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ABSTRACT

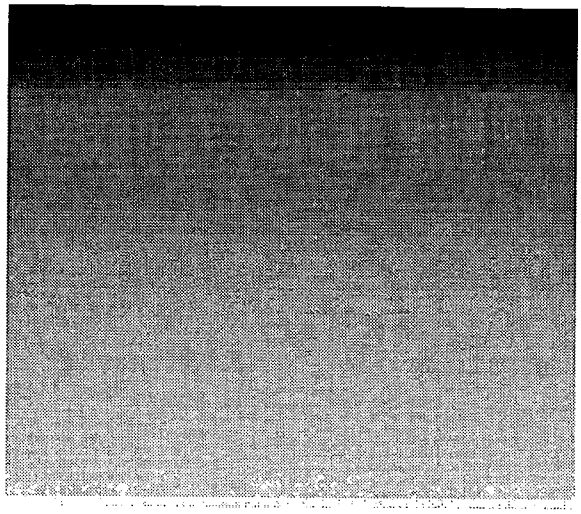
When entering this new millennium, educators and researchers need to know much more about how to address the increasingly acute diversity and equity issues in educating children in mathematics and science. This headline was the conclusion of the over 200 distinguished panelists, chairs, discussants, featured speakers, and participants who conferred at the May 2000 Annual Forum of the National Institute for Science Education (NISE). This report draws upon the papers, presentations, and discussions of the most recent NISE Forum. Chapters 2-4 are each based on a different source of information from the NISE Forum. Chapter 2 includes keynote speeches, chapter 3 presents papers by Forum panelists and remarks made by the panels' discussants, and chapter 4 provides information on the participants' small group discussions. The beginning of chapter 2--a synthesis of all the sources of information arising from the Forum--is the heart of this report. It emphasizes directions for future research on diversity and equity within the topics of course availability, assignment of students to courses and assignments of teachers; content, instructional practices, and assessments for diverse learners; effectiveness and scaling up of programs; and inadequate teacher preparation, induction, and professional development. The synthesis begins with a discussion of the need to continue a discourse on what diversity and equity goals the mathematics and science education communities are pursuing, since goals strongly affect both research directions and methods. This opening section ends by discussing improved research methods and the need for better dissemination of existing research. The second part of chapter 2 gives a broader overview of future research directions by presenting the Forum's three keynote speeches. Kent McGuire and Judith Sunley, director of the Office of Educational Research and Improvement (OERI) and interim director of the National Science Foundation's (NSF) Education and Human Resources Directorate respectively, launched the Forum by advancing a "big-picture" perspective of the need for future research and describing how OERI and NSF programs are addressing them. Drawing upon his

decades of experience, closing speaker Edmund Gordon from Yale University and the Education Testing Service (ETS) provided a historical perspective that should affect future research directions. Chapter 3 contains short papers written by each of the Forum's nine major speakers who served on three panels. The brief papers emphasize future research directions and are derived from the advanced papers these speakers wrote for the Forum. The longer papers address the issues of "What do we know?" and "What do we need to know?" The papers in chapter 3 are presented in the order of their presentation at the Forum. After each panel's papers, the chapter includes the remarks of another expert who served as a discussant. Chapter 4 begins with a short summary of Forum participant comments. Each participant was asked to write a 10-minute "think piece" during each of 3 small group discussions. The summary incorporates numerous illustrative quotes from these think pieces. The second part of chapter 4 consists of remarks made at the Forum's closing session by six participants who served as "reporters" for the small group discussions. (Contains 36 references.) (ASK)

BEYOND DESCRIPTION OF THE PROBLEMS

Directions for Research on Diversity and Equity Issues in K-12 Mathematics and Science Education

National Institute for Science Education
in collaboration with the Western Regional Education Laboratory



BEYOND DESCRIPTION OF THE PROBLEMS:

Directions for Research on Diversity and Equity Issues in K-12 Mathematics and Science Education

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National Institute for Science Education

The National Center for Improving Science Education
NCISE
A Division of WestEd

WestEd

The National Institute for Science Education (NISE) is a partnership between the University of Wisconsin-Madison and the Washington-based National Center for Improving Science Education (NCISE), a division of WestEd.

Funding. The National Science Foundation (NSF) grant number RED-9452971 supported the annual NISE Forum held in May 2000, on which this report primarily is based. Supplemental funding for producing this report came through a task order from the Office of Educational Research and Improvement (OERI) to the Western Regional Education Laboratory at WestEd. The views expressed by the contributors to this report do not necessarily reflect the opinions of the funders.

Authors/editors. The following researchers led the production of this report. Papers and comments by the 2000 NISE Forum panelists, discussants, keynote speakers and reporters of the Forum's small group discussions are noted in the Table of Contents and throughout the report. Additional staff is noted in the acknowledgements.

- **Edward Britton**, associate director of NCISE, is the lead organizer for the annual NISE Forum, project director for producing this report, lead editor, and author of chapters 1 and 2.

- **Senta Raizen,** director of NCISE, provided oversight in organizing the Forum, served as a report editor, wrote the Highlights, and contributed to chapter 4.

- **Andrew Porter**, director of NISE and the Wisconsin Center for Educational Research, authored the preface of this report and enlisted the Forum's distinguished panelists, chairs, and discussants.

- **Joyce Kaser**, senior research associate at NCISE/WestEd, contributed to chapter 4 by analyzing hundreds of 10-minute "think pieces" that were written by Forum participants.

The authors of the papers and comments presented by the Forum panelists, discussants, keynote speakers, and reporters are listed in the Table of Contents and noted throughout the report. Additional Forum staff members are listed in the acknowledgments section.

Dedication to Susan Loucks-Horsley

It is fitting that we dedicate this report, which is about making mathematics and science education effective for all students, to Susan Loucks-Horsley. Our sorely missed colleague was someone who shared this ideal—and lived it. She always reached out to and deeply affected many of us, both professionally and personally. Susan made so many invaluable professional contributions, including here at the National Institute for Science Education. The NISE book by Susan and her team, *Designing Professional Development for Teachers of Science and Mathematics*, has almost instantly become a seminal work in the field. Moreover, she was instrumental in organizing our first annual Forum, and the evolution of the Forum since then has led to a new NISE book on how to design effective meetings and conferences.

Susan's fame didn't result just from the substance of her work, but also from how she accomplished it. She "walked the walk" by making networking and collaborating her means of advancing professional development research and projects. Even more, Susan touched the people she worked with by taking a sincere and steady interest in them along the way—always mentoring, always connecting others to some new idea or person. And on top of all this, working with Susan meant you were going to have fun.

We hope she would be happy as these memories prompt us to carry on not just the substance but also the spirit of her work.

Preface

As we enter this new millennium, educators and researchers need to know a lot more about how to address the increasingly acute diversity and equity issues in educating today's and tomorrow's children in mathematics and science. This headline is a conclusion of the over two hundred distinguished panelists, chairs, discussants, featured speakers, and participants who conferred at the May 2000 annual Forum of the National Institute for Science Education. Existing research certainly provides important insights on how best to enable all students to excel in these vital school subjects. Indeed, you will read that many Forum speakers and participants felt that a much better job needs to be done of *disseminating existing research* and *scaling up effective programs*.

However, a particular theme of this report, as expressed in its summaries and many specific examples, is that *future research* is needed as well. Much previous research has fulfilled the absolutely indispensable service of documenting disparities among types of students in the kinds of mathematics and science education they receive. Such research is necessary but not sufficient. As pointed out in the Forum's opening remarks by Kent McGuire, the director of the Office of Educational Research and Improvement (OERI) at the U.S. Department of Education, the research agenda needs to expand beyond describing the problems in better detail, although such efforts surely must continue.

This report draws upon the papers, presentations, and discussions of our most recent NISE Forum. The entire institute has collaborated over the years with Forum organizers Ted Britton and Senta Raizen to make the Forum into a premier event that brings together top-flight speakers and participants and engages them in an active dialogue about pressing issues in the field. I'm grateful to the many professionals who are noted in the acknowledgments and contributors' pages for making this year's Forum such a success.

The Forum fosters an uncommon depth to participant deliberations primarily by having all speakers prepare papers prior to the Forum and circulating them for participants to read in advance. In fact, Corwin Press recently published an NISE book written by Susan Mundry and Ted Britton in collaboration with Senta Raizen and Susan Loucks-Horsley, *Designing Effective Conferences and Meetings in Education*, that is in part based on our experiences in making the NISE Forum into a knowledge-generating event (http://www.corwinpress.com).

While the Forum each year has been generously supported by the National Science Foundation, additional funding from OERI has this year permitted us to take the Forum a step farther. We have always been concerned as to how to capture the tremendous expertise brought to bear at the Forum. In the past we have produced reports that included Forum speeches and comments from participants but little analysis. Due to the importance of this year's topic and the success of the NISE Forum, OERI has enabled us to produce a more substantial document for wide circulation. It goes a level deeper than a simple proceedings document by including more summary and analysis of speaker and participant comments. Chapter 1 describes the sources of information for this report as well as their strengths and limitations.

Because nothing is more important to science and mathematics education than addressing diversity and equity issues, this has been a cross-cutting theme at NISE during its first five years. Eight NISE research monographs and information about a book by NISE fellow Sharon Lynch on diversity and equity issues in mathematics and science education are available on our Web site (http://www.nise.org). Contributors include Jane Butler Kahle, Okhee Lee, Alberto Rodriguez, and William Tate.

I earnestly hope that this report will be helpful to researchers, policymakers, education leaders, and teachers in considering future plans for research and action. If you wish to pass this report along to your colleagues, its text is available on our Web site along with information for obtaining additional copies.

Andrew Porter
Madison, Wisconsin
October 2000

Authors and Contributors

NISE Staff (Chapters 1, 2, 4)

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Joyce Kaser	Senior Researcher, National Center for Improving Science Education
Andrew Porter	Director, National Institute for Science Education
Senta Raizen	Director, National Center for Improving Science Education

Forum Keynote Speakers (Chapter 2)

Edmund Gordon	Professor Emeritus, Psychology, Yale University
Kent McGuire	Assistant Secretary, U.S. Department of Education, Office of Education Research and Improvement
Judith Sunley	Interim Assistant Director, National Science Foundation, Education and Human Resources

Forum Panelists* and Discussants (Chapter 3)

Panel 1

Elizabeth Fennema	Professor, Education, University of Wisconsin-Madison
Manual Gomez	Director, Systemic Reform Initiative, Puerto Rico
Okhee Lee	Professor, Education, University of Miami
Carole LaCampagne	Senior Research Advisor for Mathematics, U.S. Department of Education

Panel 2

Patricia Campbell	Principal, Campbell-Kibler Associates
Vinetta Jones	Dean of Education, Howard University
Maria Klawe	Dean of Science, University of British Columbia
Warren Chapman	Program Officer, Education, Joyce Foundation

Panel 3

Lloyd Bond	Professor, Education, University of North Carolina
Jeannie Oakes	Associate Dean, Graduate School of Education, UC-Los Angeles
Richard Tapia	Professor of Mathematics, Rice University
Norman Webb	Team Leader, Systemic Reform, National Institute for Science Education

* *Co-authors are identified in Table of Contents.*

Reporters from Small Group Discussions (Chapter 4)

Angela Calabrese Barton	Professor, Education, University of Texas-Austin
Tom Gadsden	Associate Director, Eisenhower National Clearinghouse
Joe Krajcik	Professor, Education, University of Michigan
Sharon Lynch	Professor, Education, George Washington University
Jerry Valadez	Science Coordinator, Fresno Unified School District
Aleta You	Senior Equity Specialist, New Jersey Systemic Initiative

Acknowledgements

We gratefully acknowledge the many individuals who made the 2000 NISE Forum a success and helped with this report. The following steering committee members provided invaluable guidance on developing the agenda, identifying experts to be on the program, and more: Juanita Clay Chambers, Jane Butler Kahle, Julio Lopez-Ferrao, Walter Secada, Richard Tapia, and William Tate. We thank Jane and Julio for their extra efforts in helping us recruit key people to be Forum attendees. We also owe an additional thank you to Juanita and her staff for helping with local conference arrangements in Detroit. The planning committee at NISE transformed the steering committee's advice into a detailed agenda, specific arrangements, etc. In addition to the authors, the planning committee included NISE co-director Robert Mathieu, project manager Paula White, and researcher Aaron Brower.

A special thank you goes to all of the accomplished experts who served on the Forum's program as panelists, keynote speakers, discussants, or reporters for the small group discussions. [See "Authors and Contributors."] We also thank the Forum participants for writing and discussing such rich ideas during the small group discussions. David Walsh's work as our conference assistant was conscientious and detail-oriented. Production of this report wouldn't have been possible without research by our intern, Betsy Moyer, editorial assistance from Nita Congress, and design work and printing by Corporate Press.

We are indebted to our funders for both their material and substantive support. At the National Science Foundation, Eric Hamilton and Eamon Kelley helped us identify diversity and equity as a timely focus for this year's Forum, Jane Butler Kahle and Julio Lopez served on the steering committee, and Larry Suter offered advice throughout the process. We also thank Maureen Treacy for arranging supplemental support from the Office for Educational Research and Improvement to produce this report. Nikki Filby at WestEd's Regional Education Laboratory and Gary Estes, a deputy director of WestEd, were very helpful in supporting our work through the OERI task order awarded to WREL. We especially want to thank the leaders of OERI and NSF's education directorate, Kent McGuire and Judith Sunley, for making room in their crowded calendars to prepare very insightful keynote presentations and to participate in the overall Forum.

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Chapter 4: Forum Participant Views

Highlights

The fifth annual Forum of the National Institute for Science Education, held in May 2000, considered diversity and equity issues in mathematics and science education, with special emphasis on research directions for the future. The topics discussed at the Forum covered a wide range of curricular and instructional equity issues in K-12 education, including the scaling up of successful programs. A number of clear research directions emerged from the Forum, as summarized below.

ACCESS TO COURSES AND TEACHERS

- **Documenting in detail the inequitable access to high-level mathematics and science courses.** How does inequitable access affect specific population groups? Does the current emphasis on Advanced Placement courses increase inequities in college admission? What is the role of school counselors in exacerbating inequities in course-taking opportunity?
- **Research on incentives to recruit science and mathematics faculty members who mirror the diversity of the student body.** What are the barriers to getting experienced, diverse faculty for the students who most need them? How effective are the emerging incentives for recruiting teachers for schools serving these students and for retaining them?

CONTENT, INSTRUCTION, AND ASSESSMENT

- **Research on culturally appropriate and effective science and mathematics content.** How can curricula balance the culture that students bring to school with the world for which their education must prepare them? What should be the orientation toward Western science and alternative views of science so as to equip diverse students to understand the dominant paradigms of scientific research and current knowledge?
- **Research on and development of instruction that will allow students from different cultural backgrounds to learn science and mathematics.** How does instruction need to be shaped to meet diverse cultural norms, for example, respect for authority, although Western science promotes questioning and argument? What influences the development of mathematical reasoning in different population groups? Why do students from underrepresented groups who earn good grades in school mathematics fail to achieve comparable scores on mathematics tests?
- **Research on assessments that will allow students from diverse backgrounds to demonstrate what they know and can do in science and mathematics.** What is the interplay between students' socialization, cultures and languages, different forms of assessment, and the opportunity they have to demonstrate their competence in science and mathematics? How can large-scale assessments be monitored to ensure their alignment with standards? What additional measures need to be developed to facilitate the use of multiple measures in assessing what diverse students know and can do in mathematics and science?

UNDERSTANDING AND SCALING UP EFFECTIVE PROGRAMS

- **Compiling programs that successfully address current inequities and research on effective replication on a broad scale.** What are the successful programs that should be scaled up? What are the lessons learned? What are effective and ineffective strategies for increasing access for and achievement of diverse student groups? How can reforms harness the system's resources to scale up from a few successful sites? What are the roles of parents and communities?

- **Improved evaluation of intervention programs.** Do evaluations document the relationships between student achievement and the system's processes of accountability and resource allocation to needy schools? Do evaluations consider unintended consequences that can thwart a program's success? Are there longitudinal evaluations in place that can determine more definitively the effects of reform initiatives on underrepresented groups?

TEACHER PREPARATION, INDUCTION, AND PROFESSIONAL DEVELOPMENT

- **Research on effective preparation and support programs for teachers to deal effectively with the needs of the diverse learners in their classrooms.** How can teaching for diversity be infused throughout teacher education as the essence rather than relegating equity and diversity issues to a separate, single problematic topic? What teaching strategies do preservice and in-service teachers need to know and practice to deal effectively with the learning needs in their classrooms?
- **Research on the support needed for beginning teachers.** How can beginning teachers be supported in learning how to address diversity and equity issues? How can we provide effective experiences in an efficient way that will help beginning teachers successfully teach mathematics and science to all their students?

BETTER RESEARCH METHODS AND DISSEMINATION

- **Disaggregation of data to more accurately reveal inequities in access and achievement.** How do diverse groups of learners respond to various interventions? How can the "achievement gap" be described more accurately in terms of diverse student populations?
- **Improving the pool of researchers to more closely reflect the diversity of the K-12 student body.** Are the voices of females, underrepresented groups, language and culturally diverse groups heard in the framing of research questions, data gathering, and analyses on mathematics and science learning? How can information technology be used to include these groups in research on equity and diversity issues?
- **Improved dissemination of existing research on equity and diversity issues in mathematics and science education.** How can existing knowledge be shared more widely? How can it be translated and packaged so that people—community leaders, administrators, leaders in mathematics or science education, teachers—can use it?

The 2000 NISE Forum Basis for Research Directions

This report is derived from the fifth annual Forum of the National Institute for Science Education (NISE) held in Detroit in May 2000: "Diversity and Equity Issues in Mathematics and Science Education—What Do We Know? What Do We Need to Know?"[1] Because diversity and equity has been a cross-cutting theme in all of the Institute's work, we were able to draw upon prior publications by NISE researchers and fellows Jane Butler Kahle (1998), Okhee Lee (1998), Alberto Rodriguez (1997, 1999), and William Tate (1997) when planning the Forum.[2] The race/ethnicity profile of the Forum's presenters and participants was diverse. (See "About NISE and the NISE Forum," below.)

The topics addressed in the Forum and in this report are far-reaching, but not comprehensive or exhaustive. The Forum topics ranged from discussion of what and how mathematics and science should be taught, to what factors make programs successful at doing this, to barriers and problems in the educational system that limit those efforts. The limits of a two-day event precluded consideration of all aspects of the Forum theme; thus, issues related to uses of educational technology were limited to gender aspects (see Klawe et al., chapter 3), and needs for research regarding learners with disabilities were mentioned but not described.

The main emphasis of the Forum—and of this report—was on K-12 topics, although postsecondary issues were also addressed to a limited degree. The NISE College Level One team is currently conducting a year study of equity issues in undergraduate mathematics and science education, however.

As Andrew Porter notes in the Preface, this report is more than just a conference proceedings document. The Forum is a knowledge-generating event wherein remarks by speakers and discussants are only an initial base of information. Because the NISE Forum is designed to elicit reflective thinking from its well-informed speakers and participants, the authors also were able to review and synthesize other sources of Forum information, including advance papers from panelists and written "think pieces" from Forum participants.

On the other hand, the analysis was not an exhaustive study wherein we could conduct a literature review and methodically map every Forum recommendation against existing work. (However, the nine Forum panelists included literature reviews on their topics as part of preparing their thirty- to fifty-page advance papers, which are available under "News and Activities" at the Institute's Web site, http://www.nise.org.) For more details about the methods used to produce this report, see "Analyzing Forum Information," below.

REPORT ORGANIZATION

Each of chapters 2-4 is based on a different source of information from the NISE Forum; Chapter 2 includes keynote speeches; chapter 3 presents papers by Forum panelists and remarks made by the panels' discussants; chapter 4 provides information from the participants' small group discussions.

The beginning of chapter 2—a synthesis of all the sources of information arising from the Forum—is the heart of this report. It emphasizes directions for future research on diversity and equity within these topics: course availability, assignment of students to courses and assignments of teachers; content, instructional practices, and assessments for diverse learners; effectiveness and scaling up of programs; and inadequate teacher preparation, induction, and professional development. The synthesis begins with a discussion of the need to continue a discourse about what diversity and equity goals the mathematics and science education communities are pursuing, since goals strongly affect both research directions and methods. This opening section ends by discussing improved research methods and the need for better dissemination of existing research.

The second part of chapter 2 gives a broader overview of future research directions by presenting the Forum's three keynote speeches. Kent McGuire and Judith Sunley, director of the Office of Educational Research and Improvement and interim director of the National Science Foundation's (NSF's) Education and Human Resources Directorate, respectively, launched the Forum by advancing a "big-picture" perspective of the needs for future research and describing how OERI and NSF programs are addressing them.[3] Drawing upon his decades of experience, closing speaker Edmund Gordon from Yale University and the Education Testing Service provided a historical perspective that should affect future research directions.

Chapter 3 contains short papers written by each of the Forum's nine major speakers, who served on three panels. The

[1] See appendix A for the Forum's agenda and participant list.

[2] These publications are described in and available from the Publications section of http://www.nise.org.

[3] ...ing remarks made by NISE fellow Sharon Lynch are included in chapter 4.

brief papers emphasize future research directions and are derived from the advance papers these speakers wrote for the Forum. The longer papers covered "What do we know?" in addition to "What do we need to know?" The papers in chapter 3 are provided in the order of their presentation at the Forum. After each panel's papers, the chapter includes the remarks of another expert who served as a discussant.

Chapter 4 begins with a short summary of Forum participant comments. Each participant was asked to write a ten-minute "think piece" during each of three small group discussions. The summary incorporates numerous illustrative quotes from these think pieces. The second part of chapter 4 consists of remarks made at the Forum's closing session by six participants who served as "reporters" for the small group discussions.

ANALYZING FORUM INFORMATION

Since the Forum, the authors of this report have analyzed the various pieces of information arising from the event. This analysis led to the synthesis in chapter 2 and the corresponding highlights at the front of the report. The following paragraphs describe the research methods used in developing these pieces.

Synthesizing Multiple Sources of Data

All sources of information from the Forum were treated as a data set and subjected to qualitative analysis. At least two researchers reviewed—several times—the entire information set from the Forum. As they read source material, researchers categorized paragraph or even line-to-line increments of information. Researchers' analyses were compared, and coding discrepancies were reconciled. Researchers reduced identified topics to seven broad themes that were used to organize and write this report.

