Science Education and Student Diversity

Synthesis and Research Agenda

Okhee Lee
Aurolyn Luykx

CAMBRIDGE

CAMBRIDGE www.cambridge.org/9780521859615

This page intentionally left blank

Science Education and Student Diversity

Synthesis and Research Agenda

The achievement gaps in science and the underrepresentation of minorities in science-related fields have long been a concern of the nation. This book examines the roots of this problem by providing a comprehensive, "state-of-the-field" synthesis and analysis of current research on science education for minority students. Research from a range of theoretical and methodological perspectives is brought to bear on the question of how and why our nation's schools have failed to provide equitable learning opportunities in science education to all students. From this wealth of investigative data, the authors propose a research agenda for the field, identifying strengths and weaknesses in the literature to date as well as the most urgent priorities for those committed to the goals of equity and excellence in science education.

Okhee Lee is a professor in the School of Education at the University of Miami in Florida. She completed her Ph.D. in educational psychology with a focus on science education from Michigan State University in 1989. Her research areas include science education, language and culture, and teacher education. She was awarded a 1993–1995 National Academy of Education/Spencer Postdoctoral Fellowship, and she was a 1996–1997 Fellow at the National Institute for Science Education at the University of Wisconsin-Madison. She received the Distinguished Career Award from the American Educational Research Association (AERA) Standing Committee for Scholars of Color in Education in 2003. She has directed numerous research and teacher enhancement projects funded by the National Science Foundation, U.S. Department of Education, Spencer Foundation, and Florida Department of Education. Her research has appeared in prominent journals in education, including the *American Educational Research Journal, Educational Researcher, Review of Educational Research, Review of Research in Education, Teachers College Record, Journal of Research in Science Teaching, Science Education*, and *Bilingual Research Journal.*

Aurolyn Luykx is a joint associate professor of anthropology and teacher education at the University of Texas at El Paso. She completed her Ph.D. in linguistic and educational anthropology from the University of Texas at Austin in 1993 and was later awarded "best dissertation of the year" from the Council on Anthropology and Education. She is the author of *The Citizen Factory: Schooling and Cultural Production in Bolivia* (1999), which has been used in numerous college courses in both education and Andean studies. She spent several years in Bolivia working on various aspects of that country's nationwide educational reform, and she later became one of the founding faculty of the Programa de Formación en Educación Intercultural Bilingüe para los Paises Andinos (PROEIB Andes), an international master's program for indigenous educators throughout the Andean region. During this time she also received a National Academy of Education/Spencer Postdoctoral Fellowship for study of the use of indigenous languages in higher education. In 2001 she relocated to Miami as a researcher on Okhee Lee's project, Science for All, funded by the National Science Foundation. Together, Drs. Luykx and Lee have published numerous articles on science education for students from linguistically and culturally diverse backgrounds. Dr. Luykx's work has been published in the *Journal of Latin American Anthropology, International Journal of the Sociology of Language, American Educational Research Journal, Teachers College Record*, and *Journal of Research in Science Teaching.*

Science Education and Student Diversity

Synthesis and Research Agenda

OKHEE LEE
University of Miami

AUROLYN LUYKX
University of Texas at El Paso

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521859615

First published in print format 2006

ISBN-13 978-0-511-22313-6 eBook (Adobe Reader)
ISBN-10 0-511-22313-7 eBook (Adobe Reader)

ISBN-13 978-0-521-85961-5 hardback
ISBN-10 0-521-85961-1 hardback

Contents

Foreword

In *Science Education and Student Diversity*, Okhee Lee and Aurolyn Luykx have achieved a comprehensive and authoritative treatment of all aspects of the topic: policy, conceptual frameworks, student characteristics, instruction, curricula, assessment, teacher preparation and professional development, school organization, and the relationships of science education to families, home environments, and communities of diverse students. It is difficult to imagine any serious educator of our time who will not be grateful for a reading of this book. The authors have gathered all the facts, given us a calm and convincing critique of our state of knowledge and practice, and drawn wise conclusions as to where and how our knowledge can further grow.

