



# WCER Highlights

WISCONSIN CENTER FOR EDUCATION RESEARCH • SCHOOL OF EDUCATION • UNIVERSITY OF WISCONSIN-MADISON

## Putting Mathematics in Context



Students dig into the mathematical domains of number, measurement, geometry, statistics, probability, and algebra.

To thrive in our fast-changing world, students must learn to think clearly and critically. They'll have to solve problems in their lives that we haven't had to face. They'll need to communicate effectively to meet these challenges.

To give students experience thinking and communicating in contexts reflecting the real world, WCER's National Center for Research in Mathematical Sciences Education is developing a new four-year curriculum called *Mathematics in Context*. It's a comprehensive mathematics curriculum for the middle grades that reflects the content and teaching methods suggested by the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* and *Professional Standards for Teaching Mathematics*.

The curriculum development project will be completed by June 1996, and some of the materials are available in prepublication form. *Mathematics in Context* (MiC) is being published by the Encyclopaedia Britannica Educational Corp. and its development has been funded by the National Science Foundation.

The philosophy underlying MiC is that mathematics is not a fixed, complete set of rules and properties that students are supposed to learn as isolated pieces. Instead, mathematics is a dynamic subject that can best be learned by doing. UW-Madison Education Professor Thomas Romberg and his development team believe that mathematics is a subject and a way of thinking that can be learned by all students, and that all students

WCER Highlights

WINTER 1995-96  
Vol. 7, No. 3

4 Restructuring  
study released

6 The myths of  
school funding

From the Director

## Restructuring study released

Of great excitement to us here are the results of a five-year study conducted by Fred Newmann and his team at the Center on Organization and Restructuring of Schools. In this issue of *WCER Highlights* you'll read a summary of the study. It concludes that, while school restructuring can improve student learning, there is no "magic bullet" or simple recipe for successful school restructuring. For a restructuring effort to work, it must focus on four key factors: student learning, authentic pedagogy, school organizational capacity, and external support.

Meanwhile, Tom Romberg's team is completing its new "Mathematics in Context" middle grades curriculum, which reflects the content and teaching methods suggested by the National Council of Teachers of Mathematics. The curriculum is being published by the Encyclopaedia Britannica Educational Corp., and some of the units are already at the printer.

Allan Odden's study counters some common myths about education funding. Odden reports that, while there has been a considerable national investment in public education during the 20th century, the funds are usually distributed unfairly and used ineffectively, whatever the level of funding. His report makes suggestions about better courses to follow.

Our research here at the Center continues to work toward improving education for all students. I hope that these stories will spark your interest; if they do, please contact the researchers for more information.

You're invited to find out more about WCER and its many projects by visiting our new World Wide Web site. Our home page is at <http://www.wcer.wisc.edu>. You're sure to find something of interest, hopefully something useful as well.

The page contains a number of WCER publications, including back issues of *WCER Highlights* in both text format and in "portable document format," readable with Adobe Acrobat software.

Andy Porter



JEFF MILLER

domains and emphasize the interconnectedness of mathematical ideas. Hence the curriculum's subtitle, "A Connected Curriculum."

## A widespread collaboration

The curriculum results from a collaboration between researchers at WCER and curriculum designers from the Freudenthal Institute in The Netherlands. "We wouldn't have the curriculum without the Freudenthal people. They are the creativity," says team leader Margaret Meyer. "They have really *designed* the curriculum. They have built in connections between units and connections between strands of the curriculum. Ideas in one unit show up in other units and in other grade levels."

Fifth- through eighth-grade teachers in districts across the country have collaborated with the development team by field testing the units. The curriculum has been taught in Miami, Memphis, Culver City, Parkway/St. Louis, Ames (Iowa), in Madison, Milwaukee, and Stoughton (Wis.) and even in Puerto Rico. Field testing shows increased student achievement (see Table 1 and "Field Test Report," opposite).

## Different teaching methods

Teachers have found it a challenge to adopt *MiC*, a curriculum that requires the introduction and development of mathematics concepts over four years. Teachers must change their expectations for what their students should know at a given time. Gail Burrill, coleader of the development team and current NCTM president, uses the example of teaching decimals. "A teacher might think 'it's my job to teach decimals exclusively and exhaustively.' But the new curriculum brings up decimals in different situations over four years, at the end of which students will have understood them thoroughly. So the teachers have to learn to trust the curriculum."