The synthesis in chapter 2 was produced one theme at a time, first by revisiting all source information that previously had been identified as relevant to that theme. Drawing upon these data, the authors discussed the points that recurred most frequently and/or that seemed to be most substantiated or advocated. Researchers also selected and incorporated quotations that most clearly explained the nature of future research suggested or best articulated the need for it.

Analyzing Participant Feedback

Participants were able to provide thoughtful, informed feedback at the NISE Forum because the typical participant is quite experienced and is provided with papers from the Forum's panelists in advance of the event. The participants' general level of experience and specific Forum preparations are key to the conference's ability to be a knowledge-generating event.

Participants are a source of three kinds of information: (1) individual think pieces written during each small group session, (2) highlights from each small group, (3) and a reporter's summary of the small group highlights. After each of the Forum's three panel sessions, participants began a corresponding small group discussion by spending about ten minutes providing written feedback on the previous presentations. Participants responded to their choice of several prompting questions when writing these think pieces, such as: "What do you feel was the most important future research topic or approach advocated, and why?," and "Do you believe there is an important area of research within this panel's topic that was not sufficiently addressed?"

At each session for small group discussions, tables of eight to ten participants were asked to advance one or two points or questions that the group viewed as important. Table leaders wrote the consensus points on index cards that subsequently were given to a few participants who were invited to serve as reporters for the small group sessions. This year, six Forum participants reviewed the dozens of index cards from the discussion tables. At the Forum's closing session, the six reporters each made a five-minute presentation of their quick analysis.

Since the Forum, NISE researchers have read and coded each of the hundreds of think pieces produced, the index cards from each table discussion, and transcriptions of the reporters' comments during the Forum's closing session. Based on this analysis, the researchers summarized participant views in chapter 4. This summary became a valuable source of data for the overall analysis in chapter 2.

ABOUT NISE AND THE NISE FORUM

The Forum

Each year, NISE brings two to three hundred leaders in the mathematics and science education communities together for a "roll-up-the-sleeves" review of pressing topics in their fields. Participants typically come from about thirty-five states for this national event, and representatives regularly come from NISE's collaborating organizations, such as AAAS, AERA, ENC, NARST, NCTM, and NSTA.

The race/ethnicity profile of this year's chairs, panelists, and discussants was especially diverse, as was the profile of Forum participants—18 percent African American, 8 percent Hispanic, 5 percent Asian, 2 percent Native American, 53 percent Caucasian, and 20 percent unidentified. Participants came from varied organizations (42 percent from institutions of higher education; 20 percent, school districts; 20 percent, national projects/organizations; 14 percent, regional projects/organizations; 8 percent, federal employees; 8 percent, school teachers or administrators).

The experts asked to serve on the panels write briefing papers that are circulated prior to the Forum. Forum participants are accomplished researchers or educational leaders who

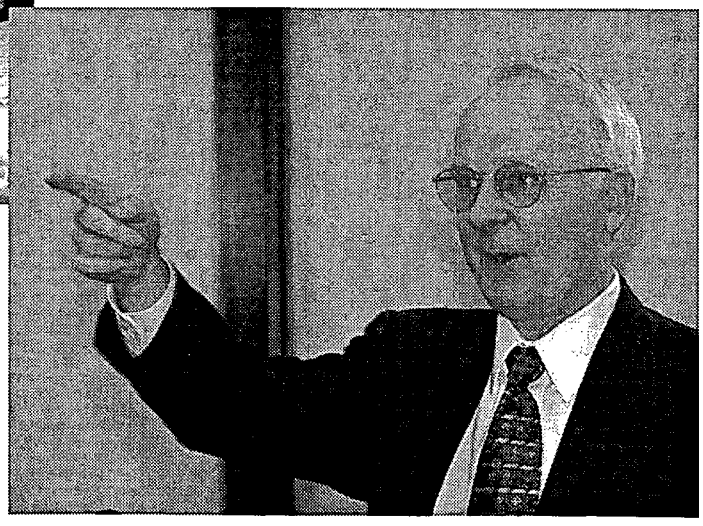
are often as expert as the panelists, making the small group discussions as valuable as the panels they follow. Forum attendance is limited to ensure productive small group discussions in which all participants are able to contribute their expertise. Participants' substantive comments are reviewed after the Forum and inform the proceedings that are mailed to every participant. Each year's participants have indicated in evaluations that the NISE Forum is exceptional in terms of stimulating intellectually rich conversations about important topics, providing quality time to network, and making respectful use of participants' time. This year's Forum was the most highly rated to date. An NISE book on designing professional meetings and conferences in education is now available (Mundry, Britton, Raizen, Loucks-Horsley, 2000). Previous Forum topics and available conference proceedings can be found under News and Activities/Forums at http://www.nise.org.

Edward Britton, associate director of the National Center for Improving Science Education, coordinates the annual Forum in collaboration with NCISE director Senta Raizen, NISE director Andy Porter, and NISE team leaders. Primary support for the annual NISE Forum is an Institute grant from NSF.

Supplemental funding for producing this report came from the U.S. Department of Education's Office of Educational Research and Improvement and the Western Regional Education Laboratory at WestEd.

The Institute

The National Science Foundation launched the NISE in 1995 at the University of Wisconsin–Madison, with the Washington-based National Center for Improving Science Education as its chief partner. The Institute's faculty and fellows are conducting research and development in science, mathematics, engineering, and technology education across grades K-16. Leading the Institute is Andrew Porter, director of the Wisconsin Center for Education Research, and co-director Robert Mathieu, professor of astronomy. The Institute's Web site provides complete information about NISE researchers, projects, publications, and other activities.



Directions for Future Research

The two sections of this chapter give an overview of the directions for future research that were recommended at the 2000 NISE Forum:

1. A synthesis that draws upon all the sources of information available from the Forum, including panelist papers, keynote speaker presentations, and participant discussions.
2. Overviews of the field provided by opening keynote speakers Kent McGuire and Judith Sunley, and closing keynote speaker Edmund Gordon.

SYNTHESIS OF RESEARCH DIRECTIONS

This report advances recommendations for future research on equity and diversity issues in mathematics and science education. Why? Why is it imperative, as we begin the new millennium, to enable all students to become literate in science and mathematics? For one thing, the need to do so is already acute and has been so for some time. Edmund Gordon, a preeminent expert on diversity and equity issues, noted at the Forum's close that "It's almost discouraging that many of the issues I came into the field struggling with in the forties are still the issues that we struggle with now."[1] And the nation's dramatically changing demographics are only escalating the need to address diversity.

In addition, we all too often, forget the genuine, exciting opportunity that diversity presents: Oakes, Muir, and Joseph note that "We must...start believing in the idea that diversity is needed to better us all." These authors go on to say that we should take to heart the challenge posed by Rita Colwell, director of the National Science Foundation: "Different perspectives, talents and experiences produce better ideas" (NSF 1999, p. ii). Fortunately, there seems to be a more widespread and deeper interest right now in forging solutions to diversity and equity issues, in part because the standards movement has put enormous pressure on teachers, administrators, and others to get all students learning to standards.

Because anyone in education today cannot help but frequently see or hear such discussions, this report does not seek to further convince of the needs or provide another literature review. So we move to the heart of this report, a very needed but less commonly discussed aspect of the challenge: What future research will help us tackle these problems more successfully?

Our discussion of research needs is organized by the following topics, which are drawn from the speaker presentations and papers at the May 2000 Forum of the National Institute for Science Education, as well as feedback from participants at that conference:

- detailing persistent inequities in courses available, students' course assignments and teachers' assignments;
- addressing multicultural issues in the curriculum more substantially;
- understanding more deeply the differences in how students learn;
- disentangling which program features work and don't work, and learning how to scale up effective programs;
- empowering teachers during preparation, induction, and development to address equity issues;
- strengthening research methods; and
- improving dissemination of research.

Goals for Diversity and Equity

Before turning to research directions that emerged from the Forum, we note that critical differences of thought exist in the field about which diversity and equity goals the educational system should be pursuing. One Forum participant asked, "How well do we agree on what the problem is and where we want to go? Could divergence undermine the overall enterprise?" To illustrate a current question about goals, set aside clear exceptions such as gender issues in the use of technology and ask: Should the recent successes in addressing imbalances in access and achievement by gender result in less research on this issue in the future?

Another illustrative debate about goals is questioning the prominent strategy of using special programs for addressing diversity and equity issues. Some experts argue for shifting to a more holistic approach wherein "rising tides lift all boats," but others argue an opposite view—that research and programs

[1] The quotations in this synthesis are drawn from other parts of the report, unless otherwise noted. See the Table of Contents to locate the cited authors' source material.

should distinguish among groups even more specifically than has been common practice to date. Tapia and Lanius use the phrase "diversity within diversity" to advocate the latter view. For example, "Hispanic" is too broad a category, because subgroups within it have many differences that can be masked or even misrepresented when describing all collectively.

An analog of these issues faced in schools is occurring at funding agencies. Moving from having targeted programs to including concepts of diversity and equity in everything the National Science Foundation (NSF) does is quite difficult, because it requires that everyone in the agency keep diversity at the forefront of issues in their minds. Judith Sunley, interim director of NSF's Directorate for Education and Human Resources, comments on this later in this chapter: "If you have a focused program that is a budget line, then in some sense, your accountability is budget accountability...When you are embedding things, however, you have to find another way of being accountable, because it can be very difficult to tease apart the diversity aspects of much broader activities."

Addressing a different goals issue, Forum discussant Norman Webb refers to an infrequently discussed form of "tracking." He points out that, in the United States, we emphasize the goal of empowering all types of students to enter and achieve a college education. But are we adequately considering the quality and nature of the system's educational goals for the two-thirds of our students who are not college bound? An argument can be made that other countries give a more equitable education than do we to the non–college bound (Britton, Hawkins, and Gandal 1996).

While these discussions are as much political and philosophical as they are empirical, issues about goals present formidable challenges to setting the research questions to be investigated and devising the research methods that should be used to address them.

Detailing Inequitable Course Availability, Student Tracking, and Teacher Assignments

Thanks to the fact that a substantial body of research already has been conducted on these topics, education communities are well aware of the topics and, more significantly, already convinced that it is essential to tackle them.

Addressing the Achievement Gap

Oakes, Muir, and Joseph note that "In a decade of policies pressing for high standards in schools that remain separate and unequal, we've made some progress in raising the levels of course-taking and achievement for all racial groups. However, we've done little to reduce the gaps among them." Moreover, aspects of that achievement gap are still not adequately understood. Gordon laments our limited progress in understanding the gap:

> I spent a good bit of my career thinking that if we could somehow do away with poverty, we could do away with the underproductivity of some schools and of some of our students. But...the higher you go with respect to socioeconomic status, the bigger the gap...The gap in achievement between black middle-class and white middle-class kids...is bigger than the gap between lower-class whites and lower-class blacks...Maybe we have not appropriately conceptualized the problem... Consider... that the reasons for academic underproductivity on the left end of the [socioeconomic] distribution may be quite different from the reasons for underproductivity on the far right end of the distribution...I don't think the history of interventions on this set of problems in this country has reflected that possible complexity.

Access to Courses

A solid body of research now exists on the inequities of tracking students, both in terms of the courses offered and the assignment of students to them. And current research is bringing to light some lesser-known and more insidious forms of inequity and discrimination. For example, is it fair for institutions of higher education increasingly to emphasize Advanced Placement courses for appraising applicants for college entrance when many secondary schools serving the most underrepresented students are not able to offer these high school courses? Here is a finding brought out by Oakes, Muir, and Joseph that was not common knowledge among Forum participants: Some school counselors exacerbate inequities in opportunity by dissuading students belonging to some underrepresented groups from taking challenging science or mathematics courses—even when their prior achievement in math and science was on a par with or better than that of white students. Further, lower-income families lack the experience of upper-class families of negotiating with counselors and school administrators to have their children assigned to better courses.

Diversity of the Student Body Mirrored in the Science and Mathematics Faculty

By now, the education community is convinced that schools with high proportions of underrepresented students need a school faculty that is itself diverse; this enables it not only to provide role models but also to relate mathematics and science more effectively to students' cultures, languages, and daily experiences. Diverse classrooms require teachers with strong content and pedagogical content knowledge who can diagnose misconceptions, address widely varying learning styles, and adjust for students' varied states of educational readiness. They typically must be able to accomplish this with inadequate supplies and facilities.

But there are severe barriers to getting experienced, diverse faculty to the students who most need them. There aren't enough of them, for one thing; and experienced teachers often leave these schools quickly in search of higher pay and better teaching conditions. Thus, disadvantaged children dispropor-

tionately have less-qualified and less-experienced teachers. A Forum participant asked, "Are the best teachers ever 'tracked' to teach the underrepresented students? Are there mechanisms for 'de-tracking' teachers?" Research is needed to study the effectiveness of emerging incentives to recruit teachers for these challenging assignments—and to retain them.

Beyond Description of the Problems

Should research on issues like these continue in the future? Absolutely. But this report's title, *Beyond Description of the Problems*, was prompted by remarks made during the opening keynote address of Kent McGuire, assistant secretary of the U.S. Department of Education and director of its Office of Educational Research and Improvement (OERI):

> And regarding future research, particularly, is where my anxiety comes in. Because what we so often do is work more on *describing* a problem than on actually trying to *solve* it. In fact, we are very good at describing problems—very good, especially in describing the achievement gap. We understand this gap in lots of different ways, with increasing statistical power and even nicer slides. We also are really good at something else, at describing "end states"–what the world would look like if we got it right.

Determining Effective Content and Instructional Practices

What mathematics and science content should be taught, and *how* should that content be taught? In answering these questions, considerable progress has been made in addressing gender equity issues; more research, however, is still needed. The most prevalent issue about content and instructional practices at the Forum was the need for much more research on multicultural education, that is, how the curriculum can address the needs of a more culturally and linguistically diverse student population.

Outstanding Needs for Research on Gender Equity

Fennema cites two examples of needed research in this area. She points out that : "Many [mathematics] textbooks and teachers are more aware of contexts that are from male-dominated fields...Can mathematics be situated equally in female-dominated fields, and if so, will boys willingly participate in such problems?" She also notes that reform recommendations encourage students "to communicate their mathematical thinking by presenting their ideas and convincing peers of their correctness by arguing and questioning...Many teachers have reported informally that girls will not do so for a variety of reasons."

Klawe and colleagues opine that considerably more research on gender issues is needed, especially with regard to the use of computers and other technologies: developing more diverse and application-oriented approaches and resources for teaching computer science, investigating how to change the popular perception of computer professionals, and developing effective preservice and in-service approaches for upgrading the equity knowledge and skills of teachers and counselors. Further, they note, that it should be investigated as to whether the findings about gender issues and the use of computers also apply to other groups underrepresented in information technology.

Research on Culturally Appropriate and Effective Science and Mathematics Content

LaCampagne summarizes the problem in this area as being "how to marry the culture that students bring to schooling with the outside world for which we want to prepare them." Most of the research on this topic occurred in the 1990s and is still at the stage of conceptualizing issues that need empirical testing. Lee explains that "Research efforts [to date] generally involve identifying educational problems or describing instructional practices, rather than implementing intervention strategies to promote teacher effectiveness or student achievement." She argues for a balanced orientation between Western science and alternative views of science rather than a sole focus on one or the other. To focus only on Western science fails to engage all learners and makes them less able to learn the content; focusing only on alternative views of science does not equip students to understand the dominant model of scientific understanding and research.

Developing Instruction and Assessments That Will Allow Students from Different Cultural Backgrounds to Learn and Demonstrate Their Competence in Science and Mathematics

Multicultural issues have implications for instructional and assessment practices as well as content. For example, students from some cultures can fail to learn when their norm is to respect authority while Western science promotes questioning and argument. Substantial professional development will be needed to help teachers who generally are unfamiliar with diverse languages and cultures, and research must be conducted on what professional development is effective in changing teachers' knowledge, beliefs, and practices in this area. Research has even farther to go for sufficient understanding of the interplay between students' cultures and languages and their responses to assessment items (Nelson-Barber and Solano-Flores 2000).

For addressing the topic of instructional practices, Lloyd Bond provides an intriguing look at something little understood in the field: Why do underrepresented students who earn good grades in school mathematics fail to achieve comparable scores on mathematics tests? In contrast to the other Forum panelists who synthesized research on their topic, Bond reports on some pilot research he has done on this important question, which he calls the "good grades/low test scores" problem. The research illustrates in detail the difficulty, found by other researchers as well, in moving students from being able to solve well-structured mathematics problems to being able to solve verbally presented tasks ("word" problems), something that Bond feels is "perhaps the single biggest instructional challenge in all of high school mathematics."

Besides urging similar research that closely explores students' reasoning and actions, Bond advocates research that would explain the influences on students' mathematical reasoning: ethnographic studies of mathematics instruction taking place in classrooms and studies of students' non-classroom engagement and time spent on mathematics. Both Bond and Gordon urged for attention to research on "stereotype threat," such as work done by Steele (1997) and summarized by Bond:

> Individuals who are the object of a negative stereo type...tend to so internalize the stereotype that it adversely affects their performance on such measures [of intelligence and scholastic ability]. When students were randomly asked to solve a series of problems under stereotypically threatening conditions ("this is a test of intelligence") and under innocuous conditions ("this is an experiment on processing strategies"), African American students randomly assigned to the former conditions did significantly worse. We need to know how pervasive this phenomenon is and to devise effective ways to counter its potentially harmful effects on student academic growth.

Understanding and Scaling up Effective Programs

What are the successful programs that should be scaled up? "Currently," Campbell and Hoey note, "There is no comprehensive compilation of programs and strategies. Compilations that include lessons learned, effective and ineffective strategies, and even hands-on activities are badly needed." Jones and Bouie cite a need to better understand what roles played by parents and communities are effective for programs, that is, "the way in which programs define their relationship with students' families, the ways in which programs that produce high student achievement work with parents, and whether these interactions differ from those in programs that do not produce gains in student achievement."

Compiling Successful Programs and Research on Effective Replication on a Broad Scale

How can we replicate successful programs was a recurring question at the Forum. Assuming that the systematic information called for by Campbell and Hoey already was available for identifying a program with features relevant to particular local needs, how would we go about adopting, adapting, and implementing it? Jones and Bouie point out: "Another critical research area is the examination of programs that have indeed successfully scaled up beyond the original pilot or site to other sites, to sites outside the district, to the district as a whole, or to other states. Quality ethnographic data on what was done and on how and why things were done could provide useful information to practitioners and researchers alike." McGuire also notes the urgency for research on this topic:

> We have increasingly elegant solutions that can happen in the most unusual or special conditions... The hardest thing for us to figure out is how to make extraordinary things happen in very ordinary places. And we have not figured that out, and it's where the suggestions for future research are least clear, least well developed, and where our plans for doing this work need the most attention.

Warren Chapman illustrates the kind of information we need by discussing the Equity 2000 program formerly led by Forum panelist Vinetta Jones (Jones and Bouie 2000): "Do we have teachers who can talk to other teachers about...how they learned it, how they took it to the classroom, and what they've learned from it? These are important things if we are going to translate this knowledge from one place to another; we've got to have translators. This is some of the research that still needs to be done."

We do know that if enough money and other resources are brought to bear on a particular problem in a specific locale, some desired changes undoubtedly will result. "But," as Gómez and Dávila note (2000):

> When the scaling-up stage is reached, most reforms fail because they are not able to harness the system's resources. Also missing from most reform efforts is a systemwide evaluation that will document improved student outcomes and the system's process of accountability and allocation of resources to meet the needs of the reformed schools. The absence of this key element breaks the reform cycle.

Improved Evaluation of Intervention Programs

More programs need evaluation components, and most of these evaluations need to be stronger. Too few evaluations have a sufficiently broad focus and are adequately financed and conducted. For example, evaluations rarely consider unintended consequences that can thwart a program's success, as Campbell and Hoey illustrate: "Hands-on science activities led by adults with no knowledge of equity strategies [may cause] students to become more stereotyped and limited in their opinions of who could do science." Typically, because of a lack of resources, few programs conduct longitudinal evaluations, a type of research that can determine more definitively what works and what doesn't.

Campbell and Hoey also note that, in designing evaluations, several tensions need to be considered: "the role of statistically significant change versus meaningful change; the value of one well-controlled study versus many studies with different flaws; and the value of comparing the impact of one program to that of another...versus assessing program impact in terms of the degree to which it meets an acceptable criterion."

Equipping Teachers during Preparation, Induction, and Professional Development

The educational system generally does not empower teachers to deal effectively with the learning needs of the diverse learners in their classrooms.

Research on Effective Preparation and Support Programs for Teachers

Teachers need more support in knowing how to reach diverse students throughout their teaching career: during their preparation program, particularly during their induction period, and continuing. Correspondingly, more research needs to take place on how to deliver effective support. A Forum participant described this needed research: "We need research focused on understanding how teachers view the interaction between culture, language, and gender with curriculum, instruction, and assessment. We also need research that illuminates how teacher education and professional development can facilitate teachers reflecting critically on their views and acting on their understanding." Lynch describes the need for a structurally different approach during teacher preparation, one that would require some research to effect:

> Teaching for diversity should be infused in science teacher education as the essence of what we do rather than relegate equity issues to a particular chapter or class session, lumping them together as a single problematic issue...Diverse learners are not exceptions, and it's time that teacher education programs took that position from the get go.

Research on the Support Needed for Beginning Teachers

There is an acute need to support beginning teachers in learning how to address diversity and equity issues. Even teacher education programs including substantial in-classroom experiences cannot fully prepare teachers for the daily reality of helping diverse learners. Merely providing beginning teachers with an orientation or a token induction program is quickly becoming recognized as a serious inadequacy of the U.S. system (Britton et al. 2000). Teacher induction programs need to be more substantial, including a focus on instructional practices that can help students from diverse cultures and languages. Since diversity and equity issues have not to date received sufficient attention in most teacher preparation and induction programs, the great majority of today's experienced teachers also would benefit from significant professional development experiences. Across the nation at large, so little support has been provided to teachers on this aspect of their profession that it is no surprise that we need much more research on how to provide effective experiences in an efficient way.

Improving Research Methods

Forum participants advocated several improvements in the methods used for future research, as follows.