This book takes on even greater importance from the context of its creation. The authors headed a team of scholars from several research institutions, collaborating through programs of CREDE, the Center for Research on Education, Diversity & Excellence, now located at the University of California, Berkeley. From 1996 through 2004, CREDE was the national research center of the U.S. Department of Education, concerned with research and development of effective educational programs for students of diverse languages, races, cultures, economic strata, and geographies – those students placed at risk of failure in schools by traditional programs designed for mainstream society. CREDE's 40 research projects (and 80 affiliated researchers) spanned the United States, from Hawaii to Florida, from Alaska to Providence, studying students of every major linguistic and cultural group. Our purpose and our achievement was to understand clearly issues of local and specific variation and to discern the underlying principles that can guide effective program design.

In the last two years of our national center work, synthesis of research results was a central focus. The authors of this volume led CREDE's *synthesis team* on Science Education and Diversity. They joined other sister synthesis teams,[1] each focused on specific topical domains of diversity and education.[2] Their purpose was to assemble and synthesize the domain's research evidence and to present it with two foci: what we know now and what we need to know next, so that clarification of the research literature can guide future inquiry.

The universe of knowledge addressed by the synthesis scholars was international. Though the preponderance of published research comes from the United States, issues of societal diversity are now global. Researchers in many nations are informing one another across borders and populations. The corpus of research reports is also heavily weighted with authors affiliated with CREDE. That "accident" is certainly due to the excellence of their work, but also to the good fortune of the generous funding available to CREDE. We were blessed with disproportionate resources as compared with our other colleagues. Because education-and-diversity research was for decades of little interest to mainstream educators and researchers, funding was meager and interest in the topic was slight. CREDE existed in that brief historical period when diversity research bobbed up in national policy concerns. There is no longer a national research center concerned with diversity, even though diversity of our population continues to grow, and the achievement gap between mainstream students and those placed at risk continues.

To assure that all pertinent research was considered in our syntheses, each team was balanced in two dimensions: CREDE- and non-CREDE–affiliated scholars, and diversity and mainstream scholars. The latter balancing was strategic. Since diversity research began in the 1960s, little attention has been paid by mainstream researchers, even in the same domain; and insufficient attention to mainstream research has been paid by diversity researchers. As with two circulating pools in the same lake, little mutual influence was exerted. Our synthesis teams were (metaphorically) locked in the same room for two years and not let out until they had synthesized. The results have been a uniquely rich set of reports.

Our hope is that this volume (and its sister reports) will be of interest to all researchers and policymakers in each domain. In the last six years, educational policy has heavily emphasized research-based practice. All readers of this book surely welcome that emphasis, while regretting that research on culturally and linguistically diverse students is rarely considered in current federal interpretations. In the resulting one-size-fits-all policy climate,

[1] Professor Yolanda Padron at the University of Houston provided the organization and coordination of the synthesis teams.

[2] The synthesis teams and their reports are discussed later in this Foreword. During the time of our planning, the synthesis of research in mathematics and diversity education was being organized separately by NCISLA, the National Center for Improving Student Learning in Mathematics and Science (University of Wisconsin, Madison).

our goal is to produce an appreciation for how research *on and for diverse students* should be the basis for educational practice in a diverse society.

Each synthesis team found a unique state of knowledge in its domain. The authors of the current volume present a rich bibliography of research, conducted by many methods and many designs, with a complex field of findings that illuminate a set of still-to-be-investigated important hypotheses. By contrast, the team synthesizing issues of Professional Development and Diversity found a wealth of policy speculation and few systematic studies of variations in preparing teachers for diverse classrooms. Not every synthesis report is of book length, but in each instance the synthesis work clarifies and charts a future research agenda.

Likewise, each synthesis team chose a somewhat different filter for inclusion. Overall, our syntheses program adopted one general inclusion rule: each team discusses the best available research in its domain. The inclusion rules are important to understand in the context of current research-design dialogue. Federal policy's recent emphasis on the Randomized Field Trial (RFT) design was an inevitable corrective to a declining discipline in educational research. Perhaps the RFT advocates are moderating their initial rhetorical excesses ("There is RFT and all else is myth"), but in any event a wiser and more balanced view of design proprieties will emerge, so that different methods and designs are understood as appropriate for different developmental stages of a domain of inquiry. In that spirit, each team adopted a different filter of inclusion, depending on the maturity of the domain. This strategy illuminates the future research agenda, and indeed suggests the methods appropriate to forward the developmental progress.