Teachers have also had to learn different instructional methods. One of the key features of the curriculum is that learning is enhanced by student interaction about strategies they used to solve particular problems. Teachers need to create an environment where different strategies are valued and where students look to each other for ideas, rather than to the teacher as the center of knowledge.

## A look at the curriculum

The four strands that appear in each grade, 5 through 8, are number, geometry, algebra, and statistics. Let's look at some snapshots:

should have the opportunity to learn mathematics—not just arithmetic, but number, algebra, geometry, and statistics.

Each of the 40 curriculum units uses content designed around real situations to develop the mathematics at each grade level. The units are tightly woven together, reinforcing each other and building on each other over four years. From fifth through eighth grade, students dig deeply into the mathematical domains of number (common fractions, ratio, decimal fractions, integers), measurement, geometry (coordinate and transformation geometry, space), statistics, probability, and algebra (patterns and functions). Although units emphasize the principles within a particular mathematical domain, most involve ideas from several



In the grade 5 unit *Side Seeing*, students explore their world in terms of what they see and how they see it. Two- and three-dimensional representations of situations are the basis for exploration from the point of view of the students.

In the unit *Figuring All the Angles*, angles and their measure are defined in terms of turns, much like an airplane would turn as it changes course. The context of air navigation is used to develop concepts involving angle.

In the grade 7 unit *Looking at an Angle*, students encounter right triangle ratios in a variety of contexts including vision lines, blind areas, glide ratios and, finally, the tangent ratio.

Other geometry units contain more traditional topics involving triangles, polygons, area, distance, and congruence. Although the topics are traditional, the contexts and connections are anything but traditional.

Are the problems fun? Yes, say the teachers. Yes, say students who have participated in field tests. The curriculum promises to provide generations of students experiences in mathematics that will provide a rich conceptual basis for further study of mathematics and that students will remember as relevant, enjoyable, and challenging.

For more information, contact Margaret Meyer at (608) 263-1798, or [mrmeier@macc.wisc.edu](mailto:mrmeier@macc.wisc.edu).

## Field test report: MiC boosts achievement

From Jack Burrill  
*Mathematics in Context* team member

Under the guidance of Jorge Lopez of the Department of Mathematics at the University of Puerto Rico-San Juan, *Mathematics in Context* (MiC) has grown from a pilot test by two teachers at a rural school, Jesus Sanabria Cruz in Yabuco, to implementation in more than 50 schools with participation of over 100 teachers.

The pilot test at Jesus Sanabria Cruz was supported by the Encyclopaedia Britannica Educational Foundation and was directed by Andrea Santiago and Juan Francisco Ortiz (teachers of grades 5 and 7, respectively). Of the 570 students at that school, 85 percent comply with Puerto Rico's defining criteria for poverty, and all of them are poor by U.S. standards. The school was selected because, in spite of the severe poverty of the area, most of the school teachers and supporting personnel and students' parents are dedicated in their support for the school.

Students in MiC dramatically improved their scores on standardized achievement tests administered by the U.S. Department of Education.



Gail Burrill (left) and Margaret Meyer review results of *Mathematics in Context* field tests.

Twenty-one of 23 students in grade 5 scored above the 90th percentile (based on the scores of students throughout Puerto Rico); the two remaining students scored at the 82nd and 84th percentiles. Title I students in the MiC project scored high enough to qualify for removal from the Title I program. By contrast, those Title I students who had not been involved in MiC showed no improvement over their scores from the previous year.

Lopez, in the final report for that project, noted that "Even though these tests cannot begin to assess the richness and depth of the higher thinking skills and the mathematics learned by the students participating in this project, the scores obtained by the students surpassed our wildest expectations."

Table 1: Ames Seventh Grade Iowa Algebra Aptitude Test 1994-95 Comparisons

Accuracy Range (% Correct)	Number of Students 1994	Number of Students 1995	% of Students 1994	% of Students 1995	Difference
80-99%	72	109	23%	32%	+9%
60-79%	67	70	21%	20%	-1%
40-59%	40	43	13%	12%	-1%
20-39%	67	67	21%	19%	-2%
0-19%	74	57	23%	16%	-7%
<b>Total</b>	<b>320</b>	<b>346</b>			

Seventh-grade students in the Ames, Iowa school district participated in a field test of MiC, completing eight of the units during the 1994-95 school year. These students saw their mean raw scores on the *Iowa Algebra Aptitude Test* rise nearly four points at the end of 1995, compared with the mean raw scores of students at the end of 1994.