Ensuring That the Pool of Researchers Is More Diverse

Even methodologically rigorous research is influenced by the perceptions and beliefs of the researchers conducting it, at least unwittingly if not intentionally. Therefore, as McGuire notes, "It will matter a lot who does this work" As an example, Fennema asks, "How was the information about values [in gender research] obtained? Were females' voices a part of the data-gathering procedures?" And Sunley points out the importance of drawing in new communities:

> One of the real problems...is that many communities of underrepresented groups are actually quite isolated from the mainstream of science and engineering, both in research and education. We need to consult with these communities, and Forums like this are one way hat we can do that.
> If we can take advantage of the current boom in information technology to make those connections and break some of the isolation, we have an opportunity to bring people in.

More Emphasis on Student Achievement as the Indicator of Effectiveness, If Appropriate Measures Are Used

There is a lot of sentiment that a better job needs to be done to tie research and interventions to student achievement, but only if the measures of student achievement are appropriate. During interviews with members of the NISE Forum Steering Committee who planned the conference agenda, Walter Secada said that if the Forum could only be focused on one aspect of diversity and equity issues, he would emphasize the need for the research community to embrace rather than shy away from this challenge. At the same time, the reticence of researchers is understandable. Standardized tests that often are used to measure student achievement can be antithetical to important tenets of standards-based mathematics and science education. For example, tests using mainly multiple-choice and short-answer items are inadequate for reflecting whether students can do science inquiry. This is an example of the importance of aligning assessments with curriculum frameworks and instructional practices. Forum discussant Norman Webb noted that large-scale assessments typically only cover about one-third to one-half of the curriculum standards, adding that "You need multiple measures and you need monitoring of any large-scale assessment program."

Disaggregation of Data to Reveal Inequities More Accurately

There were recurring calls for collecting and reporting data that are disaggregated by various student populations. The argument goes that only disaggregated data can adequately describe the "achievement gaps" that are much in the news today and, therefore, can clearly inform the education commu-

nity about the needs to be addressed. Drawing upon her recent book, *Equity and Science Education Reform* (Lynch 2000), which partly resulted from an NISE fellowship, Sharon Lynch provides a caveat:

> I think we have a research conundrum. We could take a color-blind approach in our research designs and simply aggregate data, but in so doing we wind up accomplishing little more than gap gazing. We may notice interesting things going on in classrooms populated by diverse learners, but the design wasn't sensitive enough to capture the phenomenon adequately. So we're left with anecdotes. Alternatively, we could design research that looks specifically at how different groups of diverse learners respond to interventions, but we risk the danger of overgeneralizing or stereotyping.

From her synthesis of Forum participants' "think pieces," Kaser explains that there are formidable technical and other challenges to obtaining data that can be disaggregated into more specific populations than have been reported in the past. For example, it would be difficult and expensive to obtain the sample sizes necessary for accurately describing more specific populations. Further, the number of people who identify themselves as multiracial is increasing rapidly.

Disseminating of Existing Research

While this report emphasizes needs for future research, many Forum participants strongly felt that *existing* research results needs to be better disseminated as well. The following comments by Joseph Krajcik, former president of the National Association for Research in Science Teaching, echoed those of several other "reporters" who characterized participant conversations during the Forum's breakout sessions:

> [A theme that came through] concerns the sharing of information. There is a lot of information available already, but we need some strong models of how we can disseminate that information. People want to know that information, and they need to get it in a way that is readily accessible and useful for their purposes. In fact, this is a little quote [that came through]: "useful format for busy people"...Related to that, we have to reexamine the information that is out there...We have to go back and carefully examine the information that is out there so we don't keep circulating myths.

This perception should not surprise us. Typical Forum participants are very experienced as researchers, project leaders, or administrators who have the mandate to keep on top of research on diversity and equity issues, but are hard pressed to do so among their many competing responsibilities. Indeed, it is a tall order for leaders in science, mathematics, or science or mathematics education to keep abreast of research in areas that aren't central to their original training and expertise.

Consider that this recurring request for better dissemination came from professionals who, presumably, have above-average interest in diversity and equity research, evidenced by electing to make time in their schedules for this Forum. Perhaps leaders at large have an even deeper need for better information. And what must be the information needs of classroom teachers, who have virtually no time to keep up with the literature? A Forum participant wrote: "Much research is shared, but little of it reaches the teachers and students where it could effect change. Researchers tend to talk to researchers, not teachers."

Because future research directions was the Forum's emphasis, the participants and speakers didn't produce recommendations on how to achieve better dissemination of existing work. We nevertheless note the plea for it so that policymakers might further consider the problem.

OVERVIEW OF RESEARCH DIRECTIONS: KEYNOTE SPEAKERS

KENT MCGUIRE

Opening Session

"We have not yet figured out how to move from describing problems, to developing solutions, to testing and evaluating these solutions, so that we have a set of ideas about reform that actually holds the promise of working within the day-to-day realities of most schools and school systems. This is where the suggestions for future research are least clear, least well developed, but so desperately needed."

Thank you very much for inviting me today. I am very pleased to be here because this issue is very important to me. And this is an important event. What I'll do very quickly is comment briefly on the papers that were commissioned for the conference. I'll give you my own wide-angle lens on them, and then say a few words about what we are up to at OERI. I am going to highlight what I am hopeful about, but will speak with some candor about what makes me anxious, only because I hope you will talk about these issues over the next day or two.

I am very enthusiastic about the design of this meeting. Moving from a focus on content and instructional practice, to programs that explicitly tackle equity and diversity issues, to even talking about what is actually happening to and for students right now. I think this is the right terrain, the ground we need to cover. All too often we stop short of talking about what is actually happening for the kids. I think it's very useful for us to not just walk up to the problem, but to try to work all the way through it.

I see myself as someone who has been in the equity business for many years. When I was at ECS back in the 1980s, I worked on these problems from quite a distance. I used to be one of the six people who traveled around the country trying to understand or study school finance systems. So I was very concerned with dollars, with distributive issues and policies that would try to level the playing field for kids. When I went to Indiana, I became intrigued with the idea of trying to work underneath the level of dollars, and came to learn a lot about schools. I'm still trying to learn about schools and how to get in the reform business and influence them.

Along the way, I got very interested in the notion of standards, because they struck me as a much more powerful way to operationalize this interest we all have in equity. One thing they say is that no kid should have less than $5,000 spent on him or her; that variation shouldn't be a function of wealth, but of need. But what does the money translate into? It turns into learning opportunities and standards. I thought they provided a metric, a lens, a way of trying to understand what the purchase is all about in terms of the nature and quality of curriculum, of equality, of access to good teachers, etc.

Over the last two or three years, as I've worked on standards-based reforms, particularly for The Pew Charitable Trust, I began to worry a lot about whether or not we really know enough to substantially help all kids reach standards. I'm not sure we do, which is partly what inspired me to join the Department [of Education]—a real opportunity to clarify what we know and what we don't know and to shape how we work on a given problem. It would be a mistake for us to assume we know enough when in fact we might not.

And this last point is a perfect transition to the papers, so let me say something about them, because I think they nicely set up this point I'm trying to make. Elizabeth Fennema tells us that the achievement gap persists. We do know something about why, and she talks about that. She tells us that values dominate when it comes to the research that we do in this area. So it will matter a lot who does this work. Let me repeat: *It will matter a lot who does this work.* Sharon Lynch was trying to tell us the same thing: If you want to make headway, it matters a lot who does this work. They influence how problems get framed and how solutions are laid out and elaborated for people to take those ideas and run with them seriously.

Okhee Lee says that there is little consideration of the experiences, languages, and cultures of minority students in the science we teach today—even in, to some degree, the recommendations we make about what should be taught and the standards that we promulgate. Pat Campbell and Lesli Hoey say that we can't identify programs that do what Okhee is looking for. Anne Bouie—who, by the way, is a recent colleague of mine at OERI, having participated in one of our fellowship programs this past year—and Vinetta Jones say that where we do find these programs, we also find that they tend to build on the skills and understandings that the kids bring with them to school. But Jeannie Oakes, Kate Muir, and Rebecca Joseph tell us that these programs are clearly the exception and not the rule.

So we manage to create these little boutiques, but we haven't figured out how to do this in a big way that holds the promise of reaching all the kids. And we should ask ourselves, "Why is that? What's behind that?" And it may go in some sense to whether we really know how.

On that score, I do not mean to suggest that we don't know anything. The papers are clear about that. We know that cur-

riculum is important. We know that teacher content knowledge matters. We know that we need to bundle these things up, cobble them together, in ways that busy people in classrooms trying to make decisions about what textbooks to buy, what curricular series to use, can grab and put to good use.

But there are still things we're going to need to know, and the papers point at some interesting and much-needed areas for future research. I won't summarize them so much as characterize what I think the papers are telling us. And regarding future research, particularly, is where my anxiety comes in. Because what we so often do is work more on *describing* a problem than on actually trying to *solve* it.

In fact, we are very good at describing problems—very good, especially in describing the achievement gap. We understand this gap in lots of different ways, with increasing statistical power and even nicer slides. We also are really good at something else, at describing what I often refer to as "end states"—theoretically or conceptually powerful solutions.

In other words, we have increasingly elegant solutions that don't stand a chance of happening except in the most unusual or special circumstances. We have not yet figured out how to move from describing problems, to developing solutions, to testing and evaluating these solutions, so that we have a set of ideas about reform that actually holds the promise of working within the day-to-day realities of most schools and school systems. This is where the suggestions for future research are least clear, least well developed, but so desperately needed.

So now let me turn to OERI and tell you a good news/bad news story. Let me start with some good news. I think, both at the Department in general and at OERI in particular, we are very much invested in these issues of equity, generally speaking, and in improving achievement—in math and science in particular. I don't know how anyone can really argue about the discipline and focus that we have maintained in terms of federal policy. You can argue about whether you buy this idea of standards-based reform, but you can't argue about whether there has been a sustained focus and a particular theory of action on a guiding policy over this period of time. There's been a sustained focus on content and a clear interest in reading, math, and science.

And we have big bets—placed, in some sense, through our Eisenhower Regional Math/Science Consortium—on technical assistance. We have a recent bet on the Glenn Commission[2], which in just a few months will come forth with policy recommendations about how to hit this problem with greater attention and force. OERI also has a math and science center, which has a long and productive history and will continue doing some very important design work, among other things. That's all part of the good news. We have gotten focused on a specific problem.

But we haven't figured out how to hit the achievement problem with enough force so that you could say we are in anything more than the triage business. What do I mean? Well at one level, we have these things called Expert Panels. To our credit, we're willing to go out and try to make some judgments about what we know right now, where the good stuff is. It's just that this won't be good enough. We have to get beyond promise to evidence of real effects. And we need to develop a body of knowledge on how to make more of the good stuff—programs grounded in evidence—happen.

In my opinion, mathematicians and the higher education community are deeply implicated in what will or will not happen in the reform of mathematics education. And I do not mean that the answers somehow reside on campus and simply need to be delivered to elementary and secondary schools. What, in fact, I mean is that until we focus on teaching all the students on campus and not on creaming the students off the top and then complaining about the rest, we won't really make a dent in this problem. And we won't prepare teachers who can help all kids learn math in elementary and secondary schools, either.

Now, with respect to implementation—how to know what works and to understand why—I think Andy [Porter] is absolutely right. We need a lot more work in real places, studying things in real time, to help us understand something about what it takes, not in easy places but in the hard places. I'm very hopeful we're going to see some of this because we have a nice budding relationship with the National Science Foundation through this Inter-agency Education Research Initiative. But this will be a difficult endeavor, because we simply haven't tried to do this before. We need new communities: we will need more conferences like this and institutions to bring people together to figure out what doing this work is all about. And if we don't have people engaged in the work who look approximately like the folks we're trying to help, this will be a problem, too. We must have a diverse group of people involved in finding the solution to the achievement problem in math and science.

So this work is very fragile, both in terms of our limited knowledge of how to do it and of how difficult I suspect it might be to sustain through changing regimes, changing budget cycles, and so forth. It will happen if you want it to happen, but I can tell you right now, there is very little constituency for the field. We have a lot of work to do in building a constituency that supports this kind of work.

The last thing to say is that at the end of the day we will need to be much better research planners and managers of research programs. And we'll need to figure out how to focus even more specifically on important topics that people in the field are really trying to struggle with. We're trying to do that at OERI too, right now. I pointed out Carole LaCampagne;

[2] National Commission on Mathematics and Science Teaching in the 21st Century (2000).

please know that she is right on point with respect to our planning area in the math arena. We have a similar planning effort going on in reading. To focus on these two topics has meant that we have consciously decided not to work in other areas, at least not right now. This may prove not to be a very popular move. There are many demands on, many expectations of, public enterprises like OERI.

I am optimistic, however, for three reasons. One, I believe we're at a moment that is unprecedented in that people really want help. The standards movement has put enormous pressure on teachers and administrators and others to figure out how to do this, especially in reading and mathematics. And if we haven't known how to do it before, at least we know now what it is we need to do. We need to get all kids to standard. Two, I believe scholars want to be players in the reform, and I think they're starting to figure out—we're starting to figure out—that it is in their self-interest to do this.

And, finally, I believe we understand that the problem is bigger than education per se. That's why there is so much traction associated with collaborating with the National Science Foundation. That's why you're finding so much low-hanging fruit when you bring the people from the disciplines together with the education researchers. I wasn't around in 1980, but I like to read the history. Go back another ten or fifteen years to the turbulent times of Man: A Course of Study and you saw the physicist, the biologist, and the other scientists literally run from education—it just got a little too hot. I think they're back, and I think we can draw them in. I think when we do, we have a chance to change the odds. But that is what you all should be talking about—changing the odds. Have a great meeting.

JUDITH SUNLEY

Opening Session

"One of the real problems of addressing equal opportunity, equity, and diversity is that many communities of underrepresented groups are actually quite isolated from the mainstream of science and engineering, both in research and education. If we can take advantage of the current boom in information technology to make those connections and break some of the isolation, we have an opportunity to bring people in."

Andy Porter just mentioned that I arrived at NSF in 1980. How many of you know what happened in 1980, in terms of legislation affecting NSF that is relevant to this meeting? A few may remember that the National Equal Opportunity in Science and Engineering Act was passed, one of about four or five major amendments to NSF's originating legislation. It established the NSF Committee on Equal Opportunity in Science and Engineering, which has been affecting NSF's programming in significant ways since then. I arrived in 1980 and, at that point, I was the only female program officer on the staff of the Mathematics and Physical Sciences Directorate. So guess who got assigned to the implementing working group that would deal with some of these issues? From that point on, I've had a strong ongoing interest in diversity and equal opportunity areas within NSF.

Another factor in my interest in this whole area occurred about five years after that, when I was appointed as the first executive secretary for the National Science Foundation's Education and Human Resources Committee for the National Science Board. This gave me an up-close and personal look at what was going on in areas related to education and human resources across the Foundation. It's the kind of opportunity those of us buried in the scientific disciplinary divisions don't normally have. And it makes a big difference when you come out of the specific narrow disciplinary lines into something with broader relevance.

When Andy asked me to make opening remarks, I started thinking about the various things I've seen in terms of discussions of diversity and equity over the years. About four years ago I attended—actually on behalf of then–deputy director Anne Petersen—a session held in Seattle that was run by AAAS and the Council of Chief State School Officers on excellence and equity in school education for girls. Many of you actually participated in that; I tried to match up the participant list and found that there was a moderate overlap. At that point, one of the things I did was read a brief excerpt from the strategic plan that NSF had just passed. And I want to read a similar excerpt right now, because I think that it continues to be relevant. And although now we are a couple of generations of Government Performance and Results Act strategic plans beyond the one that I read from, this is still the guiding language in terms of our thinking about diversity and education.

It started out by saying that, in a democratic society that is highly dependant on science, mathematics, and engineering for its well-being and place in the world, the scientific enterprise

cannot thrive unless it is open to all segments of the population. It went on to say that America's future depends on the next generation, those currently being educated in our schools, colleges, and universities or embarking on their careers in industry, academia, or government. Enhancing their capacity to perform; to create, innovate, and solve problems; and to demonstrate that capacity must be a vital component of NSF's activities. Finally, acknowledging excellence when it is fully apparent is comparatively easy, while recognizing potential and developing the capacity for excellence is a much more difficult task.

These things remain an integral part of NSF's efforts, and, yet, when those of us in the senior management at NSF sit down and think about issues related to diversity and equity, we continue to be stymied. While we do in fact have some feel for what works when committed individuals get in and get their hands dirty and make things happen, we are frequently at a loss when it comes to figuring out how to do that on a broader scale. As Andy said to me while we were sitting at the table, "If you're not talking about equity on the broader scale, you're not talking about equity." So here are some of the things that NSF is doing currently. Andy asked me to cover a few bits and pieces about NSF directions and that is what I will try to do.

First, what are some of our objectives? We're looking to increase the percentage of U.S. degree recipients from currently underrepresented groups, and we're looking to increase specifically participation in NSF research and education programs. The GPRA, as the Government Performance and Results Act is referred to, has a quantitative bent to it. When you start talking quantity, it is very easy to forget the language of quality that needs to be part of what NSF does. Developing approaches for broadening participation is among our core strategies at the moment.

We want to move from having targeted formal programs to including the concepts of diversity and equity in everything we do. That's actually quite difficult, because it requires that everyone in the agency keep diversity as one of the forefront issues in their minds. We want to draw on past experience, and, as I mentioned, one of the difficulties of drawing on past experiences is that it tends to be on the small scale rather than the large scale. We want to maintain focused programs that are achieving positive results, because you need those flagship efforts to keep people's attention on the issues.

We need to consult with the community, and forums like this are one way in which we can do this. We want to make connections, because one of the real problems of addressing equal opportunity, equity, and diversity is that many communities of underrepresented groups are actually quite isolated from the mainstream of science and engineering, both in research and education. If we can take advantage of the current boom in information technology to make those connections and break some of the isolation, we have an opportunity to bring people in.

Finally, we need to be able to be accountable. I think this is a real issue, and it is particularly an issue when you move from focused and targeted programs to embedding diversity in everything you do. If you have a focused program that is a budget line, then in some sense, your accountability is budget accountability. How much money is going into those programs? Did you spend the money the way that you said you were going to spend it? When you are embedding things, however, you have to find another way of being accountable, because it can be very difficult to tease apart the diversity aspects of much broader activities. This is one of the things I think is going to be most difficult for NSF in the next few years. One of the things you might think about is how can an organization like NSF be truly accountable for its actions in the areas of diversity and equity if you are moving toward an embedded structure?

Let me give you some feel for NSF investments in diversity programs. I will focus on the programs managed by the Education and Human Resources Directorate because that is my area of expertise. However, there are several small programs scattered across the Foundation that address underrepresentation in particular disciplines. These are important in bringing disciplinary communities into discussions of diversity and equity.

One element that runs through all our diversity-based activities is an emphasis on continuing research that informs our actions, our efforts to be accountable, and our interactions with the community on things that work in larger-scale efforts. In some areas, most notably for women and persons with disabilities, we have formal ongoing research activities. In others, the efforts are less explicit but nonetheless important.

I'll begin with programs for underrepresented minorities. At one point, we had several active programs in the K–12 arena, such as summer science camps and the Comprehensive Partnerships for Math and Science Achievement [CPSMA]. Now, most of our efforts are concentrated in our systemic initiatives, (NSF 1998). Although not explicitly aimed at diversity, the systemic initiatives improve science and math preparation for all students. We emphasize addressing achievement gaps with roots in racial or ethnic background. The CPMSA program was recently folded into the Urban Systemic Program.

The Louis Stokes Alliances for Minority Participation [LSAMP] program has been the key to expanding the pool of undergraduate majors in science, math, engineering, and technology. The HBCU [Historically Black Colleges and Universities] Undergraduate Program provides the opportunity for these institutions to upgrade the quality of their undergraduate programming. Alliances for Graduate Education and the Professoriate help enhance participation of underrepresented minorities in graduate education, and the Centers of Research Excellence in Science and Technology build research capacity in minority-serving institutions. Thus, at the level of higher education, the core of our programming is institutional capacity building. We have alliances of undergraduate and graduate

institutions in partnership with industry and national laboratories, and we do some direct support of students and faculty.

For women and persons with disabilities, research on pre-college and undergraduate barriers is one of the major activities. Our support for women is more strategic in character than that for underrepresented minorities. We do a lot of demonstration projects, but we don't have the large-scale programs for women or persons with disabilities that we have for minorities. The program for persons with disabilities is small, with a focus on research on assistive technology.

What kind of progress do we feel we're making? Well, we're getting some interim results now. For underrepresented minorities, we see increased baccalaureate production within NSF-supported projects and modestly strengthened institutional programs. For women, our evaluation of the program on gender equity and its predecessors is showing that we're getting some institutionalization of model program activities. For persons with disabilities, the most noticeable effect is the strong research activity. We see some interesting cross-program results as well. For example, women account for roughly 47 percent of the students within the LSAMP program. So we see strong participation of women in a program aimed at participation of underrepresented minorities.

More broadly, we see evidence of steady increases in the numbers of baccalaureate, master's, and doctoral degrees awarded to underrepresented minorities. They are not as large as we would like them to be, but they are headed in the right direction. Percentages of underrepresented minorities within the degree-holding population are also going up slowly. As one might predict, they are highest for the baccalaureate population and lowest for Ph.D. production. We need to keep track of such numbers as we go along. The data described above are for computer science, engineering, mathematics, and physical sciences, where the initial percentages were lowest and where NSF has made the strongest efforts.

We see similar results for women in these fields, although percentages of degree-holders seem to be more or less constant. Our data on persons with disabilities are almost an embarrassment; we hardly even collect it. We need to do a much better job of this.

What are some of the things that we want to be looking at? I think Andy has touched on them—the achievement gaps, the impact of the achievement gaps, and other factors in decisions that people make about entering the science and engineering workforce. I'm basically here to learn. I want to see what kinds of ideas are out there about what the next steps ought to be so that we can really use research-based knowledge in developing programs and in providing guidance to organizations that are interested in making a difference in this area. I look forward to the discussions to see if there are some ideas that I would like to try to fold into what NSF is doing. Thank you.

EDMUND GORDON

Closing Session

"We think that society has a responsibility to continue to protect the opportunity for inclusion, but it also has a responsibility for ensuring the opportunity for development...It's got to create the conditions, the context, the material, and psychological conditions that enable certain kinds of competencies to develop... Affirmative academic development simply means that one ensures that these abilities are developed in persons whether they are a part of their naturally occurring environments or not."

