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In This issue:



**Research Charts Change in School Mathematics**

Leaders of the mathematics education community in 1989 adopted a series of goals to ensure that young Americans will enter their workplaces and the democratic institutions of this society with the mathematical knowledge and skill they require (NCTM). The goals launched a national initiative, the second in the last half of this century, to reform school mathematics. The first such initiative, which was labeled New Math, took place in the 1950s. Retrospective studies of that earlier initiative showed it had not been properly implemented, nor had its effects been widespread (CBMS, 1975).

The Work Group on the Implementation of Reform at the National Center for Research in Mathematical Sciences Education (NCRMSE) has developed a far-reaching research agenda related to the mathematics education community's 1989 goals. Walter Secada, University of Wisconsin-Madison, chairs the group, which is studying implementation efforts within the culture of the school to reform the learning and teaching of mathematics. The Working Group, according to Chair Secada, will identify innovative processes, obstacles to reform, and ways to overcome obstacles. The group seeks to redefine reform, shifting toward the view that it is a complex set of relationships that require ongoing change and renewal.

The NCRMSE Working Group of reform includes researchers from across the U.S. who work with or study educational reform. Group members' interests include equity, curriculum development, authentic assessment, the study of teaching, teacher change, and school-wide change. The group includes scholars and practitioners who range in experience from those who are beginning their careers to those who are seasoned researchers. It maintains a network for its members, facilitating their study of reform in mathematics education as well as topics related to reform. Because this Working Group is set up in a manner that permits its activities to cut across or interrelate with all of the other NCRMSE Working Groups, it is able to apply quickly or to refine the findings of the other groups' research. This issue of the NCRMSE Research Review carries descriptions of school-based reform, and a review of portions of a monograph on equity developed by several group members.

*The Networks*

The Working Group on the Implementation of Reform supports a series of networks that foster collaborative efforts. For their first meeting, group members prepared written summaries of their research on reform, identified areas they appeared to share with other members, and suggested areas for future collaboration. The discussion of the summaries held at that meeting led to the development of a symposium, Multiple Perspectives on School Based Reform of Mathematics, presented at the 1993 AERA conference. At the second meeting of the Working Group, members discussed case studies of reform, including the Urban Mathematics Collaboratives Project funded by the Ford Foundation, the Interactive Mathematics Program funded by the National Science Foundation, and the role of teacher collaboration in school-level reform at QUASAR sites.

The Working Group also supports a series of research projects undertaken by networks of Working Group members. These groups meet to discuss their work, to share ideas, and to plan for research related to the Working Group's goal. One subgroup of members, for example, met to discuss plans for and react to a study on the innovative use of technological tools in geometry that was directed by Martha Stone Wiske, a Principal Investigator of the Working Group.

The Working Group identified a network of scholars who are interested in research methods for the study of teacher change. This subgroup, described under the heading Teachers and Teacher Change, developed a set of preliminary concept papers and distributed it to others with the same interests. Some of the members are expanding their concept papers so they fit into a projected monograph on the study of teacher change.

Staff members of this NCRMSE Working Group work with or maintain communication with research projects that have similar interests. Examples of such projects are The Network Incorporated's Case Studies for the Study of Reform in Science and Mathematics Education, and the National Council of Teachers of Mathematic's Exxon Foundation Task Force on reform in mathematics.

*The School Level Reform of Mathematics*

A major study of the mathematics education reform movement and its implementation was begun by this Working Group in late 1991. The nationwide study has identified a sample of schools that are involved in substantive efforts to enhance their mathematics programs. The research, directed by Working Group Chair Secada, seeks to document how sample schools have become sites that support teaching for understanding, engage students in challenging mathematical content, and support the professional development of their teaching staff. The conceptual framework on which the study is based is on pages 5-7 of this newsletter.

For the initial phase of the study, Working Group staff members solicited nominations of schools that were engaged in substantive reform efforts. The more than 7,000 individuals from whom they solicited school nominations include the supervisors of mathematics

who are members of the National Council of Supervisors of Mathematics, teacher educators who are members of the National Council of Teachers of Mathematics (NCTM), persons who are members of the American Educational Research Association's (AERA) Special Interest Group on Research in Mathematics, the nominees and awardees for the Presidential Award for Excellence in Science and Mathematics Teaching for the Years 1990, 1991, and 1992, and participants at NCTM regional and national conferences.