## Successful school restructuring involves four components

By Leon Lynn

Since the late 1980s, education reformers in the United States have sought ways to “restructure” schools to boost student performance. Has it worked? Have changes in school structure—such as site-based management, interdisciplinary team teaching, flexible scheduling and assessment by portfolio—actually boosted student achievement? What other conditions tend to make such organizational innovations successful?

From 1990 to 1995, WCER’s Center on Organization and Restructuring of Schools, funded by the U.S. Department of Education’s Office of Educational Research and Improvement, examined these questions. Center researchers analyzed data from more than 1,500 elementary, middle and high schools throughout the United States and conducted field research in 44 schools in 16 states.

The Center’s findings are summarized in the book *Successful School Restructuring: A Report to the Public and Educators*, by

Fred M. Newmann and Gary G. Wehlage. Newmann is director of the Center and Wehlage is associate director.

Results showed that school restructuring can indeed improve student learning. But there is no “magic bullet” or simple recipe for successful school restructuring. For a restructuring effort to work, it must be clearly focused on four key and interconnected factors: student learning, authentic pedagogy, school organizational capacity, and external support.

### Student learning

In successful schools, the planning, implementation and evaluation of new approaches focus on enhancing student learning. Teachers agree on a vision of high quality intellectual work, and they communicate clear goals for high quality learning to students and parents. The core activities of the school—including curriculum development,

instruction, assessment, scheduling, staff development, hiring and student advising—aim toward that vision of student learning. Unfortunately, a focus on enhancing student learning is not typical of most schools.

The Center’s vision of high quality student learning, “Authentic Student Achievement,” has three parts:

**Construction of knowledge.** Students learn to organize, interpret and analyze information, instead of merely reproducing specific bits of knowledge from a textbook or classroom lecture. They learn to apply knowledge, not just collect facts.

**Disciplined inquiry.** Using established knowledge in science, mathematics, history or literature, students develop in-depth understanding. They are asked to express that understanding in “elaborated” ways, such as writing an essay or engaging in a substantial discussion of the topic, instead of merely checking boxes or filling in the blanks on a test.

**Value beyond school.** Students produce work or solve problems that have meaning in the real world. A student’s accomplishments in school have value beyond merely proving that he or she did well in school.

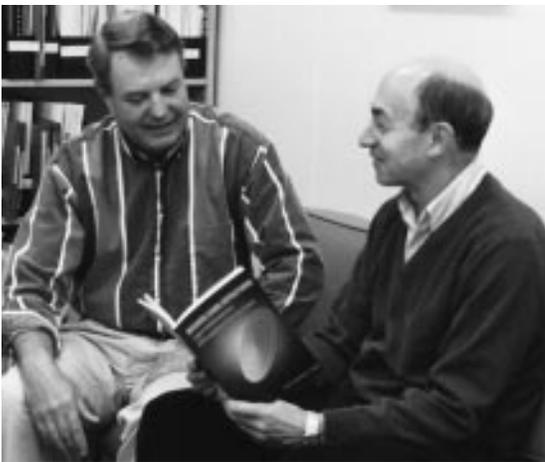
The Center’s research shows that when schools restructure around this kind of vision, it works: Students learn more, and what they learn is more important.

### Authentic pedagogy

A vision for high quality student learning is necessary, but it’s not enough. Teachers must bring the vision to life in their classrooms through the pedagogy—the combination of instruction techniques and assessment tools—they use.

The Center developed a set of specific teaching standards that measure the extent to which students are challenged to think, to develop in-depth understanding, and to apply academic learning to important, real-world problems. These standards are called “Authentic Pedagogy.” Research showed that students who receive more authentic pedagogy learn more.

What’s more, authentic pedagogy boosts achievement for students of all social backgrounds: Students benefit equally from more authentic ped-



Gary Wehlage (left) and Fred Newmann review their recently published study.



agogy regardless of their race, gender or family income. This is true whether student achievement is measured by standards of authentic achievement or with more conventional tests, such as the National Assessment of Educational Progress.

## Organizational capacity

To promote learning of high intellectual quality, a school must build the capacity of its staff to work well as a unit.