As I listened yesterday and this morning and thought and reflected on the things that you were talking about, several notions occurred to me. Early in this conference Elizabeth Fennema called our attention to the complexity of the issues. She used "complexity" to describe the problem that we're addressing. She also used "complexity" to describe the available knowledge we have, and, clearly, it also applies to solutions. And complexity is the theme that I want to use in my reflections.

The rich and provocative array of papers that are part of this conference simply reflect that sense of complexity—for example, the fact that there are no single answers and no single explanation; and that if you twiddle a little bit here, then you're going to disturb something over there; and that when you've got the stuff here adjusted, you discover that there is still another piece of the problem that isn't settled.

We know a great deal, but we still don't seem to have the answers. Looking at the data from many interventions for over fifty years, I've been struggling with these issues. And it's almost discouraging that many of the issues I came into the field struggling with in the forties are still the issues that we struggle with now. Some of you may know a report that I am associated with called *Reaching the Top*, from the College Board's National Task Force on Minority Achievement in Higher Education [1999]. In that report, we call attention to the gap between the academic achievement patterns of black, Latino, and Native American kids with that of Southeast Asian kids, Asian American kids, and European American kids.

One of the most troublesome things in the report is the following. I spent a good bit of my career thinking that if we

could somehow do away with poverty, we could do away with the underproductivity of schools and of some of our students. But from those data we report the fact that the higher you go with respect to achievement and the higher you go with respect to socioeconomic status, the bigger the gap. If you look at the gap in achievement between black middle-class and white middle-class kids, that gap is bigger than the gap between lower-class whites and lower-class blacks.

That tells us that there are some things seriously wrong, and maybe we have not appropriately conceptualized the problem. If you take the simple problem of the gap, that may not be a problem; that may be *multiple* problems. Consider, for instance, that the reasons for academic underproductivity on the left end of the distribution may be quite different from the reasons for underproductivity on the far right end of the distribution. And when you get down into the middle, that may be still a third problem.

I don't think the history of intervention on this set of problems in this country has reflected that possible complexity. We've generally tried to lift up the bottom, and thought that if we were doing something there—as through Title I and compensatory education and those kind of generic interventions—we would somehow also raise the top. In the program that Vinetta Jones ran, Equity 2000, we had some effect. But even in that excellent program, a contribution to the closing of the gap at the far right end of the distribution was not one of the effects. That doesn't mean we discontinue these efforts, because clearly we have to continue lifting the mass of folks. But if part of our concern in this society is the conjoining of academic excellence and academic equity, then some of us have to be worrying about what's happening with that group of very able or gifted folks who, despite the height of the development of their ability, are still not functioning as well with those abilities as some other people.

In our report *Reaching the Top*, we talk about something we call "the overprediction of our tests." When we get black youngsters who score 1400 or 1500 on the SAT and bring them to a fine university like Yale, the institution does not enable most of those students to perform at the level predicted by their test scores. Now that says—possibly—that there's not something wrong with those kids, but that there's something wrong with the institutions that serve them. They don't enable them, even when they come well-prepared to function at the same level as other kids function. We now have multiple ways of thinking about this problem that require multiple ways of intervening. We know that our opportunities to learn are anemic; they don't vary as much as the variations among the youngsters they serve. They are often not rich enough. In too many instances, they're simply underresourced. We know that there are real and essential characteristics of learners. Claude Steele has introduced some very interesting work that has to do with the attitudes that youngsters bring to their learning experiences, attitudes that reflect the racist, classist, and sexist notions of the society in which they live. The attitudes that they bring interfere either with their learning or with their demonstration of what they have learned.

Now that set of problems is quite different from the real problems that may be represented in deficient systems of their preparation or limitations in the resources that they can bring to bear upon education. If you follow the work of Coleman and my colleague Scott Miller, they talk about a variety of human resource capitals that are invested in education, such as health, social capital, cultural capital, and polity capital—a sense that one belongs to the community and a sense on the part of the community that that person belongs. They argue that these sources of capital are possibly among the things that enable schooling to work, and that if you don't have these capitals to bring, your schooling will be less effective.

The whole set of complexities speaks specifically to those of us who are concerned for pedagogy—the cultural and technological context for learning—whether it be math and science or any of the other varieties of learning. In the very interesting little book that the late Ben Bloom edited and which was actually written by several of his students, *The Development of Exceptional Talent*, the authors talk about a variety of characteristics drawn from the developmental experiences of these young people: the amount of time devoted to learning tasks; the exposure to increasingly able instructors; the exposure to increasingly rich learning environments; the complementarity of the challenges in their lives; and the kinds of psychosocial supports coming from families, friends, and peers. These "non-school" variables greatly influence what we do. We can refine the instructional method, but if we don't address some of these other factors, the refined teaching and learning experience may not pay off as well. On the other hand, without a refined and adequate opportunity to learn, fiddling with all these other pieces that Bloom identified won't make much difference.

Richard Tapia made a very brief reference to a notion that appears in the College Board report. It's called the "affirmative development of academic abilities." In my notes, I have headed it the "nurturance of the talented tenth and the development of talent in the masses." I hope the name W.E.B. Du Bois has meaning to several of you; he was one of my intellectual heroes. In the early part of the century, he was writing about the development of human intellect as opposed to the development of human skill. He was asserting that no society could afford to neglect the nurturance of talent in its most capable members. In the late fifties, just before he left this country for Ghana, he talked about changing that notion. He wasn't any less enthusiastic about the importance of the development of intellectual talent. But what he was suggesting was that, before the end of the twentieth century and certainly in the twenty-first century, what he thought of as the kind of education that the talented tenth ought to have would become the standard for universal education. And I think that his prediction has proved to be true. The kinds of things that we are striving for and hoping for our youngsters to achieve has come close to the kinds of stuff that Du Bois was talking about when he was talking

about the liberal arts, humanities, and sciences as a basic education for everybody.

But it's also a little bit different. Du Bois came to his maturity during a period when the educated person was a person who had a lot information, who had a lot of facts, who had relatively encyclopedic knowledge of at least one area. Du Bois was a great fan of the German universities; he even went over there to get his Ph.D.—and did not succeed. Some people think that some elements of racism in that society prevented him from getting it. I humorously refer to the fact that he had to settle for a Ph.D. from Harvard and became the author of the first of the Harvard Historical Series. But Du Bois was fascinated by that emphasis on deep and rich knowledge. I think he would have been a bit out of step in the current period when we are not talking about simple literacy but the critical literacy, when we're not talking about simple numeracy but critical numeracy—the capacity to take information, turn it around, massage it, and make new things out of it. He was not as sensitive as I would have preferred to the shift from a concern for knowledge and skill at mastery to a concern for production, interpretation, and understanding.

To some of us, it has crept into the language of this conference that learners are constructors of their own knowledge, of their own meaning, of their own technique. Du Bois wasn't sensitive to the shift from knowing to understanding. In Bond's work, at least by implication, he suggested that one of the possible problems in the difference between young students' grades and demonstrated competence in their coursework and their prompt performance on tests is a possible lack in the understanding that is enabled for them. These new notions with respect to what it means to be an intellectively competent person were not a part of Du Bois's notion, but they are increasingly a part of what we are trying to do for our youngsters. And this is part of the complexity for us.

Unless you have seen something I haven't been able to observe, we don't really know how to do this different kind of teaching. In my last years before retiring from the classroom, I was struggling to catch up with this kind of stuff. As I visit schools and colleges around the country, I see a lot of us who have responsibility for instruction struggling to do constructivist teaching, struggling to better enable youngsters to maintain their respect for the authority of knowledge—but also struggling to nurture their skepticism, to encourage their inquiry, to enable their explorations. Now these are difficulties in pedagogy that those of us responsible for it have to tackle. And if one is looking for a research program, maybe we've got to turn to a better understanding of what it means to teach and learn from constructivist, contextualist, and perspectivist world views.

Back at the College Board, where I do some consulting, we have a few people worrying about the nature of intellectual competence. The assumption is that if we are going to continue to develop tests, we ought to be much more concerned with what it is the test ought to be measuring, just as we worry about what it is we are enabling in folks. And we have long discovered the limitations of our current instruments. If we can better understand what it means now to be an intellectually competent person, that ought to be reflected in our curriculum, and it ought to be reflected in our tests. If we had more time, I'd share with you some of the notions we are beginning to toy with.

A few minutes ago I referred to the notion of affirmative development. In *Reaching the Top* we embrace affirmative action, but we think affirmative action doesn't go far enough. We think that society has a responsibility to continue to protect the opportunity for inclusion, but it also has a responsibility for ensuring the opportunity for development. And the affirmative development of academic ability speaks to that. It argues that we have enough know-how to much more effectively develop academic abilities in youngsters rather than simply look for the youngsters in whom they have naturally developed. Because even when we use that term "natural," it isn't that they are necessarily innate; in fact, I would argue that academic abilities are certainly not innate. There may be some capacity to handle them that is innate, but what we see in people who have highly developed academic abilities is that they have been highly developed. Affirmative development says let us better understand how one goes about doing that.

Now our notions for doing it are relatively modest. We began by asserting that affirmative development is by no means a new concept. We perfected it to some extent in our veterans' preference in work after World War II. And that wasn't just veterans' preference, that was veterans' development, educational development, employment, economic, health, housing, even political. So with this notion of affirmative development, we're seeing that the development of academic ability isn't limited to simply teaching people some things. It's got to create the conditions, the context, the material, and psychological conditions that enable certain kinds of competencies to develop.

Lauren Resnick talks about the socialization of intelligence. She argues that this occurs naturally for some of our kids. My wife and I have four of them, and we worked like hell to ensure that those kids were socialized to high levels of intellectual competence. I suspect many of you out here do the same things for your kids. Most of the kids we worry about when we talk about minority or disadvantaged populations don't come out of families that are prepared to do these kinds of things for them. One of the things we call for in *Reaching the Top* is something we call supplementary education. That's the variety of things, an array of things, that happen outside of schools and classrooms that ensure that classrooms work—tutorial services, travel, talking to your kids at night, reading to them, ensuring that they have reading materials, helping them understand that they are learning and that their intellective development is important. One of my students was out in California in Koreatown studying supplementary education there, and she found something like 350 programs in the radius of about

twenty blocks—after school, before school, weekend, summer—all directed at supplementing the education that kids got. Affirmative academic development simply means that one ensures that these abilities are developed in persons whether they are part of their naturally occurring environment or not.

In our discussions over the past day and a half, we've talked about a lot of the ingredients, we've talked about accelerated learning experiences; we tended to dismiss remediation, but on my list, I have targeted remediation quite high. Youngsters whose education has not been terribly rich often have simply missed critical pieces. The kind of diagnostic work that helps us understand what's missing and then puts that in is terribly important, so I am not ready to back away from remediation. But I don't want generic remediation; I want it targeted to the special needs of persons, and certainly folks who are behind need experiences that accelerate, that enrich, their exposure.

High on my list is something I call personalization. It's not just individualization; it's making that learning experience so meaningful to me that I own it. Because unless I do begin to own, I don't get the kind of engagement, the kind of persistence, the kind of time on task that is necessary for the kind of mastery we are talking about. We talk about both expectation and reward, helping youngsters to expect; Lauren Resnick says high levels of intellective development require that one expects oneself to be intelligent and to be able to engage. At my first retirement party, my oldest son was one of the speakers, and he was saying that he had learned from his dad that there was nothing that he couldn't do if he would apply his mind to it. I never told him that, but somehow through his experiences with his mom and me, he learned that your mind is something that you use in these ways. We can teach this kind of stuff to youngsters.

Let me wrap this up. Somewhere I ran into the notion that most living organisms have three options: they can adapt, migrate, or die. As we were talking about the variety of cultural concerns that have got to be considered, that notion came to me. Warren Chapman reminded us of the cultural, economic, and political globalization of the world. I'm a strong supporter of cultural identities, cultural variations; I think they need to be honored. But in an age of globalization, we're running out of space to migrate, to escape the demands of the modern world. If one's going to survive in it, one's got to learn to adapt to it.

It seems to me that it is the function of those of us responsible for education to teach youngsters how to adapt. Now that means that they take whatever cultural resources or baggage they come with and augment them with the cultural resources that are required to function in a variety of settings. So we talk about multicultural, multiperspective, multiple competencies, the capacity to survive and to enable others to survive in any environment in which one finds oneself.

Panelist Papers and Discussant Comments

The following short papers from each of the nine NISE Forum panelists are provided in the order in which they were presented at the Forum. These papers are based upon thirty- to fifty-page papers written prior to the conference, which are available at http://www.nise.org. The short papers include an emphasis on the needs for future research, often contextualized by first highlighting some important points established through existing research. Each panel's papers are followed by a transcription of remarks made at the Forum by a discussant. The discussant remarks range from specific comments on their panel's papers to broader discussions about directions for future research.

The three panels had assigned themes—content and instructional practices, programs, and achievement and course-taking patterns, respectively. After analyzing the panelists' papers following the Forum, some slightly different themes emerged and became the organizing topics of the highlights presented earlier and the synthesis in chapter 2. Following are brief descriptions of the panelists' papers, also organized by these themes.

- **Inequitable course availability and assignments, and teacher assignments.** *Jeannie Oakes, Kate Muir*, and *Rebecca Joseph* cover a wide range of inequities in the educational system, including inequities in the assignment of students to mathematics and science courses and the resulting influence of those decisions on students' access to higher education.
- **Content, instruction, and assessment.** Based on pilot work he has done to investigate the phenomenon of students from underrepresented groups who have good grades in mathematics courses yet low test scores, *Lloyd Bond* describes the need for future research on how teachers move students from solving well-structured problems to being able to solve word problems. *Elizabeth Fennema* articulates the kinds of gender research that would continue to advance goals for gender equity in mathematics education. *Maria Klawe* and colleagues describe the effects of their programs in addressing gender issues regarding the use of computers for science education and then suggest future research needs in this area. *Okhee Lee* states that research involving diverse languages and cultures in the curriculum is in an early stage and is heavily influenced by goals; she goes on to identify next stages for this research area.
- **Understanding and scaling up effective programs.** *Manuel Gómez* and *Norma Dávila* discuss lessons learned and questions still pending in their extensive work on NSF-funded systemic reform efforts in Puerto Rico. *Vinetta Jones* and *Anne Bouie* emphasize research needed on three aspects of programs that are designed to meet the needs of students from underrepresented groups: the important roles of families and communities, the institutionalization of programs, and the scaling up of effective programs.
- **Better research methods and dissemination**. *Patricia Campbell* and *Lesli Hoey* discuss the need for more and better evaluation of programs. *Richard Tapia* and *Cynthia Lanius* call for a serious redesign of mathematics and science education to address diverse students' needs; they believe explicit attention to minority subgroups is important.

PANEL ONE

Gender and Mathematics

Elizabeth Fennema

"Is mathematics really necessary for a life of value in the twenty-first century? This is a heretical question coming from a mathematics educator, but one that needs to be addressed... Are we just making the chosen roles of females in society (that often don't involve mathematics) less important, less adequate, or of less value than the chosen roles of males (that often include mathematics)?"

What Do I Know?

Research over the past three decades has made significant contributions to defining and understanding the complexity of all issues dealing with gender and mathematics. It is clear that females, less than do males, participate in post–high school mathematics study and mathematics-related careers. That differences exist in the learning of mathematics seems clear also, although many scholars believe either that learning differences are diminishing or that, if any differences do exist, they are unimportant. My best analysis of the data and literature has led me to conclude that the more the test measures true mathematical problem solving, the more apt one is to find gender differences in mathematical learning that favors males at almost any age. Females appear to hold more negative values about mathematics and their relationship to mathematics than do males, but there is some evidence that these differences are also decreasing. These simplistic statements, however, hide more than they reveal. What mathematics was being measured in tests where gender differences have been studied? How was the information about values obtained? Were females' voices a part of the data-gathering procedures? Too often the research that has reported gender differences has provided an incomplete picture at best and has only helped to perpetuate the belief that females are somehow inadequate in relation to mathematics.

What Do I Wish to Know?

Even if there was consensus on the *truth* about gender differences in mathematics, we would not have clear direction on what to do in order to achieve educational equity. Consider the current reform recommendations for organizing classroom instruction that are assumed will result in educational equity for all students. One major reform recommendation has to do with encouraging students to communicate their mathematical thinking by presenting their ideas and convincing peers of their correctness by arguing and questioning. It is widely believed that those who enter into this kind of debate about mathematics will learn better. But will girls enter into this kind of communication as willingly as do boys? Many teachers have reported informally that girls will not do so for a variety of reasons.

Another reform recommendation has to do with the use of technology in the classroom. It is clear that currently boys have more experiences with technological toys than do girls. Does this reflect interest and/or ability with technology? How should teachers take this into consideration as they plan their instruction?

Another recommendation is that mathematics should be situated in problem-solving contexts that are socially relevant. Unfortunately, many textbooks and teachers are more aware of contexts that are from male-dominated fields such as parabolic equations for projectiles or sports statistics. Can mathematics be situated equally in female-dominated contexts, and, if so, will boys willingly participate in such problems? Should classrooms be competitively organized or organized around cooperative activities? Some studies have suggested that boys learn better in a competitive situation, while girls learn better in a cooperative situation. Is this always true? Is the solution to have single-sex classrooms? And would the experiences we have had with black/white schools be repeated, and females' classrooms become inevitably less adequate?

What Do I Wish Was Known?

Research into gender and mathematics must continue in order to monitor learning, attitudes, and participation. In addition, we need to apply new paradigms of research that will provide insight into why gender differences occur. In other words, gender as a critical variable must enter the mainstream of mathematics education research. It is insufficient to say and to believe that the study of gender differences can be left to those who are specifically interested in gender. That is just not fair. Aren't we all interested in how all students learn mathematics? And doesn't that "all" include that 50 percent of the student body that happens to be female? Fairness and justice demand that all researchers be concerned with all the students even when results are obtained that cannot be easily interpreted and understood.

Specifically, we need to continue the study of gender in relation to mental processing of both students and teachers. As research on teachers continues to mature and improve, we must include gender as a variable. We probably cannot study how

the gender of the teacher influences instruction because of the limitations imposed by the relatively low number of male teachers. However, we can study teachers' beliefs and knowledge about girls and boys and the impact that teachers' cognition has on instructional decisions for both girls and boys.

Classrooms that reflect the various demands for reform are becoming more prevalent. But are they equally effective for boys and girls? One study provided some evidence that just reforming classrooms without paying specific attention to traditionally under-achieving groups is insufficient to achieve equity. The learning that results from these reformed classrooms needs to be monitored carefully. Perhaps as we do this, we will begin to develop an image of what equitable mathematics education is.

The Value of Research on Gender and Mathematics

When I became an educational researcher, I believed that I would discover truth. That has not happened, and it probably will not happen in the area of gender and mathematics. But research has deepened our knowledge about gender and mathematics, and the many, many studies about gender have provided some insight into the inequities that have existed, leading to heightened awareness of things that need to be changed. There is one question about gender and mathematics for which research cannot provide the answers, however. Is mathematics really necessary for a life of value in the twenty-first century? This is a heretical question coming from a mathematics educator, but one that needs to be addressed. There is no right answer to this question, but perhaps we should consider the following. Is it possible that I, and others who have been doing work related to gender and mathematics, have been doing a major injustice to females by pursuing issues related to gender and mathematics? Are we just making the chosen roles of females in society (which often don't involve mathematics) less important, less adequate, or of less value than the chosen roles of males (which often do include mathematics)? Is it critical for everyone to learn mathematics? Are those who learn mathematics at lower levels of less value than those who learn at higher levels?

Research on gender and mathematics has provided a powerful scientific discourse during the past three decades. The entire educational community—practitioners, researchers, and policymakers—needs to continue to engage in this discourse and explore ways to deepen our understanding of what equity is and how it can be achieved. It is through discourse about philosophical questions as well as research questions that our understanding of gender and mathematics will grow.

Mainstreaming Underserved Students in the K–16+ Continuum to Achieve Academic Excellence

Manuel Gómez and Norma Dávila

"What are the most important implementation issues faced by systemic educational reforms in addressing the needs of underserved students? How have the reforms faced these issues?"

Over the last twenty years, the University of Puerto Rico's (UPR's) Resource Center for Science and Engineering (RCSE) has pioneered a series of reform strategies that have been successful in transforming teaching and learning in Puerto Rico throughout the K–16+ continuum following an educational pipeline model. The main features of this model, which are critical to any systemic reform project if it is going to be successful, are: (1) identification of the major weak points in the pipeline, (2) systemic thinking in the design and implementation stages, (3) development of strategic alliances, (4) strategic application of limited reform resources, and (5) development of a virtual organization to orchestrate the reform and harness the system's resources to transform the system. Even though UPR has applied these principles to the entire K–16+ continuum, this fact should not dissuade other researchers from working with smaller subsets of the continuum such as the K–12 system.

To reform complex educational systems, a catalytic agent is needed to orchestrate the reform, forge the necessary alliances, analyze the system, and identify the weak or missing connections among the system's elements. Because of the magnitude and complexity of the task, a virtual organization that is not part of the existing administrative structure and that is capable of thinking and acting across systemic boundaries is needed. RCSE, an alliance of all the major higher education institutions in Puerto Rico administered from the UPR president's office, has played this role in designing and implementing the

K–16+ reform model to improve the participation and mainstream underserved (i.e., low-income) students in the educational pipeline.

RCSE interprets the education pipeline to encompass all levels from kindergarten to Ph.D. and postdoctorate. RCSE carries the reform further to include the development of UPR into a Research 1 institution conducting research and development (R&D) and contributing to Puerto Rico's economic development. At the K–12 level, the Puerto Rico Statewide Systemic Initiative (PR-SSI) is the central project; at level 13–16, the Puerto Rico Louis Stokes Alliance for Minority Participation (PR-LSAMP) and the Puerto Rico Collaboratives for Excellence in Teacher Preparation (PR-CETP) lead the way; at the 16+ level, EPSCoR (R&D) and EPSCoT (technology transfer) projects are leading the reform. In addition, the K–12 reform model is being disseminated and adapted to New York City realities through the Puerto Rico/New York City Educational Linkages Demonstration Project sponsored by the U.S. Department of Education.

