

The United States needs to improve the mathematical proficiency of all students in the nation's schools. The personal, occupational, and educational demands placed on all Americans in the 21st century call for a level of mathematical proficiency that in generations past was required of only a few. Moreover, as both a moral imperative and a matter of national interest, the nation should move to reduce the gaps in mathematics proficiency that now exist between the economically advantaged and the disadvantaged and among the diverse groups that populate the nation.

However, the U.S. educational system faces serious problems that impede the attainment of these goals. Many students are taught by teachers who are under-prepared to teach mathematics, and those poorly prepared teachers are disproportionately working with students from less-advantaged backgrounds and students of color. Useful mathematics curricula and mathematics education programs exist, but they are weakly implemented in many, if not most, American schools. Teacher development programs to help teachers achieve the required professional skills are uneven in quality, and too often those who need these programs the most do not participate in them. Nevertheless, the research, education, and education policy communities now have the knowledge and resources to make significant progress in mathematics proficiency. The nation can and must do better with the knowledge and resources it already has.

The message of this report by the RAND Mathematics Study Panel is that the research and education communities need to know more and do much more if the nation is to achieve adequate levels of mathematical proficiency for all students. The research and education communities need to identify the knowledge that can enable teachers to help their students develop mathematical proficiency, and they need to develop robust ways of helping teachers acquire and use that knowledge. The research and education communities also need to learn how children, who bring different personal experiences to school with them, learn the mathematical practices that are essential to effective day-to-day use of mathematics. Moreover, we argue that algebra, and more generally the

broad mathematical skills that algebra encompasses, are critical both to mathematical proficiency and to equity in the achievement of proficiency.

To provide the necessary knowledge *and* the capacity to use that knowledge in practice, this report recommends a significant program of research and development aimed at building resources for improved teaching and learning. Because resources are limited, the panel deliberated at length to identify the research areas that are most likely to yield improved knowledge and practice and to attain the dual goals of mathematical proficiency and equity in the acquisition of proficiency.

This report recommends three priority focus areas for programmatic research and development—developing teachers' mathematical knowledge in ways that are directly useful for teaching, teaching and learning skills for mathematical thinking and problem solving, and teaching and learning of algebra from kindergarten through 12th grade. These research areas, and the reasons for their selection, are discussed in Chapters Two through Four of this report.

The RAND panel has also made proposals on how the research and development program should be conducted. New approaches to program funding and new management styles are recommended. These approaches should ensure that the supported work incorporates effective scientific practices, uses methods appropriate to the goals of the component projects, and that the program builds knowledge over time. Further, interventions should be rigorously tested and revised through cycles of design and trial.

The program we propose will require contributions of individuals with wide-ranging skills and sustained commitment on the part of the federal offices that support research and development in mathematics education. The staff in these offices must be adept at engaging the research and education communities in the partnership that we have argued is necessary to move forward with the program we propose. Federal office staff must organize the program in ways that ensure the rigor, cumulativeness, and usability of the research and development. They must bring outstanding individuals into the planning of the work and into the selection of the proposals, people, and institutions that can carry it out most effectively. They must arrange for the regular critical review and evaluation of what has been supported and what has been learned, and they must make adjustments in the program that are suggested by such review.

However, the necessary changes extend beyond the funding agencies. The research community concerned with mathematics education must change as well. Perhaps because mathematics education research has been so poorly funded in the past, too much of the research has taken place with relatively small projects, has used diverse methods that can make the results difficult to compare, and has, therefore, yielded too little knowledge that is cumulative and

usable. The agenda that we propose in this report will require greater collaboration and interdisciplinary action in planning, more willingness on the part of researchers to do the work necessary to develop and use common measures, and more attention paid to working collectively to build both knowledge and practice.

Moreover, both funders and researchers must develop better ways to engage the practitioner community in this work. It is not enough to have a single practitioner serving as a member of a peer review group or serving on a study panel. Research and development initiatives must be more solidly informed and guided by the wisdom of practice. New institutions that can engage researchers and practitioners in joint work are needed. New partnerships between research institutions and schools and school districts must be forged. The research and development program that the RAND panel proposes is unlikely to produce usable results if progress is not made in bridging research and practice.

While some issues surrounding mathematics education, particularly concerning what it is that students should know and be able to do in mathematics, involve inherently political decisions, we believe that most of these issues can be illuminated by appropriate and timely research and evaluation. Current debates surrounding mathematics education have not been adequately informed by the work of the research community. Because of this, these debates have often been undisciplined and overly contentious. The program of research and development envisioned in this report is intended to move the nation beyond these debates to significant improvements in student learning.

Achieving what we envision will require building and enhancing a vigorous and critical research, development, and practice community. Within such a community, we hope that debate among those with varying and competing views concerning standards of proficiency, curricular designs, pedagogical styles, and assessment methods will evolve into a discourse that is based less on ideology and more on evidence.

The RAND Mathematics Study Panel asserts that our nation's future well-being depends on shifts in how research and development in mathematics education are designed, supported, coordinated, and managed. Mathematical proficiency is one of the most important capabilities needed by the people of the United States in the 21st century. Achieving mathematical proficiency equitably will require the targeted investment recommended in this report.