At the conclusion of a five-year study, Fred Newmann, Gary Wehlage, and colleagues at WCER’s Center on Organization and Restructuring of Schools (CORS) report on “authentic pedagogy”—a combination of instruction and assessment rooted in a primary concern for high standards of intellectual quality—and the resulting authentic student achievement, which represents accomplishments that are significant, worthwhile, and meaningful.

Authentic pedagogy aims to nurture independent, critical thinking in students. It intends to help students appreciate, live with, and experience the joy of working with cognitively complex problems. CORS research found that authentic pedagogy contributes to equal opportunity for all students to learn; that is, it helps students from all social backgrounds, rather than magnifying inequalities in achievement between groups that traditionally have been more and less advantaged. Until recently, arguments in support of authentic pedagogy have often been made only on philosophical grounds; the CORS study offers strong empirical justification for it.

Significant adult accomplishments, such as designing a bridge, reflect three criteria that can be used to assess the intellectual quality of student achievement as well: construction of knowledge, disciplined inquiry, and aesthetic, utilitarian, or personal value.
From the Director

Research findings to guide policy and practice

Three major WCER projects recently concluded their assignments and now are reporting findings that should help guide education policy, curriculum, and instruction in important ways for years to come.

School finance reform in Kentucky, New Jersey and Texas has led to varying degrees of improvement in the equity of these states’ school finance structures. Studies by the Center for Policy Research in Education are the first analyses of equity effect to pinpoint the structural reasons for equity impacts and ways to improve the effects. Allan Odden of the CPRE Finance Center provides an overview of these statewide reforms and their results.

The Center on Organization and Restructuring of Schools reports a relationship between high levels of student achievement and “authentic pedagogy.” Fred Newmann and Gary Wehlage explain that authentic pedagogy requires students to produce meaning instead of merely reproducing knowledge produced by others. Authentic pedagogy leads students to an in-depth understanding of problems and issues. It produces learning with aesthetic, utilitarian, or personal value beyond the classroom. The five-year CORS study found that authentic pedagogy helps boost achievement for all students.

The Algebra Working Group, part of the National Center for Research in Mathematical Sciences Education, seeks to make algebra a more meaningful and engaging part of the curriculum. Researcher James Kaput and his team found that, rather than treating algebra as a course, educators should present algebra as a form of reasoning, taught across all grade levels, beginning in the elementary grades. But deep change in the curriculum will require major sustained support for teachers and a new curriculum embodying the innovations.

For more information about this and other WCER research, visit our Web site at http://www.wcer.wisc.edu. If you don’t browse the Web, visit our WCER archives at our gopher site on the University of Wisconsin’s “WisInfo” site.

Andy Porter

Newmann and colleagues collected data from 24 significantly restructured public schools, evenly divided among elementary, middle and high schools, and located in 16 states and 22 districts, mostly in urban settings. They studied each school intensively for a year, seeking to determine how well each school’s organizational features contributed to authentic pedagogy and authentic student achievement. Many of these schools had adopted such reforms as school-based governance councils, teacher teams with common planning time, heterogeneous ability grouping of students, extensive use of small groups in instruction, and special programs to address students’ social and emotional needs.

The study found that teachers communicate what is important to learn through two main activities: the tests or other tasks they use to assess student mastery and the instruction they conduct to help students prepare for the assessments. Together, the two parts of teaching practice are considered pedagogy.

Criteria for authentic student achievement

Significant adult accomplishments, such as designing a bridge, reflect three criteria that can be used to assess the intellectual quality of student achievement as well: construction of knowledge, disciplined inquiry, and aesthetic, utilitarian, or personal value. New knowledge is produced as special conditions are addressed involving the bridge’s length, peak points of stress and load, and the impact of environmental conditions. Disciplines of engineering, architecture, and mathematics have accumulated bodies of reliable knowledge and procedures for solving the more routine problems of design. However, problems unique to each setting will require new conceptions of design and construction. When completed the bridge will be useful to travelers, and it may make a significant aesthetic statement.

In terms of students’ work, the CORS concept of authentic academic achievement demands that all three of these standards be met. Instruction and assessment activities need not always fulfill all three standards, however; in some cases, repetitive practice or memory drills might help students build the knowledge and skills that can later serve as the basis for authentic performance. The point is not to abandon all traditional schoolwork, but to keep authentic achievement clearly in view as the ultimate goal.

Construction of knowledge: learning through analysis

The “construction of knowledge” criterion is consistent with the constructivist view of the student as a meaning-making person who continuously weighs new information against prior experience. But the CORS vision goes further. Authentic performance occurs when the student goes beyond imitation or reproduction of information and analyzes or interprets that information to solve a problem that can’t be solved by information retrieval alone.

Students construct knowledge when they are engaged in higher order thinking. One fifth-grade
mathematics teacher, for example, challenged students to estimate answers to a series of increasingly complex multiplication problems. She provided no instructions, procedures, or clues. Working in groups, students developed their own insights and rules for how to solve estimation problems, and the teacher constantly challenged them to explain their answers. She helped them articulate their reasoning by questioning the adequacy of their strategies.

In general, conventional curricula excessively emphasize reproducing knowledge—memorizing algorithms to solve routine mathematics problems, for example, or naming the different functions of parts of speech, or matching authors with titles and explorers with their feats. The mere reproduction of prior knowledge does not constitute authentic academic achievement, because it does not involve the thoughtful use or application of knowledge found in authentic adult accomplishment.