RCSE served as the virtual organization that orchestrated the K–12 reform and harnessed the alliance's members (the Puerto Rico Department of Education, RCSE, and the community at large) into an effective operational coalition. The Puerto Rico Department of Education exercised its leadership by establishing rigorous nationally accepted standards for the teaching of science and mathematics, pioneered policies to decentralize school academic and administrative management by creating the community school concept, and established systemwide assessments for student performance in science and mathematics. At present, 50 percent of all public K–12 schools have been or are being developed into reformed schools using a whole-school-based approach to transform their teaching and learning culture and using the assessment, attribution, and accountability feedback (A3) strategy to help them become self-correcting systems.

PR-LSAMP followed a two-prong approach to systemic reform. A cadre of reform-inclined faculty willing to experiment with change was identified and nurtured to pioneer the educational reform of university science, math, engineering and technology (SMET) courses, curricula, and teaching methodologies. At the same time, using the A3 approach, chief executive officers, presidents, chancellors, vice presidents, and some deans were persuaded with the evidence of successful reform efforts to support the institutional cultural transformation needed to make the undergraduate educational pipeline more effective and efficient.

PR-CETP has brought together the faculties from the Schools of Education and Natural Sciences to revise their curricula in order to prepare future teachers to perform effectively in the PR-SSI reformed schools. The PR-CETP staff is using the A3 strategy to assess the pilot-tested reformed courses and redesigned curricula and to persuade higher education leaders to support the overall reform effort.

In our paper, we show evidence of the success of these strategies in achieving the goals of the reform, which is primarily directed toward mainstreaming traditionally underserved students (low-income students) using the A3 cycle. For instance, in 1998–99, at the K–12 level, students who attended PR-SSI schools for six years outperformed their private school counterparts by 58 points in the mathematics reasoning part of the college admissions tests administered by The College Entrance Examination Board. At the same time, students who attended PR-SSI schools for three years outperformed students from non-PR-SSI public schools on the same test by 32 points. Similar trends were sustained for 1999–2000. PR-LSAMP results have also been impressive for the 13–16 level. Against a backdrop of declining absolute enrollment of SMET students at UPR, the number of SMET B.S. degrees conferred by the university rose —from 1,200 to 2,100 in a seven-year period (displaced by five years to compensate for the average time to complete the degree). Moreover, graduation rates for science and mathematics have gone from 46 percent to 60 percent in the same time period; for engineering, these rates have risen from 58 to 75 percent. The number of students who go on to complete their Ph.D.s in SMET disciplines in UPR's Río Piedras campus is one in ten, a number that places UPR among the top performers in the nation.

We would now like to highlight some of the lessons that we have learned in this process as well as some of the questions that are arising along the way. We end this paper with suggestions regarding some of the issues that remain unanswered.

One of the main lessons learned is that reform strategies cannot be developed and implemented in a vacuum. Without a solid theoretical and philosophical foundation to guide the development of these models and strategies, a reform is likely to be just a project instead of a true change in institutional culture.

Another lesson that we learned is to start small and then scale up. This lesson enabled us to monitor our efforts carefully using the A3 cycle, so that we could make the necessary corrections in our design to ensure quality control. As we learned about what worked and about what did not work, we also developed the necessary human capacity to carry the reform forward and to sustain it beyond its funding period. We also learned what key elements of the reform could be transferred elsewhere through projects such as the Puerto Rico/NYC Educational Linkages Demonstration Project.

Another lesson involves the importance of establishing and maintaining strong connections between the different sectors of the educational system so it can be truly systemic. Without those connections, our reform would have been another fragmented effort to solve a systemic problem—destined by its design to fail. The virtual organization and pipeline models described in our paper are our answers to these issues, which include building strategic alliances to support the efforts.

Our systemic educational reform has transformed itself from its early days. Our experiences have led us to understand that "what got me here today will not get me where I need to be tomorrow" because of the dynamic nature of social systems. Therefore, we are constantly looking for new and better

ways to catalyze change in the system. We are also embarked on a constant search for answers to questions such as the following:

- What theoretical and philosophical elements are shared by successful systemic educational reforms?
- What are the most important implementation issues faced by systemic educational reforms in addressing the needs of underserved students? How have the reforms faced these issues?
- What elements of systemic educational reform travel best to other sites? Which elements are the most difficult to transfer to other sites and why is this the case?
- How can we learn more about the value added by the reforms?
- How can we improve pre- and post-test designs to look at the value added by the reforms?
- Why do we still focus so much of our attention on teaching instead of learning?
- What can we do as researchers and educators to learn more about the process of learning?
- Why is student performance higher in open-ended questions than in multiple-choice questions?

Equity for Culturally and Linguistically Diverse Students in Science Education

Okhee Lee

"Research efforts generally involve identifying educational problems or describing instructional practices rather than implementing intervention strategies to promote teacher effectiveness or student achievement. Research is still at the stage of conceptualizing issues that need empirical testing."

As the student population in the nation's schools becomes more culturally and linguistically diverse, it is essential to establish a knowledge base to promote academic achievement and equity for all students. A pressing problem with diverse students in science education involves the disconnection and tension between their languages and cultures and the nature of science as it is traditionally defined in the Western science tradition (Atwater 1994 and Lee 1999).

Equity is distinguished from equality. Equity is associated with justice or fairness, whereas equality is associated with sameness. In addressing the tension between Western and alternative views of science with diverse students, this paper considers equity from the cultural anthropology perspective. According to this perspective, science learning occurs when students successfully participate in Western science, while they are also engaged in alternative views and ways of knowing in their everyday worlds. This balanced orientation considers the contributions and strengths of both Western science and alternative views. Students have access and opportunities to learn the "high-status" knowledge of Western science as it is practiced in the science community and taught in school science. At the same time, alternative views of science and ways of knowing in diverse backgrounds are recognized and valued. As a result, students are able to achieve both academic success and cultural identity.

This paper addresses equity issues about epistemology and pedagogy of science content, learning, and teaching for students from diverse languages and cultures (see Lee 2000 for the full text). Highlighting the pressing problem of disconnection and tension as the key theme, the paper offers a synthesis of major issues and research findings for effective practices (i.e., what we know) and recommendations for a research agenda (i.e., what we need to know). Much of the literature is recent, published mostly during the 1990s. Research efforts generally involve identifying educational problems or describing instructional practices, rather than implementing intervention strategies to promote teacher effectiveness or student achievement. Research is still at the stage of conceptualizing issues that need empirical testing. Some innovative research provides important insights to enhance instructional practices and student outcomes.

Science Content

What counts as science or what should be taught in school science is critically important because this definition determines school science curriculum. Western science, as traditionally practiced in the science community and taught in school science, presents high-status knowledge to which every student should have access. At the same time, students from diverse backgrounds bring alternative views of science and ways of

knowing to the science classroom. This presents a challenge. On the one hand, an emphasis on the high-status knowledge without consideration of alternative views makes science less accessible, relevant, or meaningful for diverse students who have generally been bypassed in science education. On the other hand, an emphasis on alternative views, which are culturally and socially significant but may be unimportant topics in the science community and in school science, does not promote equitable outcomes. Research may address ways to incorporate alternative views in defining what counts as science and what should be taught in school science. This topic is as much a political issue as an empirical question.

Science Learning and Teaching

Students with diverse languages and cultures bring to the science classroom ways of knowing, talking, and interacting that are different from those in the mainstream. Efforts need to be made to bridge the gap between students' home cultures and the culture of science. The wider the gap, the more difficult it is to bridge. When disparities abound, there is no equity if Western science is imposed on students who do not share its system of meaning, symbols, and practices. Similarly, there is no equity if students are not provided with opportunities to learn Western science. Research may examine how diverse students learn (or fail to learn) to connect cultural norms (e.g., respect for authority) with mainstream expectations (e.g., questioning and argument). Research may also examine how diverse students achieve (or fail to achieve) academic outcomes as well as language and cultural identities.

Effective instructional scaffolding for diverse students involves consideration of many factors. Two issues emerge as central: (1) integration of the nature of science with students' languages and cultures (i.e., instructional congruence) and (2) teacher-explicit or student-exploratory approaches. Equitable science instruction meets the learning needs of diverse students while preparing them to function competently in the mainstream.

Teachers often do not have both knowledge of science and understanding of students' languages and cultures. Instead, some have adequate science knowledge but limited understanding of students, others have understanding of students but limited science knowledge, and still others have limited knowledge in both areas. While establishing instructional congruence is a demanding endeavor, it is particularly challenging when cultural norms for students' classroom participation (e.g., respect for teacher authority) and mainstream expectations (e.g., independence and individuality) are incompatible.

Challenges also occur when culturally based instruction (e.g., teacher-explicit instruction in meaningful contexts) and mainstream expectations (e.g., student-exploratory instruction) are incompatible. For diverse students, the discourse at home is inconsistent with the discourse in school. Multicultural education literature suggests that teachers provide explicit instruction about the rules of discourse in school rather than expect students to figure out the rules on their own. A danger is that teachers may misinterpret explicit instruction as drill and practice through didactic instruction and fail to promote critical and creative thinking with diverse students. This may become yet another stereotype that can potentially limit opportunities for diverse students to learn to function competently in the mainstream. The tension in competing pedagogical approaches deserves special attention. Consideration needs to be given to students' language and cultural expectations, science experiences, and the demands of academic tasks.

Teacher professional development is critically important because teachers play a central role in providing effective instruction. Although teacher change is a demanding process, the process may be more arduous when involving diverse students. Research may examine the process of change in teachers' knowledge, beliefs, and practices as they participate in professional development. Research may also examine the kinds of support required for initiating and sustaining teacher change. This information is essential in designing effective instructional interventions with diverse groups of teachers and students.

Research is also needed to relate teacher change to student outcomes. It is important to examine how teacher change influences students' academic achievement, and how student outcomes in turn influence teachers' knowledge, beliefs, and practices. In addition, how are different kinds of teacher knowledge associated with different student outcomes? The interplay of teacher change and student outcomes may provide valuable insights into effective instruction and student learning.

Overall Considerations

First, research needs to examine ways to integrate academic disciplines with students' languages and cultures. Research generally focuses on one area while keeping the other as the context. Instead, the two areas need to be addressed simultaneously to develop pedagogy that is both subject specific and diversity oriented.

Second, it is important to link curriculum, instruction, and assessment to understand a more complete scope of classroom practices. Because these three components are closely interrelated, intervention research focusing on one often faces the need to incorporate the others. Research needs to consider the alignment of curriculum, instruction, and assessment in meeting diverse students' needs in classroom practices.

Third, research needs to consider multiple theoretical perspectives, which are typically associated with particular methodological approaches. For example, in addressing conflicting pedagogical practices between culturally based instruction (e.g., teacher-explicit instruction) and mainstream expectations (e.g., student-exploratory instruction), multiple theoretical and methodological approaches (e.g., cultural anthropology and progressive education) need to be considered.

Finally, to improve educational practices, teachers must be involved in the development of a knowledge base. The practi-

cal knowledge of individual teachers from diverse languages and cultures can be incorporated into the development of the theoretical knowledge of teaching. This knowledge base can be shared with teachers from a variety of backgrounds in providing effective instruction for students who have traditionally had limited opportunities in science. Ultimately, what benefits students from diverse languages and cultures can also benefit mainstream students, making it possible to attain the vision of standards-based reform—high academic achievement for all students.

Discussion: Panel One

Carole LaCampagne

This panel cuts across a wide swath of diversity and equity issues in mathematics and science education, from Elizabeth Fennema's paper on gender equity in mathematics education, to Okhee Lee's discussion of equity for culturally and linguistically diverse students in science education, to Manuel Gómez's discussion of his successful mainstreaming of underserved K–16 students. The panel presented a very interesting tapestry. Underlying the first two presentations, the issue of values, culture, and science—or sometimes, culture versus science—seemed to predominate. An important point is that this should not become a tug of war, or our students will be caught in the middle. Our students need to live in the world of science and mathematics as it is presently constituted, if we are to help them get better jobs, compete in the world market, and prepare for the future. The problem is how to marry the culture that students bring to schooling with the outside world for which we want to prepare them.

I was disturbed to hear the results of the further study on Cognitively Guided Instruction and the identification of gender differences very early on. This is certainly something we need to look at, and we need to look at other programs in the early grades to see if there is a similar effect there. I think, however, there is very good news in the gender equity situation. Gender differences in mathematics achievement over the past twenty years have been decreasing. Girls are taking more advanced mathematics courses in high school than they did twenty years ago, and a greater percentage of women are taking mathematics majors in college—in fact, it is up to about 50 percent. However, a smaller number of women majoring in mathematics are planning to go into teaching than males, so this is not exactly equitable. Also, the number of women who go on to graduate school in math has remained stable over the years, and is not increasing significantly at this time. So we still have a problem, especially with the retention of women in graduate courses in mathematics.

I agree with Elizabeth that the effectiveness of intervention programs (of which there are many, and I've been in a few of them myself) have not been well documented; we certainly need to be considering good ways of documenting results as we set up intervention programs. We haven't done a very good job of this. Consequently, some intervention programs proliferate that perhaps should not, and other good ones are not carried forward.

I was also very interested in Elizabeth's concern for a feminist perspective in mathematics, and this certainly goes to the cultural issues too. I wouldn't want to carry this so far that girls were not learning the mathematics that they may need to know to go into science and technology fields. We need to be very careful about how we phrase our research questions—this can determine the results we get. We need to look very carefully at this feminist perspective in order to phrase our research questions in ways that will not prejudice the results from the beginning.

Lee's discussion of the postmodernist feminist perspective was interesting, and her concern not to consider this as highly as an anthropological approach was also an interesting take. To look at how students can successfully participate in Western science while maintaining their own cultural identities and values and those of their parents is certainly very difficult for teachers to do. To look very clearly at how we can help teachers cross this very interesting terrain is of extreme importance. We think, at the Department of Education, that the approach to a problem-based research agenda is a very important one. We are working, as Kent McGuire mentioned, to set long-range research agendas in mathematics and reading.

Manuel Gómez presented a very interesting and practical case for a K–20 educational pipeline to mainstream underrepresented students. He talked about orchestrating, and, as I read his paper, I thought of him as an orchestra leader. I also thought, a bit discouragingly, that there are not too many wonderful symphony orchestra leaders in the United States, nor in the world. I'm concerned as to how we might grow more wonderful orchestra leaders in this area of systemic reform. It takes this leader to pull together people, organizations, money, and funding, and to also have the capacity to generate enthusiasm, interest, and dedication—that is a tricky matter. Maybe we

need more education in developing more orchestra leaders in our systemic efforts in education. I certainly liked his model of research and practice. I think this is something we're looking at—starting small, implementing, continuing to assess, keeping the cycle going. We have not been too successful at this in the past, as a whole or as a community, and we need to do more about it.

Will the increased emphasis on changing the way we teach—that is, more emphasis on group work, more emphasis on teaching for understanding—help the equity issue with regard to educating girls? Will this help women who are entering technical fields and raising, nurturing, and mentoring their daughters? I think that history has made a difference in the gender equity situation. And I see many good friends in the audience who are working on these issues too. I don't mean to say the issues are solved, but I think history is on our side and that some of these issues have lessened over the years. Okhee, I am still concerned about how we can manage this juggling between the Western culture, or may I say (since we are becoming such a global society) almost a global look at what science is, with what children bring to school. For example, some children may bring to school from their culture the belief that the sun revolves around the earth, and some children may bring to school a creationist approach to science. How do we resolve this? How do we expect the teacher in the classroom to handle these problems? I think these are thorny issues.

PANEL TWO

Rethinking the Role of Special Programs[1]

Patricia Campbell and Lesli Hoey

"There has been little examination of unintended and/or negative effects of special programs...Unless the possibilities of unintended outcomes are explored and tested with students from different demographic groups, we may be doing more harm than good."

The Problem

Traditionally, there has been gross underrepresentation in SMET careers of female and male students of color, white female students, and students with disabilities. Although there has been progress, it has been uneven. Underrepresentation in SMET continues, but the issues surrounding it are somewhat different for members of different groups:

- When young women graduate from high school, they have basic science, math, engineering and technology skills and knowledge in numbers and percentages comparable to young men, although some gaps exist at the most advanced levels. However, young women are much less apt than young men to continue on in SMET.
- Although the science and math achievement and course-taking of students of color has been increasing, relatively few African American, Hispanic, and Native American students are graduating from high school with the skills and knowledge needed to continue in SMET. Even fewer go on in these areas.
- By the end of high school, students with disabilities have taken less science and math than other students. Little else is known about their SMET skills and knowledge.

Challenge I: Exploring Unintended Outcomes

Research and evaluation that has been done on special programs has tended to focus on program impact on delineated goals and outcomes. There has been little examination of unintended and/or negative effects of special programs, although individual evaluations have documented such findings as:

- a focus on barriers faced by women in science, causing female high school students to become less interested in going into science careers;
- hands-on science activities led by adults with no knowledge of equity strategies, causing students to become more stereotyped and limited in their opinions of who could do science; and
- students and teachers in an SMET enrichment program targeting minority students seeing it as remedial, in spite of strong evidence to the contrary.

Unless the possibilities of unintended outcomes are explored and tested with students from different demographic groups, we may be doing more harm than good. Student data must be broken out by race/ethnicity and sex to allow decisions to be made, not just about the effectiveness or ineffectiveness of strategies for "average" or "typical" students, but their effectiveness for different groups of students.

Challenge II: Moving on and Scaling Up

> Special programs need to become laboratories for trying out new ideas, rather than providing remediation or "enrichment" for some underserved students. Instructional strategies for reaching all students with high quality content needs to be a part of every classroom, not a pull-out, after school or lunch program for a few students (Campbell and Kreinberg 1998).

There is a great need to learn more about the scaling-up process, to learn more about how to bring strategies that work into the mainstream of education in terms of content, pedagogy, and funding. It is particularly important that research and evaluation on scale-up efforts include state teacher certification programs, teacher educators, and others who work with preservice teachers, so that teachers come into the profession with the knowledge and skills to attract and keep students from underrepresented groups in SMET. Equally important is the

[1] While this short paper emphasizes research issues in evaluating programs, the longer paper by Campbell and Hoey (2000) available at www.nise.org. also reviews the effectiveness of programs targeting gender and race.

need to address the areas of teacher rewards and reinforcements. It is key to determine what is needed to support teachers and others. This support should be not just in their initial efforts to change, but in their efforts to continue to implement and refine effective strategies to increase the participation and achievement of students from underrepresented groups in SMET.

To make the results of such research and evaluation useful, it is necessary to explore what acceptable evidence of effectiveness is. Issues to be covered in such an exploration include:

- the role of statistically significant change versus meaningful change;
- the value of one well-controlled study versus many studies with different flaws; and
- the value of comparing the impact of one program to that of another (or to the impact of doing nothing) versus assessing program impact in terms of the degree to which it meets an acceptable criterion (i.e., 90 percent of students continue on in geometry).

As work continues on ways to scale up and institutionalize effective strategies, additional work needs to be done to develop and test new strategies and activities. However, it is difficult to develop innovative strategies without knowing what has already been done. Currently there is no comprehensive compilation of programs and strategies. Compilations that include lessons learned, effective and ineffective strategies, and even hands-on activities are badly needed. An easily accessible compilation would mean that program developers and implementers could build on and refine existing strategies and activities rather than reinvent them.

Another factor mitigating against the development and implementation of new and possibly risky strategies is an emphasis by funders on funding special programs that have the best chances of working. Both funders and developers need to see that finding out what *doesn't* work and why can be as valuable—and should be as valued—as finding out what *does* work and why.

Challenge III: Rethinking the Roles of Evaluation and Research in Special Programs

There is an existing knowledge base that can and should be used in program and policy development. However, much is left to be learned. Typically, due to a lack of resources, few programs do the kinds of evaluation that can determine impact on student achievement, course-taking, or longer-term interest in SMET. There is a great need for longitudinal evaluation to better determine what works and what doesn't in encouraging underrepresented students from different groups to continue on in SMET, particularly students with disabilities about whom so little is known. The major challenge for the research and evaluation agenda is to increase the amount of research and/or evaluation done using the following model:

Program participation → intermediate effects→ long-term effects/student data for different demographic groups

To be successful, the research and evaluation agenda must be built on the belief that this is not about special programs, but about creating equal outcomes for students across all groups. Data-driven intervention must identify the variety of successful strategies that will allow us to serve the entire population, to close the gaps between groups without creating gaps within. To be high quality, education must serve all.

Effective Programs for Achieving Equity and Diversity in Mathematics and Science Education

Vinetta Jones and Anne Bouie

"Another area of concern is the way in which programs define their relationship with students' families; the ways in which programs that produce high student achievement outcomes work with parents..."

There is a great deal known about what works, what does not work, and—to some extent—why things do or do not have positive outcomes for student achievement. A research agenda for programs to promote equity in mathematics and science would do well to build upon and extend the existing knowledge base. This paper presents several key issues and briefly discusses why they are important in the field.

The first key research issue is arriving at some sense of the definition of a "quality" program. There are those who feel that it is not reasonable to expect that a single teacher development, teacher research, student enrichment, or even a systemic program can bring about and sustain this outcome beyond a pilot or an experimental program with the ability to control the environment tightly. Further, "student achievement as a reasonable

outcome also awaits the development of reasonable and reliable assessment tools and methods that measure indepth, conceptual understanding of mathematics and science" (Kaser and Bourexis 1999, p. 110). Hence, some sense of how mathematics and science programs themselves define "effectiveness"and "reasonable outcomes," the basis for their criteria, and the implications of their definitions of "success" and "effectiveness" are all reasonable questions which would bolster the work done by Malcom (1983); Clewell, Taylor-Anderson, and Thorpe (1993); and others who have sought to obtain evaluation criteria and data from mathematics and science enrichment programs at all levels. Once data have been obtained on the ways in which programs define effectiveness, some analysis of their outcomes in relation to their definition might provide useful information about program design and implementation and their relationship to student outcomes.

Another area of concern is the way in which programs define their relationship with students' families, the ways in which programs that produce high student achievement outcomes work with parents, and whether these interactions differ from those in programs that do not produce gains in student achievement and other measures of academic progress. These findings would be useful in helping programs design and implement family interactions that create endorsements on the part of families for the work that will be required if students are to be successful. Funders are rightly concerned that resources produce results. By paying attention to student outcomes, programs assure those who are involved with their work that resources are being spent wisely.