In this volume, Lee and Luykx recognize that science education and diversity is a relatively new field of inquiry, coming into focus only in the 1990s. Inclusiveness in methods of inquiry was an appropriate decision, as is their clear-eyed critique of methods and clarity of argument in the field and in individual studies.

The CREDE synthesis work also exists in a context of domain interrelationships, so that many readers of this volume will find additional levels of resonance by reading the article-length reports of our other five synthesis teams (Systemic School Reform (Datnow, Lasky, Stringfield, & Teddlie, 2005); Families and Communities (Cooper, Chavira, & Mena, 2005); Preservice Teacher Education (Padron, 2005); Educating English Language Learners (Genesee, Lindholm-Leary, Saunders, & Christian, 2005); and Professional Development (Knight & Wiseman, 2005)), as well as the article-length version of the present volume (Lee, 2005).

A fine example of these domain interrelationships is Lee and Luykx's discussion of science education as an arena for the development of English language competence. The latter is the specific focus of the first volume in the Cambridge University Press series reporting CREDE's synthesis work

(Genesee, Lindholm-Leary, Saunders, & Christian, 2006).[3] Research indicates that the subject matter of science has rich potential as a setting for English language learning and that the techniques of sheltered instruction (reviewed in Genesee et al., 2006) offer illumination for teachers of science who wish to stimulate the learning of English. Similarly, the understanding of language learning and science instruction can inform those with a particular interest in systemic reform for schools with diverse student bodies.

CREDE's purpose was also to discern the underlying principles that can guide effective program design for diverse students. Built into CREDE's research design was the investigation of a set of principles extracted from previous research and development literature, which characterize successful educational programs for diversity. These principles were explored in all our research, to achieve a deep understanding of their dynamics and how they are expressed in diverse cultures. In our latest research program, these standards have been fully enacted at a programmatic level, and their effects measured against student achievement (e.g., Doherty, Hilberg, Epaloose, & Tharp, 2002; Doherty, Hilberg, Pinal, & Tharp, 2002; Doherty, Hilberg, & Tharp, 2003; Doherty & Pinal, 2004; Estrada, 2004).

We describe these principles as Standards for Effective Pedagogy (Tharp, Estrada, Dalton, & Yamauchi, 2000):

- I: Teachers and Students Producing Together (Joint Productive Activity). *Facilitate learning through joint productive activity among teacher and students*.
- II: Developing Language and Literacy Across the Curriculum. *Develop competence in the language(s) of instruction and of the disciplines throughout the day*.
- III: Making Meaning – Contextualizing School in Students' Lives. *Embed instruction in the interests, experiences, and skills of students' families and communities*.
- IV: Teaching Complex Thinking. *Challenge students toward cognitive complexity*.
- V: Teaching through Instructional Conversation. *Engage students through dialogue*.

Of course, these standards must be enacted within specific domains, content, and instructional goals. Readers familiar with the Effective Pedagogy Standards will find their understanding deepened by reading *Science Education and Student Diversity*, or indeed any of the other synthesis reports. In the learning of English, the learning of science, the learning to teach – there must finally be *content pedagogy*, in which the basic sociocultural human relationships of pedagogy are conditioned by the structures of knowledge

[3] Cambridge University Press will publish book-length versions of some of the other reports in this series.

present in each discipline. This interplay of levels of abstraction offers unparalleled intellectual stimulation and clear opportunities for further investigation of how we can draw ever closer to the goal of teaching all students.

In *Science Education and Student Diversity*, Lee and Luykx have held up a finely ground mirror, in which educators and researchers can see clearly our many achievements in learning how to bring young people of diverse backgrounds into an understanding and practice of science. Much of what we see here will make us proud. The authors serve us equally well by reminding us of what we still must discover, and how to do it.

Roland G. Tharp
Senior Scientist, Center for Research on Education, Diversity & Excellence
Research Professor, University of California, Berkeley

References

Cooper, C., Chavira, G., & Mena, D. D. (2005). From pipelines to partnerships: A research synthesis on how diverse families, schools, and communities support children's pathways through school. *Journal of Education for Students Placed at Risk*, 10(4), 407–430.