The most successful schools are those that use restructuring to help them function as “professional communities.” They find ways to channel staff and student efforts toward a clear, commonly shared purpose for student learning. They create opportunities for teachers to collaborate and help one another. Teachers in these schools take collective—not just individual—responsibility for student learning, and for constantly improving their teaching practices.

Schools with strong professional communities are better able to offer authentic pedagogy and are more effective in promoting student achievement. But building professional community requires a great deal more than simply putting new organizational structures in place. In fact, introducing new structures and practices in a school can have the opposite effect and divert attention from the quality of student learning.

The Center found, however, that certain structural changes, when combined with professional skills, leadership and trust, can substantially strengthen school professional community. The following conditions are among those that can help schools develop the type of professional community needed to promote learning of high intellectual quality:

- Shared governance that increases teachers’ influence over school policy and practice.
- Interdependent work structures, such as teaching teams, which encourage collaboration.
- Staff development that enhances technical skills consistent with the school’s mission.

## External support

Schools are nested in a complex environment of expectations, regulations, and stimuli from external sources, including districts, state and federal agencies, independent reform projects, parents, and other citizens. Schools need critical financial, technical, and political support from these external sources.

External agencies can help schools to focus on student learning and enhance organizational capacity through three strategies:

- Setting standards for learning of high intellectual quality.
- Providing sustained, schoolwide staff development.
- Using deregulation to increase school autonomy.

But sometimes external influences pull schools in different directions, impose unreasonable regulations, and instigate rapid shifts in policy and leadership, all of which can undermine organizational capacity.

## Research methods and resources

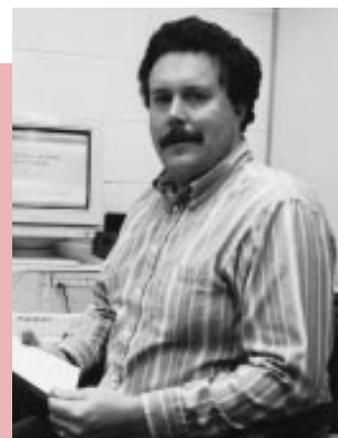
The Center’s conclusions are largely drawn from four studies:

### School Restructuring Study (SRS).

This study included 24 significantly restructured public schools, evenly divided among elementary, middle, and high schools, located in 16 states and 22 districts, mostly in urban settings. There was a large range of enrollment, with an average of 777 students; 21 percent African American; 22 percent Hispanic; 37 percent receiving free or reduced lunch. From 1991 through 1994 each school was studied intensively during two weeks of on-site research.

**National Educational Longitudinal Study of 1988 (NELS:88).** This study included a nationally representative sample of over 10,000 students, followed from grade 8 (1988) through grade 12 (1992) in about 800 high schools nationwide. The schools include public, Catholic, and independent schools. They represent a wide range of school enrollment, geographic settings, and school social composition, as well as various levels of restructuring activity. Student test data in mathematics, science, reading and history for grades 8, 10, and 12 were drawn from items from the National Assessment of Educational Progress.

**Study of Chicago School Reform.** This study included survey data from 8,000 teachers and principals in 400 elementary and 40 high schools from 1990 to 1994. Surveys reported on instruction, school climate and organizational features, professional activities, relations with parents, and reform activities. The study also included three-year case studies of 12 elementary schools, including six schools actively involved in restructuring. Case study schools represent the full range of elementary schools in Chicago, which vary substantially in social composition, but most have a majority of poor and minority children.



Leon Lynn is dissemination coordinator for the Center on Organization and Restructuring of Schools.

*continued on page 8*



## Myths cloud nature of school funding

American students don't know enough history. They don't know enough geography.

Recent news stories have called attention to the need for improved student achievement in several subject areas. Both educators and parents would like to see improved student achievement. But plans for raising student achievement usually call for spending more money. With limited, and in some cases shrinking, resources, schools and districts are expected to do a lot with a little.

Creating workable funding and spending plans will require weeding out misconceptions about education spending, says UW–Madison Education Professor Allan Odden. In a recent study, Odden and colleagues found that, despite rumors to the contrary,

- schools have much more money now than 10, 20, or 30 years ago, but most new education dollars do not get soaked up in high teacher salaries; and
- there is no “administrative blob” siphoning off education dollars, but nevertheless the new money has not been used effectively to boost student learning.

The level and uses of education funding must be understood better before attention can be properly focused on the more complex topic of how to restructure the use of resources to produce higher levels of student achievement, Odden says.