During its first year, the staff members obtained survey data on the reform efforts undertaken in more than 200 schools. Five respondents—one designated a key informant and four teachers—from each of the 200 schools completed questionnaires about their schools that included detailed questions about student experiences and the professional lives of teachers—An additional 300 schools will be mailed the survey forms during the Spring of 1993. A smaller sample of 40 schools were selected as subjects for follow-up telephone interviews. Of the 40 schools, 20 will also be visited by researchers. In-depth case studies of 12 schools will be completed. These activities are part of an effort to document the breadth and depth of reform that exists in these schools, and to understand social and organizational features in the schools that nurture or impede reform.

*Equity*

One of the most pressing challenges facing the reformers of school mathematics is ensuring that reform efforts result in increasing all students' access to high quality mathematics curriculum and instruction. The issues of access and equity are deeply embedded in the Working Group's study on school-level reform. The Working Group has developed a series of papers on innovation and equity that will be published in the book, *New Directions for Equity in Mathematics Education*. It is also assisting the Women in the Mathematics Education (WME) Special Interest Group (SIG) in its support of a small task force that is exploring emerging research and development needs.

*Teachers and Teacher Change*

If all students are to learn more mathematics, most teachers will need to change the way they teach mathematics. A subgroup of scholars in this Working Group who are reviewing research methods for the study of teacher change began work on a monograph, *Methodologies for Studying Teacher Change in the Reform of School Mathematics*, at their first meeting. The chapters were designed to provide this network of scholars with a common background from which to plan future research.

Working Group principal investigators have carried out studies related to teacher change. A two-year study investigated the influence of technological innovations—among them, the *Geometric Supposer*—on the teaching of high school geometry. The study was conducted by Martha Stone Wiske under a NCRMSE subcontract with Harvard University. Investigator Wiske documented the changes made by teachers with the data she collected during visits to three research sites and interviews with nearly 50 teachers: Their courses became more open-ended than previously; they included opportunities for

students to conduct investigations and inquiries; and they encouraged students to make conjectures and to support the conjectures with justifications. Dr. Wiske also documented the isolation that the teachers felt in their workplaces and the ways they sought support from likeminded colleagues outside their schools, in their districts, or at state and professional meetings. IN the follow-up action research phase of her study, Dr. Wiske shared a summary of her findings with various groups of stakeholders. She then sought their advice on policy changes that could be implemented to develop greater support for teachers (Wiske, M.S., Levinson, C.Y., Schlichtman, P., & Stroup, W., 1992; Wiske, M. S., & Levinson, C., 1992).

Another study looked at changes in teachers' conceptions about mathematics and teaching practices that resulted from teachers' long-term participation in a Professional Development School. The study was conducted by the late Steven Kirsner under a NCRMSE subcontract with Michigan State University. Investigator Kirsner found that those teachers who are amenable to changing their practices require time and patience. They must learn to let students struggle as they engage in problem-solving activities.

According to the research, students often leave mathematics classes confused about class tasks. Teachers who once provided answers—a from of closure—must now learn to allow each students to construct his or her own understanding of the content. Imperatives and challenges for improving the professional lives of teachers, according to the research, include providing them with time to work collaboratively, to reflect on their practice, and to observe others' teaching practices. Portions of one of the publications prepared at the end of this study (Kirsner, S.A., & Bethell, S., 1992) were summarized in the Fall 1992 issue of NCRMSE Research Review.

Researchers who are examining the reform of school mathematics or other areas within the Implementation of Reform Working Group research agenda are invited to share their work with group members. Two of the papers cited in the article are available from the National Council of Teachers of Mathematics. Copies of the other cited papers can be obtained from NCRMSE. For further information on the Implementation of Reform Working Group, readers may contact its chair: Dr. Walter Secada, National Center for Research in Mathematical Sciences Education, University of Wisconsin-Madison, 1025 W. Johnson Street, Madison, WI 53706.

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**School-Level Reform and the Teaching/Learning of Mathematics**

Walter G. Secada and Lisa Byrd

An impressive knowledge base was developed during the last decade that increasingly informs efforts to enhance the teaching of school mathematics. That knowledge base is given visibility in such documents as the NCTM Standards (1989, 1991) and the California Mathematics Framework (1992), state and national policy initiatives for teacher training and curriculum development, and high school graduation requirements that demand additional mathematics courses of students.