Datnow, A., Lasky, S., Stringfield, S., & Teddlie, C. (2005). Systemic educational reform in racially and linguistically diverse contexts: A summary of the evidence. *Journal of Education for Students Placed at Risk*, 10(4), 441–453.

Doherty, R. W., Hilberg, R. S., Epaloose, G., & Tharp, R. G. (2002). Standards Performance Continuum: Development and validation of a measure of effective pedagogy. *Journal of Educational Research*, 96(2), 78–89.

Doherty, R. W., Hilberg, R. S., Pinal, A., & Tharp, R. G. (2002). *Transformed pedagogy, organization, and student achievement*. Paper presented at the annual meeting of the American Education Research Association, New Orleans, LA.

Doherty, R. W., Hilberg, R. S., & Tharp, R. G. (2003). Standards for effective pedagogy and student achievement. *NABE Journal of Research and Practice*, 96(2), 1–24.

Doherty, R. W., & Pinal, A. (2004). Joint productive activity, cognitive reading strategies, and achievement. *TESOL Quarterly*, 38.

Estrada, P. (2004). Patterns of language arts instruction activity: Excellence, fairness, inclusion, and harmony in first and fourth grade culturally and linguistically diverse classrooms. In H. C. Waxman, R. G. Tharp, & R. S. Hilberg (eds.), *Observational research in U.S. classrooms: New approaches for understanding cultural and linguistic diversity*. Cambridge: Cambridge University Press.

Genesee, F., Lindholm-Leary, K., Saunders, W., & Christian, D. (2006). *Educating English language learners*. Cambridge: Cambridge University Press.

Genesee, F., Lindholm-Leary, K., Saunders, W., & Christian, D. (2005). English language learners in U.S. Schools: An overview of research findings. *Journal of Education for Students Placed at Risk*, 10(4), 363–385.

Knight, S. L., & Wiseman, D. L. (2005). Professional development for teachers of diverse students: A summary of the research. *Journal of Education for Students Placed at Risk*, 10(4), 387–405.

Lee, O. (2005). Science education and student diversity: Synthesis and research agenda. *Journal of Education for Students Placed at Risk,* 10(4), 431–440.

Padron, Y. (2005). Final Report: Preservice education for teachers of diverse students: A research synthesis. Berkeley, CA: Center for Research on Education, Diversity & Excellence, University of California. www.crede.org

Tharp, R. G., Estrada, P., Dalton, S. S., & Yamauchi, L. A. (2000). *Teaching transformed: Achieving excellence, fairness, inclusion and harmony.* Boulder, CO: Westview Press.

Acknowledgments

We vividly remember the day we were contacted by Roland Tharp, Director of the Center for Research on Education, Diversity & Excellence (CREDE), and Thomas Carpenter, Director of the National Center for Improving Student Learning in Mathematics and Science (NCISLA). We were asked to analyze and synthesize the research on a range of issues regarding science education and student diversity, and then offer a research agenda. We accepted the task with both excitement and anxiety: excitement, from the thought that we would have an opportunity to learn more about this promising literature and to contribute to a knowledge base from which we hope will emerge more equitable learning environments for all students; and anxiety, from the realization that the book project would require a great amount of work; fair and balanced treatment of multiple, sometimes competing, perspectives in the literature; and realistic portrayals of both the accomplishments and the limitations of the colleagues, teachers, and students who are the subjects of our endeavors.

Just the process of doing a comprehensive review of literature was a daunting task. We especially appreciate the work of Margarette Mahotiere, who conducted the electronic search of the literature. Reading all the studies that met the criteria for inclusion in the book was equally daunting. Analyzing and synthesizing the literature on each of the relevant topics were formidable jobs. At times, writing about this vast body of research seemed impossible.