A great deal of work has been done focusing on the strengths of traditionally underserved students and their families. This body of work is commonly referred to as the "resiliency frame." This frame has potential utility because it points educators to specific traits of individuals, families, workgroups, and organizations that create a positive environment that nurtures and sustains young people. When these characteristics are applied to workgroups and organizations, they are particularly compelling. Research, which determines the extent to which "effective" programs also possess the characteristics and traits of "resilient" organizations, could be very useful in program design and implementation.

Another critical research area is the examination of programs and projects that have indeed successfully scaled up beyond the original pilot or site to other sites, to sites outside the district, to the district as a whole, or to other states. Quality ethnographic data on what was done and on how and why things were done could provide useful information to practitioners and researchers alike.

A related area of concern is the extent to which such programs have been institutionalized and have effected significant change in the ways schools design and implement programs for traditionally underserved students. If indeed these programs have been institutionalized and have become a part of the host organization, which entity has adapted and changed, and what have been the effects on student outcomes? Research could support practitioners in examining effective strategies for translating relevant research findings into practices that can actually be used in real-world settings. Research should be reported in ways that are practitioner-friendly as well as suitable for referred journals.

There are a fair amount of data that seem to indicate that programs and staff of schools that are successful—as defined by student achievement, academic self-confidence, enrollment, and success in advanced mathematics and science classes—differ from other schools in some very important areas. It appears that successful programs differ from ineffective programs in these four critical areas. First, they seem to view the student and what he or she brings to the classroom differently. Second, there appears to be a difference in the relationship between the staff and students and between the staff and the families of the students. Third, it appears that the kind of content presented and the ways in which it is taught often differ dramatically from presentation and delivery in conventional classrooms and programs. These are all areas that could benefit from research and, as stated earlier, made user-friendly so that they may be adopted by other programs. Finally, the extent to which these four areas might inform preservice teacher training programs is certainly worthy of exploration.

Gender Issues in Computer Science Education

A.R. Davies, Maria Klawe, C. Nhus, M. Ng, and H. Sullivan

"While these initiatives seem promising approaches to tackling some of the core factors affecting the low female participation in information technology, more research and programs are clearly needed. One important area of research is to find out whether the findings for females also apply to other underrepresented groups in information technology."

The low participation by women in both the information technology (IT) industry and in computer science courses in secondary and postsecondary education is an important equity issue in science education. In addition to the increasingly intense need for more highly skilled people in the IT sector, women are missing out on many of today's most attractive career opportunities. Equally importantly, the IT field is missing out on the broader range of perspectives and talents that would result from significantly increased participation by women. Both the percentage and total number of bachelor's degrees awarded in computer science to women decreased almost every year over the last decade. This is in direct contrast to almost every other area of science and engineering, where participation by women has significantly increased. Only 14.4 percent of employees in IT are female (Myers 1999). The current percentage of computer science B.S. graduates from U.S. research-intensive universities is approximately 17 percent (Camp, Miller, and Davies 2000). Moreover, course-taking patterns in high school indicate that the gender imbalance in computer science has already established itself prior to university.

Research by many groups, including the SWIFT (Supporting Women in InFormation Technology) project at the University of British Columbia (see http://taz.cs.ubc.ca/swift), has identified several factors contributing to the lack of female participation in IT careers:

- In North America, socialization has the effect of labeling computer science as a hard-core male activity. This gender stereotype is entrenched by the male-oriented computer games that form the primary computer experience for most children. In addition, the lack of female IT teachers and the small number of females involved in the IT industry result in an absence of female role models.
- There is a significant gender imbalance in access to and ownership and usage of computers. The tendency for boys to dominate computers at school and at home and the scarce use of computers as a teaching tool in schools results in girls graduating from high school with less experience in computer usage, especially in programming.
- The combined result of the above two factors leads to more computer anxiety and lower levels of self-perceived ability in computer science among female students.
- The images of IT jobs (programming sixteen hours a day with little human contact) and of the people who work in them (geeks with no life) are not appealing to females.
- Introductory computer science courses usually focus on the technical elements of programming and computers rather than on computing applications. This approach is not appealing to females who tend to value computers for their uses rather than their intrinsic technical interest.

These findings point to the need for more research and programs related to gender-inclusive computer science education and software development. In addition, there needs to be significant improvement in the awareness of students, parents, and teachers about IT careers. Initiatives in these directions by the SWIFT project include:

- Research and development of gender-inclusive educational computer games (see http://taz.cs.ubc.ca/egems). Our findings indicate that female students are as interested and as competent as male students in playing educational computer games when the games are designed to take a broad range of playing and learning preferences into account. Simple interventions in the classroom such as providing one time per week when only girls are allowed to play at the computers (and an analogous time for boy-only play) have had dramatic results in increasing girls' time on the computers.
- Development of the Virtual Family software activity which provides a fun introduction to programming in Java via the programming-by-example method.
- Delivery of hands-on workshops for girls in grades 7–10 that are designed to raise their awareness of IT careers and engage girls in interesting and enjoyable creative computer activities.
- Development of a university computer science course that introduces computer science concepts through applications in biology, psychology, and the fine arts.

- Development of ARC, a two-year postbaccalaureate program combining academic computer science courses and work experience that is designed to be attractive to women. The key "women-friendly" elements in ARC's design include requiring no prior programming experience; aiming the program at students with an outstanding previous academic record in any discipline (e.g., English, music, political science, psychology, biology); providing smaller classes, extensive additional tutoring, and nurturing instructors; explicitly specifying that the program aims to have women be at least 50 percent of each cohort; and providing an opportunity for a paid work experience. So far approximately 60 percent of ARC students have been women.

While these initiatives seem promising approaches to tackling some of the core factors affecting the low female participation in IT, more research and programs are clearly needed. One important area of research is to find out whether the findings for females also apply to other underrepresented groups in IT. Another important area is to upgrade computer science and equity knowledge and skills of in-service and preservice teachers and counselors. A third area is the development of more culturally diverse and application-oriented approaches and resources for teaching computer science. Although a number of different groups have made significant efforts to find ways to make IT more attractive to female students, much remains to be done in making the various programs systematic and integrated with the school and university system. Perhaps the most important area is to change the popular image of computer professionals. The image of computer professionals as nerds who work in isolation in front of computer screens is neither accurate nor appealing to females.

Discussion: Panel Two

Warren Chapman

I am a program officer at the Joyce Foundation, and systemic reform is what the education program does at the Joyce Foundation. We put money out there to help school systems change. It is not an easy field to be in, and it is a very expensive endeavor; sometimes it doesn't look like you're getting anywhere.

But let us think for a second about why I know that I'm going to win and the systems are going to lose. There are two very simple reasons I can stand up here very proudly and say, "Yes, I do systemic school reform and I pay for it." They have nothing to do with the amount of money I spend, nor with the politics going on in schools right now. They have to do with many other things, and these things relate to why the issues brought up in these three papers are important.

The first one is inevitable; it is happening right now. On December 31, 1999, the United States ended the second largest baby boom in its history. Twenty-three percent of the children born in the last baby boom, from WWII to its peak in 1972, were minority children. Around 2020, 40 percent of all children attending school in this country will come from minority backgrounds. That is a huge increase, and what it says is this country's educational system, whether it be public or private, will have to educate the largest number of minority students in history. The second reason is that the economy is global. It's that simple. We no longer compete between Detroit and Chicago. Chicago and Detroit compete against Calcutta, Singapore, Paris, and Stockholm. If you want to make money, you have to compete on those fields. Therefore, when we think about diversity and equity in science, math, and technology education programs, we have to ask ourselves, what does it mean? To me, it means the future. The numbers are there, the economy is there, and we have to do things differently than we've done before.

There are three questions I want to go over; also, I want to talk about some things these papers have in common. The first question is that we must think about a new definition of success in education. It doesn't mean success has to be less than it is—it just means we have to look at it differently. The second question is that we have to think hard about how we measure success. How do we take these programs and successfully scale them up? As a historian of education, I don't know if we've ever scaled up an educational program. We've mandated and put a lot of money behind it and done it. For example, look at what Sputnik did for math and science in schools. We put a lot of money behind it and just did it—not a lot of research, but a lot of money. Third, how does this conversation of special programs no longer become special programs, but become the norm, or the culture, of the schools? Because it will have to become the norm to be successful.

I think the others did a very good job of capturing some points here, and describing some good things which are happening in terms of "these are successful practices." And let me

tell you that as a program officer who is responsible for giving away about $10 million a year in grants, I have never had anyone come into my office and say, "I'd like for you to fund a bad program." All programs are good. But there are some common things here that we must pay attention to when we try to answer these three questions. The first one, as made clear in the papers, is that kids may not feel invited to learn the subject area. Women didn't feel they were invited into this field. Whether it is a math or science program or any other program out there, what we begin to ask is: Are the students welcomed into the class? Are they expected to learn? And is the curriculum rigorous? Do they get a sense of efficacy from the faculty that is teaching them, from the teacher in front of them? Do they get the message "I am here to teach you, I believe you're going to learn; I'm going to teach you this subject area, and you really belong here"? We also have to figure out, then, if they're not invited, how do we invite them?

Another issue is that these three studies show a lot about what we have learned, and we've learned an awful lot in this field. Have we learned it all? No. But we have some knowledge. One of the problems we have is that the knowledge may exist here in this room with two hundred of us, and maybe you can multiply that three or four times, but how does that knowledge begin to spread into practice? What I didn't see here was the hard wiring that takes the knowledge and puts it into the practice. You really brought back home some studies I have been reading over the last few years about minority achievement. Look at the differences in the Equity 2000 cities. In Milwaukee, with which I am very familiar, and other cities, look at what happened over the years. Do we have any indication of what was learned in those cities, about how they took an idea from its gaseous state and made it into a solid entity? And if we did, do we have teachers who can talk to other teachers about how they did it, how they learned it, how they took it into the classroom, and what they've learned from it—and then carry it on? These are important things, because if we're going to translate this knowledge from one place to another, we've got to have translators. This is some of the work that still needs to be done.

Also, it may be as important to discuss how we teach as it is what we teach. That one and one equals two, we will give that as a common thread. We can teach that over and over—but how do we teach that? Maybe it goes back to the question about how to take what we've learned and make it into the norm, because the norm probably needs to be a new norm. How do you take the knowledge you have and integrate that with other areas? Now I'm going to push this a little. Maybe if the hands-on experimental approach, if the very active learning that must go on and that arose in almost all of your studies were necessities, and if the mentoring for all those things that seem to be common denominators across the board really produced strong results in academic achievement by children who were learning nontraditionally, then we must begin to look into other areas, other fields, about how to take this and integrate it.

Let me give you an example. A very interactive field of learning is the arts. Whether it's theater, drawing, speech, filmmaking, painting, sculpture, or poetry, it is a very interactive field. Who says you can't take one area of math or science and begin to integrate arts with it in a very interactive stance? I'm not saying we have the answer about how to do that or that we can demonstrate it. I have seen some schools that have used dance to teach geometry—and it worked, the scores were up. The mayor was pleased. The superintendent was pleased. Therefore, the program was a success. Did those programs become a norm in the city? No. The trick here is that even if you raised the scores, the politicians don't understand what happened. They just want to make sure the scores are up. All they will do is make sure that the person at that school or set of schools continues to do what he or she is doing, so when they bring the other politicians, they can demonstrate it. The trick is for us to take that unique piece of learning that happened there in teaching and begin to expand upon it in different ways.

The real issue once again is how do we take this and move it on. There is knowledge out there of substantive value. It is deep—although perhaps not deep enough. It is broad—although perhaps not broad enough. Most educational innovations in this country were not based upon anything much deeper than the will of the people, and the will of the folks who had the power to vote in legislative chambers to make change, followed by the acceptance and hard work of folks in classrooms to accept that change to create a new norm. What we have here is evidence that we need to build upon, and the studies talked about here lead me to believe that there is more work to be done. The job is not over, but we have begun to do that work.

PANEL THREE

Good Grades/Low Test Scores: A Study of the Achievement Gap in Measures of Quantitative Reasoning

Lloyd Bond

"Perhaps the single biggest instructional challenge in all of high school mathematics is the difficulty teachers have in moving students from being able to solve well-structured problems to being able to solve verbally presented tasks (i.e., "word problems"). The most pressing immediate research imperative, I feel, is of a more ethnographic nature. What antecedent instructional conditions facilitate and what antecedent conditions frustrate the development of proficiency in quantitative problem solving?"

This investigation,[2] although it identifies a limited number of aspects of a complex problem, points up fruitful areas for future research. We have seen that students who have the requisite declarative knowledge to solve a class of quantitative reasoning problems nevertheless fail to use that knowledge when it is required. Additional research is needed to describe more completely the nature and structure of the mathematical knowledge that students with the "good grades/low test scores" achievement pattern have. More research is also needed on the features of quantitative reasoning problems that make it likely that students who have the required knowledge will correctly solve them. It was noted earlier that one relevant task feature appears to be the extent to which the problem is "concrete" (i.e., employs specific numbers) versus "abstract" (i.e., employs unknown variables). Kintch and Greeno (1985), Mesa and Herbst (1997), and others have stressed the verbal processing demands of many problems that are intended to measure quantitative ability. Perhaps the single biggest instructional challenge in all of high school mathematics is the difficulty teachers have in moving students from being able to solve well-structured problems to being able to solve verbally presented tasks (i.e., "word problems").

The most pressing immediate research imperative, I feel, is of a more ethnographic nature. What antecedent instructional conditions facilitate and what antecedent conditions frustrate the development of proficiency in quantitative problem solving? Two general categories of studies come immediately to mind: studies of the instruction taking place in actual classrooms and studies of student non-classroom engagement and time spent on things academic.

It is axiomatic that good teaching is essential for good learning. To be sure, some students can, on their own, achieve remarkable levels of proficiency in certain domains, but for the vast majority, quality teaching is prerequisite for high or even adequate achievement. What constitutes "quality teaching" in elementary, middle, and high school mathematics? Eminent scholars such David Berliner, Lee Shulman, and Gaea Leinhardt have studied expert teachers in action. Their work, along with the highly influential series of standards and associated performance assessments of the National Board for Professional Teaching Standards for certifying public school teachers has contributed significantly to our understanding of precisely what constitutes good teaching. One surprising, but consistent, finding is that credentials per se (e.g., number of advanced degrees) are largely unrelated to teaching expertise. Teachers with bachelor's degrees do as well on the board's rigorous assessments as do those with master's and doctoral degrees. The inference that one is a good teacher must be made on the basis of his or her actual classroom practice: What does the teacher assume about the state of knowledge of his or her students? Is instruction appropriately paced? Does the teacher sequence hierarchically ordered concepts in a rational and coherent way? How does he or she respond to individual differences in readiness? What kinds of assignments does he or she give the class, and what is the nature and quality of his or her individual student feedback? How does the teacher monitor and assess student progress, and what level of student proficiency do his or her grades reflect? A related set of questions involves the extent to which teachers take the easy way out by limiting instruction and assessment to the developmental level of their students, thereby avoiding more challenging tasks altogether. If we are to relate student achievement to teaching expertise in any defensible way, this level of specificity is essential. A well-designed ethnographic study of actual classrooms would be an enormous contribution to our understanding.

Issues of readiness and "social promotion" must also be systematically studied. Many students, especially those in over-

[2] Bond refers to original research that he describes in a more extensive paper, which is available at www.nise.org along with the more extensive background papers the panelist's short papers provided in this report.

crowded urban schools where many math and science teachers are certified in areas other than math and science, may advance through the mathematics sequence with acceptable grades but fundamentally unprepared for the next level of math instruction. As a consequence, much of the knowledge they have may be precarious and almost entirely verbal. The present investigation would suggest that this is precisely the case. To repeat, a well-designed ethnographic study of actual classrooms, of the content of instruction, of the assignments given and the grading criteria used, would be an enormous contribution to our understanding.

In addition to in-classroom studies, research is needed on exactly how students spend their non-classroom hours. Other things being equal, can individual differences in proficiency be traced systematically to the amount and quality of non-classroom time that students are engaged in relevant tasks? Student self-reports are often unreliable and generally insufficient. Observational studies of non-classroom activities, while expensive, are not impossible.

Finally, it should be noted that, although I have deliberately omitted discussion of social and psychological factors involved in performance on cognitive measures, including measures of quantitative reasoning, such factors are clearly important. Claude Steele's highly original and insightful investigations into the phenomenon of "stereotype threat" are a case in point (Steele 1997). He convincingly demonstrated that individuals who are the object of a negative stereotype (as African American students are with respect to measures of intelligence and scholastic ability) tend to so internalize the stereotype that it adversely affects their performance on such measures. When students were randomly asked to solve a series of problems under stereotypically threatening conditions ("this is a test of intelligence") and under innocuous conditions ("this is an experiment on processing strategies"), African American students randomly assigned to the former conditions did significantly worse. We need to know how pervasiveness this phenomenon is and to devise effective ways to counter its potentially harmful effects on student academic growth.

Future Research Related to Equity in Achievement and Course-Taking

Jeannie Oakes, Kate Muir, and Rebecca Joseph

"How can states, districts, and schools undo the structural impediments to equitable course participation—e.g., uneven resources for high-level math and science among schools, tracking practices within schools, and the uneven assignment of teachers to schools and to tracks within schools?"

Our review of research on equity in mathematics and science course-taking and achievement reveals that, in a decade of policies pressing for high standards in schools that remain separate and unequal, we've made some progress in raising the levels of course-taking and achievement for all racial groups. However, we've done little to reduce the gaps among them. Although the increases are encouraging, they have served to raise standards for admission to competitive colleges in ways that prevent most low-income and minority students from translating their improved accomplishments into enhanced educational and life chances. However, our review also supports the claim made last year by the Task Force on Minority High Achievement that we have learned a great deal "about how minority educational outcomes can be improved, despite having made only modest investments in educational R&D" (College Board 1999, p. 14). We conclude with the task force that we must "redouble our efforts and our investments" to promote minority opportunities and high achievement (p. 14). To forward this agenda, we offer a set of research questions about the general educational system as well as questions specific to math and science education. We believe that both types of questions are necessary, as researchers and policymakers implement what we already know and mount new, vigorous initiatives to learn more and do more to achieve equitable course-taking and achievement.

Questions about Diversity and Learning

Currently we are unable to draw on the full range of talents in our diverse population due to our lack of specific understanding of the value of diversity to learning and social advancement. We must dismiss the idea that we value diversity for diversity's sake and start believing in the idea that diversity is needed to better us all. We must take the challenge posed by Rita Colwell in her foreword to *Women, Minorities, and*

Persons with Disabilities in Science and Engineering: 1998, in which she writes:

> A challenge for our country is to attract the best talent from all sources to science and engineering to stimulate creativity, innovation, and change; contribute to the advancement of science and engineering; and foster a scientifically literate population. Different perspectives, talents and experiences produce better ideas (NSF 1999, p. ii).

The answers to the following questions will help us better engage a broader section of our population in learning and contributing to science and mathematics:

- What can educators learn from science about the advantages of diversity in the natural world?
- What contributions do diversity and heterogeneity make to learning and change in social institutions?
- What could constructs from sociocultural perspectives on learning, such as learning in "communities of practice," through "apprenticeship," as "changing participation over time," as "identity development," etc., contribute to our general understanding of learning in diverse settings?
- How can math and science courses capitalize on diversity and heterogeneity to maximize learning? How, for example, might a greater emphasis on diversity contribute to all students' multiple ways of knowing math and science?

Questions about Creating More Equitable School Structures and Cultures

We have specific evidence from research and equity interventions about school conditions likely to promote more equitable course-taking and achievement. A college-going culture at school, high-quality curriculum, well-prepared and knowledgeable teachers, special academic assistance when needed, supportive relationships with caring school adults, and connections with families focused on high achievement and college-going all seem to foster the outcomes we seek for low-income students and students of color. But to translate these features of exemplary schools and effective special programs into the routine, everyday practices experienced by low-income students of color presents enormous challenges. Research focused on the following questions should help:

- How can states, districts, and schools undo the structural impediments to equitable course participation—e.g., uneven resources for high-level math and science among schools, tracking practices within schools, and the uneven assignment of teachers to schools and to tracks within schools?
- How do schools create academic, college-going cultures where adults and peers see college-going as expected and attainable, and where they see the effort and persistence that preparation for college requires as normal?
- How can we piece together what we know from effective "equity programs"—including their provision of intensive academic and college-going support and close relationships between students and adults—to create an equitable science and mathematics educational system?
- How can schools, working with community organizations, develop connections with parents and neighborhoods that enhance their knowledge of and access to mathematics and science courses, high achievement, and college preparation?

Questions about the Form and Substance of Equitable Courses

How can we create courses that make mathematics and science content more accessible to all American students? In contrast to commonly held views that low-income and minority students devalue education, studies suggest that they more likely to turn away because of a real or perceived lack of opportunities (Steinberg 1996). A recent RAND study of low-income high school graduates who were eligible to attend the University of California but chose not to found that the students were most deterred by their beliefs that the university is "not for people like me" (Krop et al. 1998). These perceptions arise, in part, as students internalize negative labels assigned to their racial and cultural groups—what Claude Steele (1997) terms "a stereotype threat." Creating courses where minority students can see the connections between themselves and the content of science and mathematics and where teachers use pedagogy that builds on students' cultures and languages is one way to counter this threat. However, we need to know far more about what such courses might be like. Research into the math and science education questions below should help us develop a system in which students hold identities that are simultaneously multicultural and academic:

- How can science and mathematics be treated as everyone's "everyday practices"?
- What are multicultural curricula and culturally relevant pedagogies in mathematics and science?
- Does the absence of multicultural and diversity issues in the *National Science Education Standards* prohibit equitable implementation of the standards?
- What assessments capture and respect multiple ways of knowing mathematics and science?
- Is Advanced Placement and the pipeline of courses that lead to it an equitable (or even the "best") approach to advanced study in mathematics and science?

Questions about Social and Political Support for Equitable Schooling

The National Task Force on Minority High Achievement puts it simply: "America is a diverse society in which educational differences have the potential to become a progressively larger source of inequality and social conflict" (College Board 1999, p. 1). Efforts to construct the math and science education system in ways that the literature suggests are necessary to make participation and high achievement possible for low-income students of color will inevitably bring political resistance from powerful forces bent on preserving the status quo. California's recent rejection of affirmative action provides a sobering example. This response is understandable in a strati-

fied educational system where opportunities are based on ideologies of intelligence and merit that disadvantage some groups and favor others. Are we to just sit by and let conflicts build? Or could research on the following issues reveal ways that Americans might move more harmoniously toward a diverse, high-achieving, and equitable society?