*Schools as Units of Analysis*

Policy initiatives typically have focused on the nation, state, or district levels, and recent research has been designed to inform policy development at these levels. The research relates the levels to a classroom, a teacher, or a student. Few research efforts have considered a school or a school's mathematics department as a meaningful unit of analysis. In their studies of elementary-school mathematics in California (Prawat, Remillard, Putnam, & Heaton, 1992; Cohen & Ball, 1990), for example, members of the research team from the Elementary Subjects Center focused on how individual teachers interpreted and enacted the mandates of the California Mathematics Framework in their classrooms. The school—as an intervening unit—was not included in their analyses.

The work of several researchers provides some excellent ideas of how good teaching or teachers might look under the aegis of reform (Lampert, 1990; Ball, 1993; Fennema, Franke, Carpenter & Carey, in press). But these analyses do not take into consideration the place where teachers work and where mathematics is taught—the school.

Some work on schools as organizations and on the larger processes of schooling has considered mathematics. Work on tracking (Oakes, Gamoran, & Page, 1992), on effective schools (Good & Brophy, 1986), on school restructuring (Newmann, 1993), on high school departments including mathematics departments (Little & McLaughlin, in

press), and on cooperative groups (Cohen, 1992) provides insight on how schools are organized and how their organization and operation affect the teaching and learnin gof mathematics. The mathematics content that is taught and how the quality of that content may constrain the teaching/learning process typically have not been considered.

There are sound reasons why researchers school be concerned about the school as a site for enhancing the teaching of mathematics. Teachers and policy makers alike face challenges when they try to implement change in the larger context of the school. Unless efforts to improve mathematics teaching are understood in settings that are more expansive than an individual teacher's classroom, these challenges will not be understood. Curriculum development efforts, for example, often rely on individual-teacher volunteers to test materials. School-wide efforts to adopt changes or test new materials seldom take place. Without an understanding of how materials are treated within a school and related issues such as cross-grade articulation and within-school variability in adoption, it is unlikely that the full effects of the primary curricula will become apparent. Suppose a class were to receive outstanding mathematics instruction on worthwhile content for a year during its schooling. Would the class be returned to instruction-(business)-as usual after that year? Or would the school make programmatic or school-level efforts to ensure continuity across several grade levels?

The preceding paragraphs define the issues that inform the research efforts of the Working Group on The Implementation of Reform at the National Center for Research in Mathematical Sciences Education. Their study of school-level reform is focused at the intersection of two major lines of research: improving the teaching and learning of mathematics, and the restructuring and reorganization of schools.

*Framework for the Study of School-Level Reform*

Four key constructs provide the framework used by Working Group staff members for their study of school-level reform. The constructs are derived from multiple fields of inquiry: effective schools, school restructuring and organization, and teachers' professional lives. Mathematics is viewed as one of many aspects of the study set within the larger environment of schools. The key constructs of the framework are collective action, student experiences in mathematics, equity, and ideal practice.

Collective action

This study distinguishes between collective action and the work of the individual teacher who endeavors to enhance the mathematics learning of his or her students, but who often works in isolation, without the support of the collective efforts of a group of teachers or a program, department, or school. The construct, collective action, is used to convey the notion that the school, or some significant unit of it, may adopt a particular mission. In this case, the mission would be the enhancement of mathematics teaching and learning. The school or a unit of it may then take concerted, coordinated actions to achieve a particular mission.

## Student experiences in mathematics

The second key construct, student experiences in mathematics, refers to the constellation that students may experience in school mathematics that: (a) supports reasoning, (b) contains worthwhile content, and (c) forms a coherent whole. Aspects of these experiences include the curriculum, the teaching and assessment students encounter, the technologies and other tools students us, the oral and written communication in mathematics that students take part in, the locus of mathematical authority in students' classrooms, the attention given to student beliefs about and attitudes toward mathematics, and the access to mathematics courses provided all students. The construct, student experiences in mathematics, is used to obtain information about the importance of connections both across disciplines and within mathematics, of cross-grade coherence and program articulation, and of the gestalt—how students experience mathematics as a discipline and as an entity that is dynamic and useful to them.

## Equity

Equity is used in the study to refer to the range of concerns and actions that schools, teachers, and districts take when they act on the belief that all students—regardless of race, gender, social class, or language ability—can learn mathematics. It includes educational opportunity (to learn mathematics) and educational achievement (in mathematics). Are there, for example, systemic, school-wide efforts to ensure that diverse student populations are encourage to take mathematics and that their experiences in mathematics are worthwhile? The research seeks knowledge about how schools construe equity in mathematics education and how they act upon that meaning.