We were fortunate to have the support of the two national centers, CREDE and NCISLA in Mathematics and Science, and their respective directors, Roland Tharp and Thomas Carpenter. We were also fortunate to have the input of the Task Force members, who represented a range of academic disciplines and research areas:

Humberto Campins, University of Central Florida
Yolanda George, American Association for the Advancement of Science

Joseph Krajcik, University of Michigan
Julia Lara, Council of Chief State School Officers
Julio Lopez-Ferrao, National Science Foundation
Sharon Lynch, George Washington University
Sharon Nelson-Barber, WestEd
Trish Stoddart, University of California at Santa Cruz
Beth Warren, TERC

These valued colleagues helped at every step of the way, from the conceptualization of issues to feedback on draft versions of the manuscript. In particular, Sharon Lynch provided critical feedback on one of the later drafts of the book.

We are indebted to Cathy Murphy, editor at CREDE, who helped us with various draft versions of the manuscript. We also appreciate everyone at Cambridge University Press who worked on the book.

Our work was both strengthened and challenged by the fact that the two authors of the book complement each other in many ways. Okhee Lee is an educational researcher focusing on elementary science education and student diversity. Aurolyn Luykx is a linguistic and educational anthropologist with a critical theory orientation. Our differing perspectives would often lead us to argue over single words or phrases until we could come to an agreement. Our mutual respect for the differences in our academic training not only strengthened the manuscript but also deepened and broadened our respective understandings of educational research and practice. While collaboration across such differences inevitably implies many moments of frustration, these are far outweighed by the pleasures of colleagueship and intellectual growth that it provides.

Finally, we thank our families for their support and love.

Introduction

Ever since our nation first embraced the goal of mass schooling, it has faced the challenge of balancing the concern for educational quality with the desire to reach as many students as possible. Today, this dilemma is reflected in the dual aims of promoting high academic achievement while simultaneously pursuing educational equity for an increasingly diverse student population (Darling-Hammond, 1996; McLaughlin, Shepard, & O'Day, 1995). To achieve these aims, it is necessary to develop a knowledge base that situates recent advances in our understanding of educational processes within the realities of today's schools. This need is especially urgent, given the current climate of standards-based instruction, high-stakes assessment, and accountability. The literature review presented in this synthesis is a step in developing such an empirically based integration.

Knowledge about science and technology is increasingly important in today's world. Aside from the growing number of professions that require a working familiarity with scientific concepts and high-tech tools, the future of our society hangs in the balance of decisions that must be made on the basis of scientific knowledge. Documents on science education standards (American Association for the Advancement of Science [AAAS], 1989, 1993; National Research Council [NRC], 1996, 2000) represent the science education community's best efforts to define what constitutes science learning and achievement (see the summary in Lee & Paik, 2000; Raizen, 1998). According to these documents, science learning involves a two-part process: "to acquire both scientific knowledge of the world and scientific habits of mind at the same time" (AAAS, 1989, p. 190).

The development of scientific knowledge involves "knowing" science (i.e., scientific understanding), "doing" science (i.e., scientific inquiry), and "talking" science (i.e., scientific discourse). Knowing science involves making meaning of scientific concepts and vocabulary. One way that students come to know science is by doing science, that is, engaging in science inquiry by generating questions, designing and carrying out investigations, analyzing data, proposing explanations, interpreting and verifying evidence, and constructing ideas to make sense of the world. Although knowing and doing have long been acknowledged as important components of science learning, recent science reform also emphasizes "talking science," whereby "teachers structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse. A fundamental aspect of a community of learners is communication" (NRC, 1996, p. 50).

The cultivation of scientific habits of mind entails adopting scientific values and attitudes, as well as the scientific worldview. Most cultural traditions embrace some values and attitudes that are associated with science, such as wonder, curiosity, interest, diligence, persistence, openness to new ideas, imagination, and respect toward nature. Other values and attitudes are particularly characteristic of Western modern science, for example, questioning, thinking critically and independently, reasoning from empirical evidence, making arguments based on logic rather than personal or institutional authority, openly critiquing the arguments of others, and tolerating ambiguity. Furthermore, science is a way of knowing that "distinguishes itself from other ways of knowing and from other bodies of knowledge" (NRC, 1996, p. 201). The scientific worldview is defined by a tradition of seeking to understand how the world works – to describe, explain, predict, and control natural phenomena. It is distinguished from alternative worldviews: "Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific" (NRC, 1996, p. 201).