For the past five years the U.S. Department of Education's Office of Educational Research and Improvement's Finance Center of the Consortium for Policy Research in Education (CPRE) at WCER has been studying education money: where it comes from, how it is distributed, and how it is used by districts and schools. Odden and other Center researchers analyzed spending patterns

across the 50 states with state-level data and studied spending and staffing patterns at the district and school levels. They studied individual schools in California, Florida, and New York in terms of expenditures by function and program, staffing patterns, and use of dollars across curriculum content areas.

### Funds used ineffectively

The study reports that, while there has been a considerable national investment in public education during the 20th century, funds unfortunately are distributed unfairly and then used ineffectively, whatever the level of funding. When funding is increased, the largest portion is used to hire more teachers. More teachers are used both to reduce class size and to provide more out-of-classroom services, primarily “pull out” instruction for handicapped and low achieving students. Another portion of increased funding is used to raise teacher salaries, but these dollars have not been used strategically to enhance teacher professional expertise. These fiscal “regularities” are true of high- and low-spending, rich and poor, and urban and rural districts. But these spending behaviors don't boost student achievement very much, the study reports.

If continued, these spending patterns will not accomplish the goals of education reform, Odden says. “If the education system is to teach all students to high standards, both programmatic and fiscal regularities must be uprooted,” he continues. “Schools will need to be restructured and school finance will need to change. Funds will need to be focused strategically on programs and strategies that produce high levels of student achievement.”

The study addresses several important questions about education funding and spending:

#### 1. How much do we spend per pupil on education and how has that changed over time?

Contrary to the feeling of many in education, the numbers show that education has been a fiscal growth industry since 1960 in inflation-adjusted dollars. Spending per pupil doubled in the two decades between 1960 and 1980, and then increased another 50 percent in the 1980s, so that by 1990 expenditures per pupil were more than three times what they were in 1960. Per-pupil funding has been relatively flat for the past five years, however.

Since 1970, teacher salaries have not gained much, relative to other occupations.





## 2. How much do teachers make and how has that changed over time?

Average teacher salaries increased from 1960 to 1990, with the largest gains occurring from 1960 to 1970, when average salaries, after adjusting for inflation, increased by 34 percent, from \$23,495 to \$31,560. But while average teacher salaries increased in nominal terms throughout the 1970s, they dropped by about 10 percent when adjusted for inflation. Teachers make more today than they did in 1960, but since 1970 they have not gained much relative to other occupations.



Funding is not likely to increase much in the future, Odden says.

## 3. How much of the education dollar is spent on instruction, administration and other noninstructional areas?

About 60 percent of the education dollar is spent on total instructional services. This includes regular instruction in the classroom for the core academic subjects (mathematics, language arts, writing, science, history, social science, and other content areas), and also instruction for special needs (special education for the physically and mentally handicapped, limited English proficient, and low achieving student, for example). The figure of 60 percent for instruction is consistent across districts and states.

The remaining 40 percent of education dollars is spent as follows:

- 8–10 percent for educational supports—student services, curriculum and professional development
- 9–11 percent for operating and maintaining the physical plant
- 4–6 percent for transportation
- 4–6 percent for food services
- 9–11 percent for administration.

Which leads us to the next question:

## 4. Is there an administration “blob”?

Generally, administrative expenditures are less than 10 percent of the budget, a modest level compared to benchmarks in other organizations. Further, in most cases, larger amounts of administrative expenditures are at the school level, that is, the place where educational services actually are delivered. Such modest expenditures on administration have been found by other education research as well.

The study found that administrative expenditures in the largest urban districts were *less* in percentage terms than the average in their respective states. Center research in California, Florida, and New York found that the percent spent on admin-

istration in each state’s largest district was less than the statewide average. Further, the percentages spent on administration in these districts are so low that, if the value added provided by central office services were deemed not “worth it” and the central office were eliminated, there would not be large amounts of money to disperse to school sites.

## 5. How do resource use patterns vary between high- and low-spending districts?

High-, low-, and average-spending districts tend to allocate their resources in the same proportion, about 60 percent of their budget for instruction. But similar *percentages* of budgets produce much different *dollar amounts* on direct instructional services between high- and low-expenditure districts: 60 percent of a \$7500 per pupil budget is \$4500, while 60 percent of a \$5000 budget (the average district) is \$3000, and 60 percent of a low-spending district (\$3500) is \$2100.