The study is designed to provide an understanding of how each of the constructs; collective action, student experiences in mathematics, and equity are constituted and interact at a school. What are the parameters, for example, of (a) collective action, (b) student experiences in mathematics, and (c) equity at a given school? How did each of these parameters develop over time? What trade-offs took place during their development? How are the parameters maintained and nourished? What are the obstacles that had to be overcome? How are the various parameters related within and across the major constructs?

## Ideal practice

Documents such as the *Standards* (NCTM, 1989, 1991), represent ideal practice. Other visions of ideal practice can be derived from work on learning with understanding (Hiebert & Carpenter, 1992), constructivist prescriptions for teaching (Davis, Maher, & Noddings, 1990), teaching as a profession (Liebermann, 1988), reflective teachers (Zeichner, in press), and other theoretical analyses of teaching. Descriptions of ideal practice are being derived for the key constructs.

Finally, the study of reform seeks information about how ideal practice gets translated into school wide practice. An ideal seldom is encountered in actual contexts. Substantial

variability occurs in actual contexts because of the constraints imposed by the competing forces of school environments. Schools, in addition, may choose to pursue different avenues for reform or focus on different issues. They may also be at different points in their development of reform activities. Hence, in order to implement practices that move in the direction of reform, most schools make trade-offs.

The constructs of collective action, student experiences, equity, and ideal practice with its variability, provide structure to this study of reform. They are also useful guides in a search for schools whose efforts to enhance mathematics programs are substantive. Each of the constructs has multiple dimensions that will undergo further elaboration. Schools may find this beginning framework useful as they begin or increase their efforts to implement reform. They will need to consider balancing their efforts and resources in an optimal way as they change their mathematics programs. While schools may find it necessary to make trade-offs in the process of seeking ideal practices, they should be conscious of the impact of the trade-offs that relate to the four constructs.

*Some Initial Results*

A series of survey forms and structured interview formats were developed to collect research data from the sample of schools that were nominated as sites where substantive reform in mathematics education has been achieved. Both the survey form designed for a school's teachers and that designed for a key informant include questions that relate to the four constructs. Individual questions are worded in nonjudgmental ways to avoid eliciting responses based on social desirability. Some questions were included on both teacher and key informant survey forms. The answers to the questions that the two forms have in common permit researchers to reach—by triangulation—a perception of the school's efforts. Brief written descriptions of a school's efforts to improve its mathematics program provided additional support for the school-wide perceptions.

Initial tabulation of data from 200 schools includes responses from 715 teachers: 85.9 percent of teachers in these schools indicated strong supports for their school's efforts to reform its mathematics program. When asked whether the goals and priorities for their school's mathematics courses were clear, 38.6 percent of teachers strongly agreed and 50.3 percent agreed. More than 31 percent of teachers did not think that mathematics teachers in their school made conscious efforts to coordinate assessment practices or the manner in which they structured and taught their mathematics classes. The largest percentage of teachers preferred planning sessions devoted to the coordination of content that also suggested materials and activities to guide instruction.

Secondary analyses revealed high school mathematics teachers do more team teaching and collaborative planning for curriculum and assessment that do their elementary and middle school colleagues. The initial results are taken from an extensive data summary prepared for the 200 schools in March 1993. Additional information on the 5-year study can be obtained from Dr. Walter Secada, National Center for Research in Mathematical Sciences Education, University of Wisconsin-Madison, 1025 W. Johnson Street, Madison, WI 53706.

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**Review of NCRMSE Research**

Making school mathematics more equitable is one of the most complex issues facing educators. One objective of The National Center for Education Research in Mathematical Sciences Education is to inspire new approaches to equity. To that end, the Working Group on The Implementation of Reform in 1991-1992 sponsored a seminar series, New Directions for Equity in Mathematics Education. The presenters for the series offered innovative ideas on equity. Of the presenters, sixteen have prepared papers enriched by the content of seminar discussions and the presentations of other participants. The series of seminars was organized by Professors Elizabeth Fennema and Walter Secada, School of Education, University of Wisconsin-Madison. This review provides brief summaries of several of the papers.

In his overview of the papers, Walter Secada observes that equity efforts must be interpreted within a context of social, political, and symbolic processes and beliefs. Such processes and beliefs create and sustain a mathematics education community, but they may also act to limit or prevent change. Some of the mathematics education community's shared beliefs and assumptions about reform and research are problematic from an equity perspective. Secada cites, for example, conceptions of good teaching and suggests that teaching standards may restrict our view of teaching to what happens inside classrooms and focus only on the teachers' content and pedagogical knowledge. A more appropriate description, according to Secada, would encompass teaching that keeps diverse students in the mathematics pipeline. This alternate criterion would include teachers whose knowledge, beliefs, and classroom interactions with students seem to align with the descriptions provided in NCTM's Professional Standards for Teaching Mathematics (1991), who are also concerned about equity. It would also include teachers who would not otherwise be included if only the criteria of the Standards were applied. To Secada the primary issue is access.