- What is the impact of our culture's framing of mathematics and science achievement as "culture free" and ideologically neutral? How do we dismantle the elite and esoteric status of science and mathematics as fields of study?
- How can we change prevailing attitudes about who can learn mathematics and science? What alternative measures of competence and potential help reduce race and social class sorting?
- How do we develop norms whereby Americans see deep engagement, high achievement, and hard work in mathematics and science as *normal* and expected of all?
- How can we counter the often-unspoken race and social class fears that complicate efforts to create equitable course-taking and achievement?
- How can we unseat ideologies of competition and merit in schools that perpetuate social and racial stratification in school and beyond?
- How can more equitable schools hold on to children from families used to having a competitive advantage?
- How can we make salient that our goal must not simply be to accommodate "minorities," but to educate everyone well in an increasingly diverse society?

Underrepresented Minority Achievement

Richard Tapia and Cynthia Lanius

"We often see 'minorities' as one huge homogeneous class of people. This is especially true of Hispanics, but vast disparity exists among different Hispanic groups. We would like to see more research on meaningful classifications of minority subgroups with meaningful data collection based on those groups."

How could so much time, money, and effort be put into a problem with so little success? For at least three decades, this nation has attempted to increase the participation of underrepresented minorities in science, mathematics, engineering, and technology with dismal results. Countless research projects have been conducted with numerous programs implemented with so little improvement that one wonders if the same increase would have occurred if none of these efforts had ever been expended.

In this paper we will resist lamenting the failures of the past but will rather call for a major reexamination of the system. It is time to ask if new programs grafted onto an ailing system will solve the problem. Thirty years of failure should tell us that for underrepresented minorities, the system is irreparably flawed, and no fine-tuning of existing structures is going to fix it. We call for research to define an educational system that supports minority success.

City Culture: A Value System of Its Own

Have you noticed that as long as teen violence remained confined to cities, it was not seen as an American problem? We expect urban minority kids to be violent. Not until teen violence emerged in rural and small-town white America did the country see it in crisis proportions. What do we as a nation believe about cities (and we really mean inner-cities), and how

ETHNICITY OF SELECTED URBAN SCHOOL DISTRICTS

Ethnicity	Chicago	Houston	New York	Los Angeles
Latino	34.2%	52.5%	37.7%	69.1%
African American	52.5%	34.1%	35.7%	13.6%
Asian/Pacific Islander	3.2%	2.8%	10.8%	6.5%
Native American	0.2%	0.1%	0.3%	0.3%
White	10.0%	10.6%	15.5%	10.5%

Sources: http://www.cps.k12.il.us/AboutCPS/Statistical_Information/statistical_information.html; http://www.lausd.k12.ca.us/lausd/demographics/; and http://www.houstonisd.org/About/Pubs/AboutHISD/index.htm.

much of the cities' failures do we merely accept as a consequence of minority culture? None of us see cities as just very big small towns. Cities and city schools are driven by parallel minority cultures. Large urban school districts are 85 to 90 percent underrepresented minorities. (See table on previous page.) Do we just expect them to be bad?

We have to learn more about these cultures and our expectations if we are ever going to invent an educational system that is a good fit for urban America. How can we invent a new educational model for our cities until we expect better for them?

Diversity within Diversity

As a nation, we understand so little of the issues of diversity. We often see "minorities" as one huge homogeneous class of people. This is especially true of Hispanics, but vast disparity exists among different Hispanic groups. Two-thirds of the American Hispanic population are Mexican American, yet the majority of Hispanic scientists in America are European, South American, Central American, or Cuban American. We would like to see more research on meaningful classifications of minority subgroups with meaningful data collection based on those groups.

Minority Males: Missing in Action

What has happened to minority males? After examining 1997 SAT data, Donald Stewart, former head of the College Board, identified African American and Mexican American males as the lowest performing subgroups (College Board 1997). Walk into historically black universities and colleges, and you will see a majority female population. Consequently, gender equity programs directed toward females in cities with majority "minority" populations make little sense. What kinds of programs are needed to engage minority males in science?

Lessons from the Women's Movement

Over roughly the same time period that the nation has attempted to increase participation of minorities, we have also attempted to increase the participation of women. It is clear that in most areas, the women's movement has been more successful than the minority movement. We hasten to add that this work is not complete; women have made great strides in many fields, but are not at parity in engineering or computer science, for example. Yet there may be lessons learned that can be exported to the minority movement.

Discussion: Panel Three

Norman Webb

I found these three papers to be very stimulating. There were a lot of data, and a lot of facts—and I like data, being in the evaluation business. Looking across the three studies, I would conclude the following: that schools with underrepresented students need to provide them with access to a full range of college preparatory mathematics. In these courses, teachers need to strive for their students to gain both clarity and procedural knowledge, and we need to think about students as individuals and not as groups or broad categories. Gloria Ladsen-Billings at the University of Wisconsin says that student performance is not predetermined. As we look at indicators and we put people into groups—and Professor Tapia said this well, "diversity within diversity"—we have to look at individual students and see what their needs are, and educate them. As Jeannie Oakes also said, we need to educate a diverse society. That is a key point—we need to think of students as individuals and not think of their performance as predetermined. I think of the article by Oakes, Muir, and Joseph as being a cross-section of a problem. I think of the Tapia and Lanius paper as looking at the longitudinal question. And I think of the Bond paper as looking at learning needs and issues at the microlevel. All of them get at the learning issue, which I think is very critical.

In Oakes, Muir, and Joseph's paper, there were many important ideas. Many students reside at high schools that do not offer the necessary set of mathematics and science courses for them to be eligible for higher education. That is a problem we need to deal with. Low-progress schools offer a higher number of below algebra courses and less AP courses. Students in poverty have less-qualified teachers—this is a very important issue that none of the speakers discussed but which was included in their papers. The papers provided very compelling evidence of the ills of tracking.

The Tapia and Lanius paper showed very little increase in the percentage of African Americans, Hispanics, and Native Americans who have obtained bachelor's, master's, and Ph.D.s in science and engineering. This is a problem. I thought they provided very compelling evidence of that. I like the idea of "diversity within diversity"—I think this is a very strong and important point in this paper.

College admissions need to consider other criteria than less-biased mechanisms, such as using only the SAT—this notion of the SAT as a threshold is a very important point. You give a baseline of value, but anybody who can reach above that—then you make a variety of decisions. Tapia and Lanius also use the words "affirmative development"; this is another critical idea in their paper, another area in which we need to take action. They point out that the three particular barriers were recruitment, admissions, and retention, things that have policy and learning implications—and also implications in trying to address the problems.

Concerning Lloyd Bond's paper, I thought Larry Suter did a good job of pointing out some issues differences between declarative knowledge and procedural knowledge.[3] He thinks you must look at what students learn. What was so powerful about this paper is that Bond really identifies some learning issues. He says that these students have the clarity of knowledge and they have the facts, but how can they put the facts together? In his paper, he shows the protocols and interviews students on how they are thinking; he demonstrates that, yes, the students have the facts, but they don't have the procedures to put them together to solve complex problems—this gets back to education, learning, and qualified teachers. Another important issue to look at is what is the teachers' knowledge? What is the procedural knowledge and what is the declarative knowledge of the teachers? This is something people don't like to talk about, but we need to. We need to open things up as we look at education for a diverse society; we need to think about many different issues.

I'd like to draw on some of my experience in past work I've done with NISE. One is this issue of alignment. The Texas state assessment issue that Professor Tapia pointed out is very critical, and part of the issue is alignment. We've done a number of studies of state assessments as they match standards. Basically, large-scale assessments cover only about 33 percent—or even less than half—of the standards, so it is very difficult on any large-scale assessment to cover everything. In our assessment world, where we talk about multiple measures, you need multiple measures and you need monitoring of any large-scale assessment program. This is costly, and this is something we are looking at in Milwaukee. Recently, Milwaukee adopted a yearly testing program because the state wanted more information on value adding. But we wondered how you can guard against standardized tests becoming the curriculum, which it sounds like the Texas state assessment has become? Well, you can do it. You need other kinds of mechanisms. You also need to look at the monitoring process. One thing they built into the Milwaukee program is classroom-based assessment—that is, there will be more open-ended assessments, assessments that will be large scale, and that will be more aligned with what you want instruction to be. The idea is to have more than one mechanism with which to make decisions.

We also have looked at the issue of curriculum reform. When we look at transcript data of schools with a large proportion of minority students, we see that this leads to more of the underrepresented students taking four years of high school, college-qualified mathematics. We compare that with students who began high school in the algebra strand. This raises the question of what we mean by high school mathematics, and how it should be organized. The European countries think of math as 1, 2, and 3; they don't divide it into algebra, geometry, algebra 2, precalculus, and calculus; focusing on AP as the pinnacle of education and of high school is a problem. It is something we have to think about, although I know it is part of our culture.

One of the things this leads to—and something that the speakers have talked about—is looking at college as the reason for high school. We clearly need more representation among college graduates, and also in graduate education, but we're not serving our students well if we only provide them with a college track. I think that this is a form of tracking. I recently heard statistics that stated that, for the first time in a long time, the United States does not have the highest percentage of students with college degrees; England does. England has about 35 percent of its students with college degrees, while the United States has about 33 percent. We're talking about a third of our population with college degrees. What about the other population, the other two-thirds? Are they not doing anything? There are a lot of things available, and there are a lot of jobs available that are not being filled by trained people.

[3] Larry Suter, chair of this Forum session, presented Lloyd Bond's paper because he was unable to attend.

Forum Participant Views

Obtaining and using substantive feedback from Forum participants through multiple means is a key part of making the NISE Forum a knowledge-building event. (For details about data collection and analysis methods, see chapter 1.) This chapter presents participants' views in two sections:

1. Analysis and illustration of "think pieces" written individually by all participants and comment cards generated by small groups of participants.
2. "Reporter" presentations providing a quick analysis of the small group comment cards as made by Angela Calabrese Barton, Tom Gadsden, Sharon Lynch, Joseph Krajcik, Jerry Valadez, and Aleta You.

ANALYSIS AND ILLUSTRATION OF PARTICIPANT VIEWS

The following summaries and selected quotations are organized according to the major themes that emerged from the Forum, as discussed in the chapter 2 synthesis.

Access to Courses and Teachers

Summary

The effects of tracking need to be documented not only for lower-track but also for higher-track students. Although there is good understanding of the effects of tracking for students in the lower tracks, not much is known about the effects of tracking for students in the upper tracks. Several comments mentioned a fear of hurting upper-track students while trying to increase the achievement of the underrepresented students. Some participants also questioned the advisability of Advanced Placement classes as a measure of success in mathematics and science.

A perplexing situation is that so many more males choose science, mathematics, engineering, and technology (SMET) careers in spite of the fact that gender differences in K–12 course-taking patterns and achievement in mathematics and science have been reduced over the years. The changes in classrooms and schools do not seem to affect ultimate career choices of young women. As one participant noted: "Do teachers encourage males in science and mathematics (over females) because they believe or know that the males will be favored in jobs that require science/math/technology backgrounds? If there is gender equity in the workplace, will that affect gender equity in the math/science classrooms?"

Regarding teachers, there needs to be documentation of their career paths, especially for beginning teachers. Participants referred to this as the "tracking" of teachers. They were primarily concerned with what teachers teach what types of students. Where do new teachers start out? Are they assigned the most difficult students in the most challenging schools? How long do they stay?

Additional Quotes

- "We need research on inclusion of African American students in high-stakes science and mathematics courses in middle and high schools."
- "How do minority students who take AP mathematics and science courses perform in college courses compared to their peers who have had either honors or advanced science or mathematics?"
- "More research is needed on AP issues, including in rural and poverty areas, not just among minority populations."
- "What is the impact of inclusion of higher-level courses in high-minority-enrollment schools? If given the opportunity, will students take the courses, and who will teach them?"
- "Will the increase of technology in both mathematics and science affect gender equity gains that have been achieved to this point?"
- "The diversity record in physics is worse than that in the other sciences, mathematics, or engineering. Why is this true? Is there a single factor at work or many?"
- "It is important that we find out if an integrated curriculum (Core-Plus, IMP, etc.) provides access/success for underserved populations in mathematics as opposed to algebra 1, geometry, algebra 2, etc."
- "Research should be done on the impact of NSF-sponsored mathematics and science curricula on learning for underrepresented students."
- "New teachers of color often find themselves in the most difficult sites within a district and at the lowest end of the content strand. Do they stay in the profession? What is their level of job satisfaction?"
- "What difference did having ethnically representative teachers make with regard to science and mathematics achievement in the Equity 2000 project?"

- "How do we change the reward system so that high-quality teachers and counselors have an incentive to work in low-progress schools?"

Content, Instruction, and Assessment

Summary

The key question here is what works for whom. Participants felt that research/evaluation should focus on the student and the program and, at the same time, have implications for educators. Participants expressed the need for research on various mathematics and science curricula along with the tracking of students. The concerns focused on various NSF curricula, AP courses, and the sequence of curricula through the grades, all in light of diverse populations. One participant raised an excellent question when he asked, "How different is good teaching from teaching for diverse groups?" Another participant put it somewhat differently: "At the core of good science teaching is a good science teacher." To the extent that teachers understand the cultural differences among students, the more likely they are to have a wide range of strategies and approaches upon which to draw. A secondary concern was to conduct research on how to assess students. Specific issues included the most appropriate types of assessments, the alignment of assessment with curriculum and instruction, and less reliance on traditional testing methods—again all with a multicultural lens.

Additional Quotes

- "Every student comes with a different home culture, even if he/she outwardly looks alike. We need to know how to draw this culture out of students in order to identify their prior conceptions and why they have them."
- "What are the connections between language and culture and an understanding of what math or science is and how it is learned?...There is a dilemma between getting diverse students access and honoring their home culture."
- "To what extent does the culture of the teacher affect what the teacher chooses to teach in science?"
- "What is the interaction between the cultural background of the teacher and the cultural background of the learners?"
- "Can we develop a curriculum and instructional methodology that is effective across cultural groups? Can we develop a curriculum with multiple approaches to teaching the same content?"
- "Since two-thirds of our students never realize a college degree...what type of rigorous academic curricula would be relevant for them?"
- "Must we fundamentally redefine what mathematics and science are and how we can know about the world around us in order to accommodate different language and cultural perspectives? Would our society benefit from this broader view?"
- "How do reform efforts that improve performance for underserved groups affect the performance of the groups who are achieving under the current system? We don't want to fix one problem and create another somewhere else."
- "Some people feel that striving for equity may reduce the quality of content and instruction. How do we address equity needs and maintain quality?"
- "We need success stories that identify, research, and describe instances of successful science instruction with diverse student populations in multiple contexts. This research is important in helping to show some possibilities in terms of what is actually happening in classrooms for comparing and contrasting with theory."
- "We need to do the 'what works for whom' component of research on instructional practice...while realizing that group membership does not predict individual characteristics."
- "Do different ethnic or language groups need different 'scaffolding' to develop the scientific process and skills we currently value?"
- "More research is needed on dealing with how students learn mathematics and science. For example, we teach number sense based primarily on number and number relations. How might males and females do if a more geometric length perspective were taken instead of just number to first discover relationships of commutativity, etc.?"
- "Do gender-specific programs work across cultures, and do multicultural programs work across genders?"
- "What are the characteristics of rural and low-income populations and cultures?...There needs to be more research on the types of instructional strategies that truly meet the needs of our rural and low-SES [socioeconomic status] students."
- "More research is needed on assessment and achievement in nontraditional methods (not SAT, IOWA, etc.). Minority students are known to score poorly on these tests, so why use these methods to filter out students from higher-level mathematics and science courses?"
- "We need empirical data showing what types of assessments lead to increased student achievement."
- "We need to use different types of assessment—lowering the emphasis on standardized test scores...and focusing on higher-level thinking skills with instruction (problem solving and reasoning) with diverse students, as well as all students."
- "Assessment and its integral relationship to curriculum and instruction, in the context of teaching in a diverse society, is a critically important area for research. This research is needed not only at the classroom level, where it is a fundamental force in teachers' and students' engagement in teaching and learning, but also at larger scales, including school, district, state, etc. Acknowledging, celebrating, and understanding diversity in learning necessitates similar action in assessing that learning."

Understanding and Scaling up Effective Programs

Summary

Participants strongly expressed the need to know how to scale up and institutionalize programs that work. Even when we are sure about an effective strategy or program, we don't know how to institutionalize it in our schools. As one participant said, "What are the components of the scale-up—moving from programs to change culture? Several panelists identified scale up, capacity building, and institutionalization, but I'm not sure we've discussed how they are achieved."

Additional Quotes

- "Scaling up, scaling up, scaling up! It is difficult to do because it involves structural changes."
- "How do things that work become the norm, especially with diversity and equity issues? There are pockets of good things going on for all groups. How do we mesh this to being beneficial for all students?"
- "How can we develop conditions so that excellent education is provided to all students in all schools—not just 'boutique' or to some small research project?"
- "Are there programs that have been successful in scaling up and becoming institutionalized? What are some of the unintended consequences and failures, and what lessons can be learned from these?...What programs are most effective at the elementary level? Have any successful programs at the secondary level been tried at the elementary level and with what results?"
- "We need research on barriers encountered when trying to scale up in order to affect the whole system."
- "Does a change in systemic approaches adversely affect any particular group, or do all students benefit?...Is standards-based instruction, as we define it today, enough to effectively engage and excite all students in mathematics and science?"

Preparation, Induction, and Professional Development for Teachers

Summary

There need to be more models of effective teacher training and professional development for training teachers in science and mathematics content with a multicultural lens. Research is needed on how to effectively train teachers to embrace multiple perspectives regarding culture, race, ethnicity, language, gender, disability, and socioeconomic status differences among students. Teachers, and educators in general, just do not know enough about all the variations that students bring to the classroom to make necessary adaptations in curriculum and instruction that will allow all students to learn. One participant cautioned: "It appears that learning to teach science takes awhile. Learning to teach science when the teachers also need to make cross-cultural connections is bound to take even longer."

Additional Quotes

- "We need research on teacher background (cultural, educational, etc.) related to the impact on their instructional practices."
- "What are ways to help teachers make these connections [between science instruction and cross-cultural understanding]? How long should this be expected to take? How do we give teachers time during the induction years to reassess what they need to do to better reach their students?"
- "How do diversity and equity issues play out in the teacher population itself? How should we take these matters into consideration when designing and delivering staff development?"
- "In professional development, one of the key components is learning how to learn from student assessments and how to adapt in response. How can the teacher ask questions and observe in ways that produce valuable data? How can the teacher analyze and interpret the data in ways that are cognizant of student cultural differences?"

Better Research Methods

Summary

Neither research nor program evaluation is able to supply educators with quick, concise answers to achieving equity in the classroom. For example, participants wanted to understand how different groups learn and how they could accommodate these differences in the classroom. They posed such questions as "Do single-sex classrooms work?," and "Do charter schools to a better job with diversity?" One repeated suggestion was for longitudinal studies to attempt to answer such equity-related questions.

Many participants wanted more disaggregated data—for example, Hispanic groups broken out by country of origin (Mexicans, Cubans, Puerto Ricans, Central Americans) and, within that, by gender. The problem is that such data cannot always be obtained because of needed sample sizes. The situation may get worse as the government has broadened its racial/ethnic categories (more cells), plus there has been an increase in the numbers of individuals whose heritage is mixed and who therefore could check multiple categories.

Additional Quotes

- "There need to be more researchers who reflect the culture of those being researched."
- "More information is needed on the evaluation of programs. How do you measure success regarding equity and diversity?"
- "We need other measures of student success in SMET areas than academic degrees and numbers enrolled in the majors."

- "What do the SATs really mean in terms of long-term outcomes by gender, race, and ethnicity?"
- "If we agree we should collect achievement data, what type of data should we collect? What do these data mean?"

Dissemination

Summary

The need for better dissemination came up as a major theme in the small group responses to every panel presentation. Some participant comments indicated that they were not familiar with research findings that are readily available, or that they were hearing this information for the first time at the Forum. It was clear that the research community has not done a good job in communicating findings from research and program evaluation. As one participant said: "Existing research needs to be shared with districts and schools of education to inform and shape teacher preservice, in-service, and professional development."

Even when results are disseminated, researchers cannot assume that practitioners know what their findings mean and don't mean and how to apply the findings to the classroom. Thus, research findings need to be targeted to different groups: administrators, teachers, parents, guidance counselors, preservice teachers, teacher trainers, etc. It appears that a much better job has been done in communicating problems than solutions.

Additional Quotes

- "There needs to be an accessible compilation of what is known about 'special programs.' Too many programs are 'reinvented' because they don't know what is out there."
- "We do know what works; implementing those criteria is a question of will. So what we need to do is get the criteria out in ways that can be used by policymakers, administrators, and teachers at all levels."
- "There is more research out there than is being disseminated. People just do not know all that is available regarding equity in mathematics and science. That is true for educators and even truer for parents."
- "How can data be used more effectively in schools, districts, and states to help close achievement gaps? Too many decisions are currently made based on emotion rather than on existing data or even by trying to figure out what data might be needed to answer a question. A major barrier seems to be lack of comfort with data and data analysis techniques."

REPORTS FROM SMALL GROUP DISCUSSIONS

Angela Calabrese Barton

Report on Small Group Discussions

What I tried to summarize in our small group sessions were the overarching critical issues in teacher education and professional development as they relate to equity and diversity. The overarching theme that came out of our conversation was that we believe we need to have a philosophical and research-based vision and conceptualization of teacher preparation and development programs that focus on equity and diversity.

There were three subthemes. The first concerns data. What do we have? How are the data useful or not useful? Specifically, we need to look at students' performance, achievement, and attitudes and beliefs; at teachers' beliefs, practices, and expectations; at teachers, educators, and policymakers in terms of their beliefs and practices; and then at communities in terms of opportunities, resources, beliefs, and practices. But then what data do we need? How ought we to generate these data, and why? The consensus was that we need to have more of the type of data listed above but in many and different kinds of ways. We need much richer contextual detail, as Joe Krajcik mentions, and we also continue to need numbers in disaggregated form as well.

Then we considered the question of who ought to participate in data generation. How, why, and when are really critical. Whose data are these, anyway? The next question under data was what do about the misuse of data, such as linking high-stakes performance exams to funding for schools or to tracking issues. We really need to take a critical look at that.