## 6. What level of resources are targeted to core academic subjects?

The data show that the greatest staffing in core subjects is in the English/Language Arts area, a subject area U.S. schools emphasize from grade school through secondary school, and the area in which student achievement is the best internationally. But staffing for core academic subjects varies little by spending level, even though spending may differ by thousands. In New York, for example, the expenditure of the district in the first quintile is thousands of dollars less than that of the fourth quintile. Yet the teacher staffing provided for the core academics is almost exactly the same. Odden says it would be reasonable to infer that such a pattern of resource use would make it less rather than more likely that greater spending would lead to greater achievement.

Case studies also reveal that instructional staffing in the core academic subjects in secondary schools comprises less than half of the total staff in each school. Of all instructional staff, staffing for core academics (mathematics, science, English/language arts, social studies, foreign language, music and art) comprises a small 60 percent majority.

## Time for a reorientation

The substantial investment the country has made in its public educational system needs to be

*continued on page 8*



**WCER  
HIGHLIGHTS  
STAFF**

Director Andrew Porter  
 Editor Paul Baker  
 Editorial Consultant Deborah Stewart  
 Production Office of University Publications

*WCER Highlights* is published three times a year by the Wisconsin Center for Education Research, School of Education, University of Wisconsin–Madison. WCER is funded through a variety of federal, state and private sources, including the U.S. Department of Education and UW–Madison. The opinions expressed in this publication do not necessarily reflect the position, policy, or endorsement of the funding agencies. Fourth-class, bulk-rate postage is paid at UW–Madison, Madison, WI. Send changes of address to WCER, UW–Madison School of Education, 1025 West Johnson Street, Madison, Wisconsin 53706 or call (608) 263–4200. Include the address label from this issue.

No copyright is claimed on the contents of *WCER Highlights*. In reproducing articles, please use the following credit: "Reprinted with permission from *WCER Highlights*, published by the Wisconsin Center for Education Research, UW–Madison School of Education." If you reprint, please send a copy to *Highlights*.

*WCER Highlights* is available electronically at our Web site: <http://www.wcer.wisc.info>. It's also available on "WisInfo," the University of Wisconsin's Gopher server. Use your Gopher client software to find the University of Wisconsin, or Telnet to [wiscinfo.wisc.edu](mailto:wiscinfo.wisc.edu). Then select "Newsletters and Other Special Interest Publications."

ISSN 1073–1822  
 Vol. 7, No. 3  
 Winter 1995–96

**Restructuring**

*continued from page 5*

**Longitudinal Study of School Restructuring.** This study included four-year case studies of eight schools that had embarked on different forms of restructuring in four communities. Representing a variety of school social composition and enrollment, the schools included two urban elementary schools, two urban middle schools, two urban high schools, and a rural middle school and high school.

The full report, *Successful School Restructuring: A Report to the Public and Educators*, by Fred M. Newmann and Gary G. Wehlage, can be ordered for \$9.95 from:

American Federation of Teachers  
 Attention: AFT/Successful School Restructuring  
 555 New Jersey Avenue, N.W.  
 Washington, DC 20001

Association for Supervision and Curriculum Development  
 1250 N. Pitt St.  
 Alexandria, VA 22314–1403  
 (800) 933–2723

**School funding**

*continued from page 7*

restructured so the investment pays off in terms of large increases in student achievement over the next two decades, Odden says. The long term task is to get schools to act more like producers of high levels of student achievement rather than mere consumers of educational resources. But there are no straightforward ways to bring about this reorientation.

The country's education goals call for the schools to teach all students to high standards. This will require quantum improvements in student achievement. The goal literally is to have all students achieve at a level that only about 10 percent of students attain today—to have all children achieve mastery over the complex subjects of mathematics, science, writing, history, geography, and civics.

Since money is not likely to increase much in the future, Odden says, the only way the goods can be accomplished is by improving the productivity of the American public education system, a difficult task both technically and politically. For more information, contact Odden at (608) 263–4260, or [odden@macc.wisc.edu](mailto:odden@macc.wisc.edu).

Wisconsin Center for Education Research  
 School of Education  
 University of Wisconsin–Madison  
 1025 West Johnson Street  
 Madison, WI 53706

Address correction requested

Nonprofit  
 Organization  
 U.S. POSTAGE  
 PAID  
 Madison, Wisconsin  
 Permit No. 1622