Edward A. Silver, Margarent Schwan Smith, and Barbara Scott Nelson describe the approach taken to promote equity and mathematics education reform by the QUASAR

Project. An educational reform project, it fosters and studies the development and implementation of enhanced mathematics instructional programs. QUASAR targets students who attend middle schools in economically disadvantaged communities. There are two central equity issues addressed in the QUASAR Project: (1) the need to increase access for all students to high-quality mathematics instruction that challenges them to think and reason, and (1) the need to increase to relevance of mathematics to their lives. The authors provide vignettes of classrooms in QUASAR schools where the emphasis is placed on the development of understanding fostered through both oral and written communication of ideas. Students are active participants who are involved in the construction of their own new knowledge and understanding. Thinking and reasoning are valued and argument and justification are supported. While the curriculum has expanded beyond the topics and skills of typical middle school instruction, the authors note that changes in instructional practice have proceeded slowly and unevenly.

In the past, mathematics programs promoted as new or better have not, in fact, alleviated existing inequities—even though these programs were based on a large body of research on the learning of mathematics that suggests that all children, regardless of their cultural backgrounds, learn mathematics in similar ways. When classrooms are structured to take into account this knowledge of how children learn, learning is enhanced. Cognitively Guided Instruction is based on the principle that teachers who possess research-based knowledge about children's thinking in general are able to apply that knowledge to the thinking of individual children. Teachers are able to assess accurately a child's knowledge and to make decisions about instruction based on that child's thinking, rather than on expectations related to the characteristics of the leaner such as race, gender, or ethnicity. Deborah Carey, Elizabeth Fennema, Thomas P. Carpenter, and Megan Franke describe the impact of Cognitively Guided Instruction on teachers and students in schools with student populations that are greater than 70 percent African American. According to the authors, "Students' potential for engaging in relevant, thoughtful problem-solving tasks was realized and this challenged existing norms about what might be considered appropriate mathematics content for 1$^{st}$-grade children in urban classrooms, who traditionally have been subjected to low-level drill-and-practice type activities."

Girls and women are underrepresented in mathematics and mathematics-related careers. Their underrepresentation traditionally has been described as a problem between girls and mahtematics, a "girl problem." When girls are viewed as causing the problem by something they do or, more often, by something they lack, it follows that girls must solve the problem. Patricia B. Campbell recommends that the problem be redefined to include the role of education. The educational process affects girls' learning of mathematics as well as their attitudes toward mathematics. Individual classrooms and research on gender differences must change. Campbell calls for research on the questions, "Why are gender differences in math/science majors and careers so much greater than cognitive math/science differences?" and for attention to educational, rather than biological causes, and their solution. She recommends efforts to prevent the "girl problem" from developing in the first place and devotes a special section in her paper, Special Programs: What Works, to reinforcing these efforts.

Suzanne K. Damarin reviews recent work of feminist epistemologists and philosophers. Then, guided by the critiques of science developed by feminist scholars, she critiques research on gender and mathematics. She notes that the feminist critique of science is part of a general movement that challenges the notions of objectivity, reality, and truth and seeks to redefine science. To women scientists, some scientific findings, particularly those about women, have been unacceptable and two primary streams of research that counter the findings have emerged. Feminist empiricism, she explains, begins from the premise that, while scientific methods may be sound, some unsound practices of procedures lead to findings that are biased. Among the examples she recounts are drawing conclusions about the general population from studies of male samples and relating research results to make norms. She concludes that the empirical research on "gender and mathematics has...reframed the scientific study of women and mathematics..." But the Feminist Standpoint Epistemology, says Damarin, would have research question how women experience mathematics, and it offers a direction for future research on women and mathematics. The research that fits into this philosophic stream examines women's confidence in their mathematical knowledge and ability while at the same time examining the messages women receive that affect their sense of confidence. Individual women (and their teachers), she says, must struggle with these issues if "they are to learn and teach mathematics."

