pomona, in 1991. Her research interests focus on science teacher preparation and cognitive issues in the learning of science, including the role of the nature of science. She was an elementary and middle school science teacher in South Central Los Angeles before moving to Iowa. Currently, she coordinates the elementary science methods courses at Iowa State University, and co-directs the master's of arts in teaching program in Science Education.

Karen Ostlund

Karen Ostlund is professor and director of The Center for Science Education at the University of Texas, Austin. Her many honors include the NSTA Distinguished Teaching Award and Alpha Chi Favorite Professor at Southwest Texas State University, 1996. She is a past president of CESI and has served on the NSTA board of directors. Among her many publications are *Rising to the Challenge of the National Science Education Standards: The Process of Science Inquiry, Primary Grades and Grades 5–8*, in two volumes (with S. Mercier), and *Science Process Skills: Assessing Hands-On Student Performance.* She has

authored numerous invited chapters, journal articles, and specialty publications. She has been a major contributor to several science textbook series for use at the elementary and middle levels. She has presented at more than 100 workshops across the country.

Deborah J. Short

Deborah J. Short, PhD, is director of the Language Education and Academic Development division at the Center for Applied Linguistics in Washington, DC, and co-developer of the SIOP Model for sheltered instruction. She was coprincipal investigator for a research study on the effects of sheltered instruction on English language learner achievement and directed the national English as a Second Language Standards and Assessment project for TESOL. She currently directs a study on secondary English language learners funded by the Carnegie Corporation and the Rockefeller Foundation and is a senior researcher on a U.S. Department of Education evaluation study of programs for students in grades K–3. She has extensive experience in school-based research on the integration of language and content instruction and on programs for English language learners. She regularly provides professional development to teachers around the United States and abroad. She develops curricula and instructional materials for students and has authored or coauthored numerous publications, including two ESL series, *High Point* and *Avenues*, from Hampton-Brown. She has taught English as a second or foreign language in New York, California, Virginia, and the Democratic Republic of Congo.

Miosotys S. Smith

Miosotys S. Smith was born in Cuba where she spent the first 15 years of her life, after which she immigrated with her family to the United States where she continued her education. She completed her undergraduate studies at St. Thomas of Villanova University in psychology, received her teaching certification at Florida International University, and earned a master's degree in early childhood education from Nova Southeastern University. During her 17 years of teaching, she has taught grades prekindergarten through five, and had the opportunity to work closely with ELL students and interact with their families. She is certified in gifted education and has been teaching gifted children for the past eight years. In order to encourage parental involvement, she has developed and implemented numerous workshops for parents in the areas of reading and problem solving. She also has sponsored and led schoolwide programs and competitions such as science fairs and spelling bees, oratorical and book-writing contests, Odyssey of the Mind, and Math Bowl.

Marlene Thier

Marlene Thier is a veteran of the classroom, a science materials developer, a teacher educator, and a leader in the movement to link science and literacy education. She has made presentations on the subject at conferences from California to South Africa and has worked closely with the New York City

schools to implement a program based on her concepts. She is codeveloper and teacher education coordinator for the Science Education for Public Understanding Program (SEPUP) at the Lawrence Hall of Science on the Berkeley campus of the University of California. She is also cocreator of more than a dozen other inquiry-based science courses and modules for SEPUP. Marlene is a coordinator of SEPUP's Elementary Science Teacher Leadership program, funded by EXXON/Mobil, which develops workshops and printed materials to help preservice and inservice educators teach science more effectively. She has worked as a coauthor on the program's 10 guidebooks on subjects such as curriculum integration and combining math and science.

Joaquin S. Vilá

Joaquin S. Vilá, PhD, is a native of Puerto Rico where he completed his BA in English with an emphasis in linguistics and secondary English education. Upon graduation, he taught ESL in grades 7–12 in both public and private schools. He received both an MA and a PhD in Linguistics from Michigan State University. He has been involved in higher education for close to 20 years in the development, implementation, and administration of ESL teacher-preparation programs and intensive English language programs. His professional pursuits also involve development of inservice training opportunities for school personnel in the areas of reading, assessment, and content-area instruction for ESL learners. His current research interests include content-literacy development for ESL learners, ESL assessment, and professional development for school personnel. He is currently associate professor and ESOL adviser with the English Department at Salisbury University in Maryland where he is actively engaged in teaching graduate and undergraduate level courses as part of TESOL programs, supervising TESOL interns, collaborating in professional development projects, participating in TESOL/National Council for Accreditation of Teachers professional program reviews, and advising students about the rewards and challenges of a teaching profession.

Section 1

Parallels in Language and Science Teaching

Chapter 1

Teaching English Through Science and Science Through English

Ann K. Fathman and David T. Crowther

Eduardo came to the United States a little more than three years ago. He spoke little English. After a brief time at an intake center, Eduardo was sent into a regular sixth-grade classroom. He immediately found friends who spoke his native language and translated for him. After all, he was smart and had attended school in his native country—he just didn't understand English. And he had a very supportive family who encouraged him to learn and be successful.

Fortunately for Eduardo, he was in classrooms in which teachers were trained in sheltered instruction, used cooperative learning strategies and lots of hands-on instruction, accommodated different learning styles, and used assessment strategies that allowed him to demonstrate his knowledge of a subject even with his limited command of English. Over time, he became more comfortable in the welcoming environment provided by the teachers and began to understand the new language he was immersed in.

Window *Into the* Classroom

Eduardo was pulled out of his regular classroom for English instruction during his first two years. By his third year, he had learned conversational English, could read and write basic English, and had begun to understand some of the technical aspects of academic English. He began to feel confident in his learning again. As Eduardo's confidence increased, so did his skill. He needed less and less help from his English instructor.

When Eduardo reflects upon his experience in America, he fondly remembers his science class where he worked with real wires, bulbs, and batteries as he constructed a simple circuit. He still is surprised at how this experience both fascinated him and encouraged him. He was able to construct both science knowledge and English language that described what he was learning. He remembers that when the wires were put together in the right order with the battery and lightbulb, the bulb lit up and that made a "complete circuit."