Although the standards documents generally define science in the Western modern science tradition (AAAS, 1989, p. 136; NRC, 1996, pp. 201, 204), alternative views of science have been advocated by scholars in emerging areas of multicultural education, feminism, sociology and philosophy of science, and critical theory (Atwater & Riley, 1993; Calabrese Barton, 1998a; Eisenhart, Finkel, & Marion, 1996; Hodson, 1993; Lee, 1999a; Rodriguez, 1997; Stanley & Brickhouse, 1994, 2001). These scholars raise issues of power and the marginalization of nonmainstream groups, and challenge the very notion of science and the traditional definition of learning science (see the discussion in the section entitled "Views of Science: Is Science Independent of Culture?" in Chapter 2).

As immigrants, children of color, and children living in poverty come to represent an increasing fraction of the U.S. student population (García, 1999; National Center for Children in Poverty, 1995), science classrooms must address the educational needs of these children, who face the dual challenge of navigating the language and culture of the U.S. mainstream while also learning the academic norms, content, and processes of science disciplines. Thus, a vision of reform aiming at academic achievement for all students requires integrating disciplinary knowledge with knowledge of student diversity. Traditionally, disciplinary knowledge and student diversity have constituted separate research agendas. In the case of science education, although reform documents highlight "science for all" as the principle of equity and excellence (AAAS, 1989, 1993; NRC, 1996), they do not provide a coherent conception of equity or strategies for achieving it (Eisenhart et al., 1996; Lee, 1999a; S. Lynch, 2000; Rodriguez, 1997). On the other hand, the multicultural education literature emphasizes issues of cultural and linguistic diversity and equity, but with little consideration of the specific demands of different academic disciplines. In addition, although English language and literacy development in the context of subject area instruction is emphasized for English language learners – ELL students (Teachers of English to Speakers of Other Languages, 1997), research in this area focuses primarily on English language proficiency, with limited attention to achievement in subject areas such as science (August & Hakuta, 1997). Integration of "discipline-specific" and "diversity-oriented" approaches is necessary for achieving the goal of making science accessible for all students.

International studies, such as the Third International Mathematics and Science Study (TIMSS), reveal alarmingly poor performance of U.S. students on standardized science assessments (National Center for Education Statistics, 1996; Schmidt, McKnight, & Raizen, 1997). Additionally, the rank of U.S. students declines even further as they move up into the higher grades. Studies based on U.S. national samples, such as the National Assessment of Educational Progress (NAEP), indicate that the average scores for students of every age level and race/ethnicity have increased only slightly since the 1970s (Campbell, Hombo, & Mazzeo, 2000; O'Sullivan, Lauko, Grigg, Qian, Zhang, 2003; Rodriguez, 1998a). Furthermore, achievement gaps among students of diverse racial/ethnic and socioeconomic backgrounds have persisted in science achievement, as well as in science course enrollments leading to careers in science and engineering fields (Chipman & Thomas, 1987; National Science Foundation [NSF], 2002; Oakes, 1990).

Given overall poor science performance and the persistent gaps in science outcomes between mainstream and nonmainstream students in the United States, there is a pressing need to address students' cultural, linguistic, and socioeconomic circumstances in relation to science outcomes. Traditionally, while the science and science education communities advocate for greater participation of nonmainstream individuals in science-related fields, they expect these individuals to assimilate to the established institutional culture. There has been little recognition of the cultural and linguistic resources that nonmainstream individuals and groups bring to the science classroom, and little thought has been given to how to articulate these resources with the values and practices of science in order to enhance science outcomes in school and beyond.

Although classroom practices, local institutional conditions, and broader policy contexts affect all students, they are more likely to negatively impact nonmainstream students. All too often, teachers' knowledge of science and/or student diversity is insufficient to guide students from all backgrounds toward meaningful science learning. Furthermore, beginning teachers or those with inadequate teacher preparation tend to be assigned to inner-city schools where nonmainstream students are concentrated. Additionally, resources are scarcer and teacher attrition is higher in inner-city schools. Limited resources often force a trade-off between providing modified instruction that takes student diversity into account and reinforcing general standards to raise the quality of instruction for mainstream students (often to the detriment of other student groups). The trend toward standardization of curricula and assessment may also work against educational equity (McNeil, 2000), although there are efforts to promote both goals simultaneously (Delpit, 2003).