The second subtheme revolved around whose voice matters. This concerns building a teaching and resource course that reflects the students of our schools. Linked to that are issues of recruitment, preparation, and retention. We have to focus on really listening to the voices of all stakeholders. That means really listening to the voices of teachers, parents, families and caregivers, the community and those who work with children and youth in the community, the children and youth themselves, and also other researchers and policymakers. I think that we do a good job with this last one; I don't think we do a good enough job with all the other stakeholders as yet.

We didn't get to the last subtheme in very much detail, that is, how to translate all of our research and experience into practice as we think about revising our teacher education and preparation programs so that they are responsive to the needs mentioned above.

Tom Gadsden

Report on Small Group Discussions

The first comment I need to make is that the "what we know" and "what we need to know" parts overlap so much that our group did not really distinguish a great deal between them. Each place where there was research that needed to be shared, there was also research that was needed additionally. I think the one thing that came through very clearly was that schooling today is extremely complex and that diversity and equity are two of the key issues that have not been adequately explored yet. Even though they have been investigated a great deal, there is so much more to know.

Every teacher and every student enters the classroom surrounded by their culture. Call it a cloud of culture, an aura of culture, a filter of culture, whatever. That culture shapes the interaction that teachers have with the students, with the knowledge they are teaching. It is a tremendous challenge because of the great richness and diversity of ideas and beliefs and backgrounds that come into that classroom. At each intersection of content and practice with the teacher's culture and the student's culture, there is need and there is opportunity for research and understanding. Whether that involves professional development as one of those interactions, or the act of teaching, or the act of learning, all of these are points at which there is much opportunity for interaction with the culture. And for each of these intersections, we have some knowledge. That knowledge needs to be carefully compiled and interpreted and disseminated, so that we have a body of knowledge to which the practitioner can refer.

But we also need to identify what we don't know, and I think that we have done a great deal of that over the past two days here. We need research that informs us continually and helps us improve our understanding. As one group pointed out very wisely, we need to address all of the concerns raised during the Forum simultaneously.

Joe Krajcik

Report on Small Group Discussions

We were given a stack of papers and all those cards that the participants filled out. I considered synthesizing this rich and diverse material as another research challenge, and it was a challenge indeed. In our small group sessions, we tried to create a series of themes, and that is what Tom Gadsden and I are going to present today. But remember that there is a filter when one or two people speak for just a few minutes about so many rich ideas.

The first theme is around teacher education, both from a preservice and an in-service perspective. We need to know more about how to attract and retain quality teachers who understand content, who know the pedagogy, and who are also sensitive to gender and equity issues. Particularly we need to figure out how we can retain high-quality minority teachers of mathematics and science. The second area within teacher education comes under the heading of learning more about how to provide effective professional development to support equity and gender issues. This is not only an issue at the K–12 level; it's particularly important at the university level. How can we provide professional development opportunities for people who are teaching undergraduates and graduate students with respect to equity in general?

The second theme concerns the sharing of information. There is a lot of information available already, but we need some strong models of how we can disseminate that information. People want to know that information, and they need to get it in a way that is readily accessible and useful for their purposes. In fact, this is a little quote that sort of came through twice: "useful format for busy people." A lot of the people in this room are the administrators, the classroom teachers. They don't have time to go through stacks of papers. I thought that a lot of the papers we got in advance of the Forum were wonderful. But they took hours to write and also hours to read. Somehow, we need to get that sort of information down in a usable format. Related to that, we have to reexamine the information that is out there. There are a lot of myths around, so we have to go back and carefully examine the information that is out there so we don't keep circulating myths.

A third theme that arose was one of alignment. Participants in our group sessions wanted to make sure that the curriculum, the instruction, and the assessment were aligned. If these three aspects are not aligned, we are never going to be able to address equity issues. And we need alignment not only across the instruction, the assessment, and so forth, but also alignment of K–16. We have to get elementary, secondary, and higher education articulated again; otherwise, we won't make progress.

A fourth theme was one of examining educational practices in other countries and what we can learn from these. For instance, do gender gaps really exist in other countries? If they don't, we can probably learn a lot from these countries.

A fifth theme revolves around knowing more about the critical features. For instance, what are the critical features of successful SMET programs that promote gender and equity issues? And how could these successfully be transferred to other sites? We heard some really interesting work yesterday related to the Puerto Rican efforts, but what are the key elements? And which of those can be transferred to places like Cleveland, New York, Houston? Some people also had questions about best practices, and wanted to know what they looked like in detail, to really "see" them. They were calling for very detailed case studies so that they can actually discern what the critical features look like in practice.

This next area really wasn't a theme, but it showed up very clearly in one of the cards and it seemed to be a little-touched

issue in the Forum: We need to learn more about how to provide quality SMET education for students who are physically or learning disabled. This does seem to be an important issue, even if it was not raised by many of participants.

The last theme is concerned with providing quality SMET education for all. There was a strong emphasis on having to understand more of the cultural divides that exist in trying to provide quality science instruction for all students. Here is a question I composed: How do we take into consideration and be sensitive to the cultural diversities of students, yet at the same time ensure that they attain a quality SMET education? I think it is really important to look at people's backgrounds and be sensitive to them, but at the same time we have to provide them with a quality education. Those are the themes that ran through our discussions.

Sharon Lynch

Report on Opening Session

I appreciate the opportunity to talk about my new book, *Equity and Science Education Reform*, which was written with the support of NSF and NISE. The effort began in 1994 when AAAS Project 2061 put together an equity blueprint committee, which I co-chaired with Cora Marrett. After three years, the committee's work became the basis for the lead chapter on equity in Project 2061—*Blueprints on Reform*. However, one chapter in Blueprints did not seem enough, and that is where NSF and NISE were invaluable. By combining my sabbatical leave from George Washington University with a generous NISE fellowship, I was able to write the lion's share of the book in 1998.

Equity and Science Education Reform covers a great deal of territory. The primary audience for the book is science teachers, the people I work with everyday. The book is filled with stories about diverse students and teachers in classrooms, as well as statistical data gleaned from sources such as NSF and other national reports and policy and research papers. Teaching for diversity should be infused in science teacher education as the essence of what we do rather than relegate equity issues to a particular chapter or class session, lumping them together as a single problematic issue. Diverse populations of students have already become the norm in many American schools, and the rest are soon to follow. Diverse learners are not exceptions, and it's time that teacher education programs took that position from the get go. E*quity and Science Education Reform* can be used in pre- or in-service science teacher education courses in tandem with whatever text or materials the instructor normally uses so that student diversity in context plays a central role in all discussions of teaching and learning. This is more important than ever because the diversity of science and mathematics teacher populations has never mirrored the diversity of the student population—and this gap does not seem to be improving. We need to get better at teaching other people's children as well as increase the diversity of science and mathematics teacher populations.

In writing this book, I was also struck by the need for more research into the issues we'll discuss at this NISE forum. I think we have a research conundrum. We could take a color-blind approach in our research designs and simply aggregate data, but in so doing we wind up accomplishing little more than gap gazing. We may notice interesting things going on in classrooms populated by diverse learners, but the design wasn't sensitive enough to capture the phenomenon adequately. So we're left with anecdotes. Alternatively, we could design research that looks specifically at how different groups of diverse learners respond to interventions, but we risk the danger of overgeneralizing or stereotyping.

Researchers definitely need to be culturally sensitive. One way to ensure this is to achieve a sort of base validity—that is, to have people on research teams whose backgrounds reflect those of the children whose achievement we are seeking to improve. Looking around this room today, it's nice to see that, perhaps, we are on the way. It's my hope that NSF will continue to take the lead in research activities that explore diversity and equity issues.

Sharon Lynch

Report on Small Group Discussions

Several of our groups were very intrigued with the notion of diversity within diversity and better disaggregation of data. For instance, there was a discussion about categories like "Hispanic" and what that meant in terms of the various groups that this might include. One participant pointed out that there was information indicating that students who had recently arrived from Mexico were performing better in American schools than Mexican Americans who have been here for awhile. Also, there were suggestions for disaggregating the Hispanic data in terms of various Central American or South American groups, Cubans, and Colombians, also taking into account the interaction between social classes and Spanish speakers. Interestingly, a similar case was made for people of African origins. There are a lot of students in our schools who come from various African countries, African American countries, the Caribbean, and so on. The suggestion was to disaggregate data accordingly. The same point was made with regard to students of Asian origin. We even talked about children who were categorized as "white." That is an awfully big category. There are rural children, poor children, and recent immigrants. So the question was, if we knew ethnic origins in greater detail, what would we do with the information?

Another group took up the issue of language and assessment, and its members thought they had a problem that might be solvable. If there are lots of students in a system who are

English-language learners and who speak another language at home, isn't it possible to do a better job of developing accommodations when giving assessments to these English-language learners? A possibility is to have tests available both in English and the language of the home. Another possibility is to give the tests orally. We were not naïve; we recognized that there are some states that have English-only policies, making it very difficult to make such accommodations. NAEP [the National Assessment of Educational Progress] did a large-scale study of the effectiveness of accommodations for English-language learners and NAEP test results, as well as for students with disabilities. We thought we should be able to do a better job, especially in science and mathematics, of having kids represent what they know through translation and other accommodations.

There also was a lot of discussion regarding attitudes on course-taking and assessment Participants talked about teacher attitudes and how to change teacher beliefs. Sometimes these are reflected in the amount of time or the unwritten messages that teachers give to students as they take tests. We also talked about how students are excused from tests. Depending on the state, there are different regulations on this matter. The rationale often is given that too challenging a test would make a child feel bad. But on the other hand, if students in a school are excused from tests, you get absolutely no information on what they have learned or on how to improve the curriculum or the instruction.

We concluded that there is a great deal of information needed on policies that allow students to be excused from tests. TIMSS dealt with this problem. It regulated the number of kids that could be excused in a given country if the data from that country were to be included in TIMMS. So what is happening on inclusion in the United States? There also is a question about whether or not performance-based assessments might be more promising than some of the standardized assessments in terms of both narrowing gaps and changing teachers' beliefs. If teachers start teaching to a different sort of test, might we have changes in the instructional practices and curriculum?

We had another set of questions around systemic reform and accountability. The key question here was: Where are the data? How do you find the data on the effectiveness of the SSIs? How can we know that data better? How does NSF use these data? What are the next steps? What are the expectations given the data we have? The discussion also considered whether the reform curricula being used by states that are doing a good job in changing curricula and teaching practices, and doing what the systemic reform seems to be asking for, open doors for students in the long run. Or do these curricula close them? If a good reform-based curriculum has been implemented well, does that lead to opening the door to college admissions? Or are those doors being shut because of the fact that the curriculum has changed? Narrowing that achievement gap for college preparation is a tough challenge that we have all faced. Do you strive for better understanding of science and mathematics for all students, based on the philosophy behind systemic reforms and what the reform curricula have to offer, or do you help students go through the pipeline as it currently stands?

Related to that issue is the concern that in certain schools, depending on what school you went to, a 4.0 is not equal to a 4.0. One participant told the story of working with a high school student from a school that is not highly valued by local colleges. And although the young woman had a 4.0 it was pretty clear she wasn't going to get into college, even with perfect grades from her high school. There was an intervention that allowed the student to finish her education at a different high school that had a better reputation, thus increasing her chances of getting into college. She was fortunate in that she had an advocate who knew how to play the game. But what about the rest of the students in the United States who are not lucky enough to have parents or other advocates offer them that sort of intervention? What do you tell kids when they have done perfect work at a high school and then get into college and find they are still not ready?

In sum, there seems to be an interaction between language, culture, teachers' beliefs, and students' sense of self-efficacy in science and mathematics. This in turn leads to the assessment issues, achievement patterns, and course-taking patterns the groups discussed. We know that people do and pursue what they feel they are good at. If you feel confident about what you are doing, you go to it. Given the current systems of accountability and assessment, how are we going to give students of diverse backgrounds the message that they can do science, mathematics, and technology?

Jerry Valdez

Report on Small Group Discussions

On the course-taking issues, the key idea that came up included a study of de-tracking solutions and their outcomes. We see a number of districts and schools claiming to have de-tracked and gotten rid of all remedial coursework, but when you get down to the school site, you see that tracking has just taken another form. So we really need to focus on the outcomes of de-tracking, not so much on what the course title says. Also, we need to study the role of integrated curricula, as Sharon Lynch had mentioned, and what is happening to the students that have progressed through such a course sequence. Are they truly taking more advanced coursework? I think Los Angeles is about to publish some information in Science Teacher, similar to some of our data, indicating that we have more students progressing through what we now term college prep courses. They are going on to take more advanced science coursework. Is that a phenomenon due to California's integrated science sequence, or is there something researchable going on here?

Another issue concerned our continuing reversion to the deficit model of how children learn, especially with English learners. In Fresno, we have a very high percentage—32 percent in fact—of kids classified as limited English proficient. There is a preponderance of strategies that have been attempted. For one thing, because we were a district that underwent OCR [Office of Civil Rights] review, we were required to track the kids by language. Trying to accommodate the policies required by the OCR created a whole slew of problems. We ended up in a situation where kids were tracked by language, and then we had to find teachers and bilingual assistants who would facilitate their learning. In many cases, they were not credentialed properly in the content areas, especially mathematics and science. There needs to be a focused study on the content of preservice education programs for effective teaching of diverse students.

I was glad to see the issue raised again in the Forum of addressing the belief systems of teachers, administrators, professors, and other educators. I think it would have been a great opportunity here over the last day and a half to have some ethnographers sitting in the rooms recording the discourse going on. The discourse here was wonderful, but I'm afraid a lot of it is going to be lost, because once we leave the discourse stops. All of us came to this meeting because we were really concerned about these equity issues. When we get back to the districts and universities, we have to argue with about those belief systems. For example, there needs to be a study of the effectiveness of AP course-taking, whether universities really care whether these kids come in with AP coursework or not. It's somewhat anecdotal, but I know a lot of universities in California will make kids retake the courses. Parents have this belief that if their kids take a lot of AP courses, it will help with tuition reduction because they will take less coursework when they get to the university. In mathematics and science, this is very much not the case, but this is not communicated to parents. Schools don't want to communicate this, because many accreditation organizations in fact evaluate high schools based on how many AP sessions they offer.

There also needs to be a study of the role of counselors in course-taking patterns for students of color. I was one of those students back in 1966 when my counselor called me in and said: "You're not the type of student who belongs in chemistry, we're going to put you in ornamental horticulture so you can be a gardener when you graduate from high school." That happened to a student in Fresno last year. I think there needs to be some really focused study on the training of counselors. Most of the counselors are not classroom teachers, much less teachers of mathematics and science, so they have no clue about the learning that is required in those subjects. Their number one concern is to get the kids to graduate. Schools, and counselors, are evaluated on the numbers they graduate, and that's it.

There also needs to be a concerted study of the data collected by NSF-funded programs, as Sharon Lynch has mentioned. The last five years, especially in the USI [Urban Systemic Initiative] districts, there have been great quantities of data collected. I'm not sure about the other districts, but we have had almost no graduate students come in and ask us about the data that have been collected, much less look at opportunities to use the data for their studies.

Also, there needs to be further research on the characteristics of effective teachers, especially effective teachers of diverse students. In our district, we are finding that the most effective teachers tend to be the younger ones who haven't been contaminated by other beliefs. There also needs to be research on how data in studies are used or not used by schools in districts. We had a short discussion on the lack of a trickle-down from our research and evaluations in the districts to school sites, and how the data are used by principals. I know when we took the data about course-taking patterns for AP and advanced coursework to our principals and our board members that they didn't want to hear it. They didn't want to hear that we only had one African American in the last three years in AP physics. They wanted to put it aside because it's not something they wanted to share with the community.

Aleta You

Report on Small Group Discussions

I am struck by the interconnections that have been made between the first and second panels. So if some of this is repetitive, please forgive me, but I think the repetition serves to reinforce those areas that warrant further attention. My task was to summarize the small group discussions that took place regarding the elementary, middle, and secondary schools and programs that address diversity and equity issues.

Once again, the need was identified to determine what models of professional development are effective in promoting science, mathematics, engineering, and technology learning. In order to improve professional development, further research needs to be done on determining effective teaching and learning strategies for culturally diverse classrooms. Research is also needed on the use of learning technologies to promote SMET in diverse classrooms. More research needs to be done in that area because there is a wide range of information available, but it has not been effectively translated for classroom practice. This is one of the challenges for people in higher education and research, to make their findings very pragmatic in terms of implementation in K–12 school systems.

Regarding the importance of disaggregated data, I know we in the SSIs are focusing very much on the use of such data, because we know that there are ways to hide the achievement scores of underrepresented groups. If you don't have that disaggregated data, there is no way to analyze or make informed decisions for effective practice.

High teacher mobility also is an area of concern, along with the associated problem of recruiting well-qualified teachers.

We know that, within the next ten years, the baby boom generation will be retiring, and there is going to be a nationwide shortage of teachers. Especially, and already today, there will be a shortage in the area of mathematics and science as well as in special education.

Scaling up effective programs is another area we discussed. There are a number of successful models out there, but how can we scale them up so they become the norm rather than the exception? What about transference? How do we extend special and successful programs to wider areas of the population? This warrants further attention.

We also need to know more about the impact of de-tracking on high-performing kids. Jeannie Oakes is very well known for advocating the abolishment of tracking, but we know a lot of pressure comes from parents who have high-achieving students and who are very influential with school boards. Their concern is: if you start de-tracking, then will my kid get into Harvard, Yale, or Princeton? And will de-tracking water down the curriculum in any way? I think we have to acknowledge that there are many reasons that keep schools from considering the whole idea of de-tracking. Also, what about the effects of constructivist teaching on AP, SAT, and ACT test scores? How about developing tools to assess effective curriculum implementation to benefit linguistic and cultural minority students?

We heard from Pat Campbell about research on unintended consequences. What about the unintended consequences of doing research? What are some of the things we can learn from those experiences to assist us in the implementation of what does work? The notion of best practices and more research in terms of dissemination also was mentioned earlier. We need to inform teachers, administrators, and guidance counselors about research. I think this deals with the whole area of marketing. We have a captive audience here, and the notion of getting outside of the educational community is not something we have emphasized. We can learn from the corporate world in terms of getting the word out to a wider audience.

We also endorsed the need for research on the use of technology, specifically with respect to gender differences and closing the gender gap. What about research on gender differences related to instructional technology and participation? For example, one group wondered whether the expanded use of technology might lead to a reversal in girls' SMET achievement—a very interesting question. What research has been done or could be done about differences in male/female cognition with respect to instructional technology? And what about student access to computers and technology outside of school? I know in New Jersey, Bell Atlantic has contributed computers to a particular grade level in a school that enabled the students to have access to the computers at home. This school has a high Hispanic population, and the subsequent test scores were just amazing. So we have a bit of information about that, but I think more needs to known in this area.

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Appendix A: Agenda and Participant List

Fifth Annual NISE Forum: May 22-23, 2000
Westin Hotel, Southfield, MI
Diversity and Equity Issues in Mathematics and Science Education:
What Do We Know? What Do We Need to Know?

Sunday, May 21

4:00-9:00	*Registration*	*Lobby Atrium, 1st floor*

Monday, May 22

7:30-8:30	*Registration*	*Algonquin foyer, 1st floor*
	Continental breakfast provided	*Algonquin*
8:30-9:30	**Opening Session**	*Algonquin*

NISE Update	Andrew Porter, Director, National Institute for Science Education
NISE Project	Sharon Lynch, Professor, Graduate School of Ed., George Washington U.
Federal Perspectives	
Judith Sunley	Interim Assistant Director, National Science Foundation, Education and Human Resources
Kent McGuire	Assistant Secretary, U.S. Department of Education, Office of Education Research and Improvement
9:30-9:45	*Break, beverages provided*

9:45-11:15	**Panel 1: Content and Instructional Practices**	
Juanita Clay Chambers, Chair	Associate Superintendent, Detroit Public Schools, Education Services	
Carole LaCampagne, Discussant	Senior Research Advisor for Mathematics, U.S. Department of Education	
Elizabeth Fennema	Professor, Education, University of Wisconsin-Madison	
Manuel Gomez	Vice-President for Research and Academic Affairs, Univ. of Puerto Rico	
Okhee Lee	Professor, Education, University of Miami	
Instructions for Small Groups	Ted Britton, Forum Coordinator, NISE	
11:15-12:30	**Small Group Discussions about Panel 1**	Charlevoix, Portage, Windover rooms
12:30-1:45	*Lunch - View Displays*	

Buffet lunch provided. Participants also can view handouts and posters.

Monday, May 22, continued

1:45-3:15	**Panel 2: Programs for Addressing Diversity/Equity Issues**
Julio Lopez-Ferrao, Chair	Program Officer, Educational System Reform, NSF
Warren Chapman, Discussant	Program Officer, Education, Joyce Foundation
Patricia Campbell	Principal, Campbell-Kibler Associates
Vinneta Jones	Dean, School of Education, Howard University
Maria Klawe	Dean of Science, University of British Columbia
College-Level NISE Work in Diversity/Equity	
Robert Mathieu	Associate Director, NISE
3:15-3:30	*Break, refreshments provided*
3:30-4:45	**Small Group Discussions about Panel 2**
4:45-6:00	*Reception* *Light food and beverages provided. Dinner is on your own.*

Tuesday, May 23

7:30-8:30	*Continental breakfast provided*
8:30-9:45	**Panel 3: Achievement and Course-Taking Patterns**
Larry Suter, Chair	Program Director, Research, Evaluation and Communication, NSF
Norman Webb, Discussant	Team Leader, Systemic Reform, NISE
Lloyd Bond	Professor, Education, University of North Carolina-Greensboro
Jeannie Oakes	Associate Dean, Graduate School of Education, UC-Los Angeles
Richard Tapia	Professor, Computational and Applied Mathematics, Rice University
9:45-10:00	*Break, beverages provided*
10:00-11:15	**Small Group Discussions about Panel 3**
11:15-11:30	*Break*
11:30-12:30	**Closing Session**
Senta Raizen, Chair	Team Leader, Interacting with Professional Audiences, NISE
Reports from Small Groups	TBA
Final Reflections	Edmund Gordon, John M. Musser Professor of Psychology, Emeritus, Yale University

12:30 *Box lunch*
A box lunch will be provided. Stay and eat for a final opportunity to network, or take a lunch with you as you leave for home.

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