Marilyn Frankenstein argues that education in general and mathematics in particular will become more equitable only when the class structure in society becomes more equitable. Teaching about class structure, she maintains, can contribute to equity in mathematics education. In her teaching, she covers socio-economic issues in the context of a business and consumer mathematics course, with the assumption that students' increased mathematical understanding will enable them to examine the class structure of their capitalist society. She asserts that participants in her class are empowered when they realize they understand more mathematics than their test results indicate. The class uses economic data to support mathematics learning. When students participate in discussions about the structure of society, they probe behind data questioning, for example, the categories created to sort data, the persons placed in the categories, and the information that has been obscured by mathematical transformations of data. While her students are developing tools for understanding and performing statistical analyses, they also expose the myth of a classless society.

The University of Minnesota Talented Youth Mathematics Program (UMTYMP) provides 140 to 150 mathematically talented students with an intense, accelerated mathematics program. The students cover four years of high school mathematics in two years, and two years of university-level calculus while still in high school. According to UMTYMP director Harvery B. Keynes, program statistics on early enrollment, retention, and achievement once favored males. A series of interventions such as social, cultural, and counseling activities and changes in recruitment and UMTYMP classroom structure now achieve more equitable results. Keynes describes the interventions and the outcomes related to them in his paper, "Can Equity Thrive in a Culture of Mathematical Excellence?" He concludes that the interventions developed to improve female involvement in the program also enhanced the involvement of students of color and the

rest of the students. Based on the UMTYMP experience, he says, "Equity has strengthened excellence."

Gloria Ladson-Billings' premise is that all students can be successful in mathematics if their understanding of mathematics is linked to cultural referents that are meaningful to them. The instruction students receive must convey to them the teacher's belief in their ability to master the subject matters. Two vignettes of 6th grade classrooms, one taught by a very experienced female teacher in a low income, predominantly African American school district, and another taught by a young male student teacher in an upper middle class community, are contrasted. Students in the woman's class remain engaged and excited throughout the mathematics class. Students in the man's class refuse to settle down and attend to the lesson. Ladson-Billings identifies the characteristics that distinguish the classrooms: 1) Students treated as competent are likely to demonstrate competence, 2) instruction scaffolding for students allows them to move from what they know to what they do not know, 3) the major focus of the classroom must be instructional, 4) authentic education extends students' thinking and ability beyond what they already know, and 5) effective pedagogy requires in-depth knowledge of the students as well as of subject matter.

Large numbers of Hispanic students have limited English proficiency, yet only 3.2 percent of the nation's teachers are prepared to teach limited-English proficient (LEP) students. Lena Licon Khisty notes that Hispanic students consistently perform well below the United States average in mathematics. There is, she notes, nothing inherent in Hispanic students, their culture, or their families that accounts for the discrepancy in performance. She further argues that teachers' use of language in mathematics instruction is a major factor. Simply increasing the number of bilingual teachers or improving their clarity of speech, however, is not the answer. At issue are teachers' conceptual explanations and their ability to use questions and cues to extend students' talking and thinking in both languages. In the learning context minority students must be engaged in higher level critical thinking, and in their dialogues, teachers and students must come to understand the different "cultural language" of each other. To improve instruction in mathematics for Hispanic students, teachers will need to create learning environments that, rather than ignoring or devaluing students' home language and experiences, capitalize on them.

The current science teaching model does not work for the nation as a whole and is even more unsatisfactory for minority students. That model of teaching requires that students assimilate textbook information, recall facts to answer questions, and make abstract connections out of context or in contexts that are unrealistic. This type of teaching marginalizes students who do not possess mainstream ways of knowing and communicating. Beth Warren and Ann S. Rosebery describe a collaborative project in which they, with bilingual, ESL, and science teachers, teach science from a sense-making approach. They create a community of scientific practice in language-minority classrooms because they view scientific practice as a socially and culturally mediated process of meaning construction and criticism. Warren and Rosebery describe the activities of a classroom organized around students' own questions and inquiries. They

also describe the changes in the students' discussion and thinking about mathematics in such a classroom, and the changes in teachers and the teacher education process. Teachers experience participation in sense-making activities themselves as they are treated, not as persons who are learning to be scientists. Creating science education programs that include rather than exclude linguistic minorities demands more than new curricula and new teaching strategies. Egalitarian sense-making science teaching practice will, according to these authors, transform teachers and students alike. Both will be empowered to think, talk, and act scientifically.

The papers summarized in these columns will appear in *New Directions in Equity for Mathematics Education*, a book edited by Walter Secada, Elizabeth Fennema, and Lisa Byrd. Drs. Secada and Fennema are Associate Directors and Lisa Byrd is a Project Assistant as the National Center for Education Research in Mathematical Sciences Education, The University of Wisconsin-Madison, Madison, WI 53706.

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