If we start from the assumption that high academic achievement is potentially attainable by most children, then achievement gaps among racial/ethnic, linguistic, or socioeconomic status (SES) groups can be interpreted as a product of (a) the learning opportunities available to different groups of students and (b) the degree to which circumstances permit them to take advantage of those opportunities. This poses questions for researchers and educators: What constitutes equitable learning opportunities, how do they vary for different student populations, and how can they be provided in a context of limited resources and conflicting educational priorities?

The literature reviewed in this book presents promising results about effective science education for nonmainstream students. These students come to school with already constructed knowledge, including their home language and cultural values. *Equitable learning opportunities* occur when school science values and respects the experiences these students bring from their home and community environments, articulates their cultural and linguistic knowledge with science disciplines, and offers educational resources and funding to support their learning at a level comparable to that available for mainstream students. Provided with equitable learning opportunities, these students are capable of demonstrating science achievement, interest, and agency, becoming bicultural and bilingual border crossers between their own cultural and speech communities and the science learning community.

This book analyzes and synthesizes current research on how cultural, linguistic, and socioeconomic factors in school and at home promote or hinder science achievement among nonmainstream K–12 students who have traditionally been underserved by the education system. Specifically, it examines how science achievement and other outcomes (broadly defined) are related to various factors involving science curriculum (including computer technology), instructional practices, assessment, teacher education, school organization, educational policies, and home and community connections to school science. The book emphasizes science education initiatives, interventions, or programs that have been successful with nonmainstream students. Based on the research synthesis, it proposes a research agenda to strengthen those areas in which the need for a knowledge base is most urgent, as well as those which show promise in establishing a robust knowledge base.

In analyzing and synthesizing current research, the book considers primarily peer-reviewed journal articles that provide clear statements of research questions, clear descriptions of research methods, convincing links between the evidence presented and the research questions, and valid conclusions based on the results (Shavelson & Towne, 2002). The rigor of the research methods employed is critically important in assessing the evidentiary warrants for the claims being made in each study and, more importantly, in assessing the robustness of a knowledge base in each area of research. The book provides descriptions of research methods along with results in each study, as well as discussion about methodological orientations and key findings in each area of research. The methodological and other criteria for the inclusion of research studies in the synthesis are described in detail in the Appendix.

There are four sections to the book, each with multiple chapters. In the first section, a range of conceptual and policy issues is addressed. The discussion starts with science achievement (i.e., measured outcomes) and student diversity as two key constructs in this synthesis. Based on this discussion, desired science outcomes for nonmainstream students are defined. Then, conceptual and policy issues guiding the synthesis are discussed, including the epistemological debate over definitions of science and school science, theoretical perspectives guiding research studies, and the policy context of high-stakes assessment and accountability in science education.

The second section starts with student characteristics and science learning linked to gaps in science outcomes among different student populations. Student learning occurs in the context of classroom practices – what materials are used, what content is taught, how the content is taught, and how students' mastery of the content is assessed. This section is organized into the following chapters: (a) student characteristics and science learning, (b) science curriculum (including computer technology), (c) science instruction, and (d) science assessment. Within each category, studies addressing bilingual or ELL students are discussed separately.

The third section addresses school- and home-based factors supporting or hindering science education in relation to gaps in science outcomes among different student populations. Classroom practices occur in the broader context of teacher education programs and educational policies. Although educational policies and practices influence all students, the impact is more consequential with nonmainstream students who are less likely to live in homes that provide the sort of academic supports that the school takes for granted. Thus, establishing connections between home/community and school science is critically important for nonmainstream students. This section consists of the following chapters: (a) science teacher education, (b) school organization and educational policy, and (c) home and community connections to school science. Within each category, studies addressing bilingual or ELL students are discussed separately.

Finally, we draw conclusions regarding two areas: (a) key features of the literature with regard to theoretical perspectives and methodological orientations, and (b) key findings about school- and home-based factors related to science outcomes of nonmainstream students. We offer recommendations for a research agenda to improve science outcomes and narrow achievement gaps among diverse student groups.