**Disciplined inquiry strives for deep understanding**

Authentic achievement is grounded in a field of knowledge, which usually includes facts, a specific vocabulary, and a set of concepts and theories. Authentic achievement in a field reflects a deep understanding of a particular problem or issue; superficial acquaintance with knowledge is inadequate. Through disciplined inquiry, students learn to establish some ideas as intellectually more worthy than others. Through substantive conversation, students engage in extended exchanges with a teacher or peers and build an improved and shared understanding of a topic. Deep understanding is expressed through elaborate forms of communication that make use of written, visual, and/or symbolic language to express ideas, nuances, and details.

Fifth-graders in one school were instructed, “Draw geometric designs of your own making on a grid. Write a BASIC program that will replicate those designs.” CORS researchers rated this task high on disciplinary content because it required students to understand the relationship between aspects of Cartesian geometry and algorithmic processes in mathematics. Because conventional schoolwork dwells mainly on transmitting prior knowledge—the first part of disciplined inquiry—it rarely helps students develop deep understanding through which they can explore issues, relationships, and complexities within focused, limited topics.

**What’s the value beyond school?**

The CORS criteria for authenticity also call on instruction to make “connections to the world beyond the classroom.” When adults write letters or news articles, design buildings, and create paintings or music, they are trying to communicate ideas, make products, or have an impact on others beyond simply demonstrating that they are competent. Achievements of this sort have a value that is missing in tasks contrived only to assess knowledge (such as most quizzes, lab exercises, or final exams). Authenticity calls for student accomplishments to have value beyond simply showing the teacher, the parent, or an employer that the student has mastered the requirements of schooling.

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**Authentic academic performance for “average” students receiving low, average or high authentic pedagogy**

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<th>Low Authentic Pedagogy</th>
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An average student is one with mean score on the NAEP Achievement and mean socioeconomic status in the School Restructuring Study sample. Authentic academic performance scores include students in both math and social studies. Low authentic pedagogy is one standard deviation below mean pedagogy; high is one S.D. above mean pedagogy in SRS sample classes.


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*continued on page 8*
An algebra for all students

“To prepare students for the 21st century we absolutely need the curricular space that is now locked up by the 19th-century high school national curriculum now in place.”
—James Kaput

It’s no news that many students find algebra one of the most alienating parts of their school curriculum. Based on their experiences in algebra, or even on whether they are permitted to take the course, many students come to view themselves as having little potential for involvement in further mathematical studies. In effect, algebra becomes a filter for a large proportion of ninth-grade students: Traditionally, performance in algebra is the primary criterion used by parents and teachers to determine a student’s mathematical future, which in turn determines opportunities later in life.

One of many educators who would like to see more students succeed in algebra is James Kaput of the University of Massachusetts-Dartmouth. Kaput chaired the Algebra Working Group, one of seven international networks of researchers created by WCER’s National Center for Research in Mathematical Sciences Education (NCRMSE). NCRMSE's work, directed by UW–Madison education professor Thomas Romberg, was designed to provide a research base for the reform of school mathematics nationwide as reflected in the National Council of Teachers of Mathematics’ Curriculum and Evaluation Standards for School Mathematics and the Professional Standards for Teaching Mathematics.

Having examined the character and purposes of algebraic reasoning and its relationship to other forms of mathematical reasoning, the Algebra Working Group proposes that development of algebraic reasoning can be fostered in all students and should be integrated with the learning of other mathematics.

Begin algebra in early grades

The researchers studied algebra instruction in U.S. schools and compared it with that of the more mathematically successful countries in the world (Japan and the Netherlands, for example). They concluded that, despite its almost universal acceptance in the U.S., our algebra curriculum—late, abruptly introduced, and isolated—is simply beyond repair. Kaput says, “It will not suffice to tinker at the edges by creating prealgebra courses, introducing the same algebra earlier, or trying to fix the Algebra 1 and Algebra 2 courses in their standard position as isolated high school courses. Rather, the development of algebraic reasoning needs to begin in the early grades. It should be interwoven with the learning of other mathematics and should continue through the school years as an integral part of the K–12 math curriculum.”

The processes of generalizing and formalizing are a major aspect of algebra, and of all mathematics. It is at the heart of what makes thinking mathematical, Kaput says. “It should be a defining characteristic of a curriculum rather than a topic that is covered. The intrinsic embeddedness of algebraic reasoning is violated by treating it as a separate course.” Moreover, he says, making generalizing and formalizing a part of the way we approach all topics from the very beginning would add a depth and a coherence to elementary school mathematics that has never been present.

Algebra is also a web of languages, both for expressing generality and for manipulating that generality. That point of view likewise supports an early and integrated algebra: early because students require repeated use of a language over an extended amount of time to become fluent in its use; integrated because, to learn a language, students need to use it to express something significant to them, such as the quantitative relationships arising inside mathematics (for example, that occur in arithmetic and geometry) and outside mathematics when they seek to model their world.

Teachers need support

Introducing important ideas in algebra and quantitative analysis in lower grade levels will place new demands on teachers. Many teachers do not have backgrounds that exposed them to algebraic reasoning, nor did their education prepare them to teach it. If the researchers’ new view of algebra is to be realized in classrooms, teacher education programs and teaching credentials will need to change. And teachers will need instructional materials that fertilize the roots of algebraic reasoning, creating the mathematical experiences appropriate for the early grades. Teachers also will need help in identifying and nurturing early forms of algebraic reasoning, particularly since it is initially expressed using ordinary language, intonation, and gesture, rather than through the use of formal symbolism. Kaput suggests that, because other countries have begun the process of integrating algebraic content with other mathematical content, their methods and materials can inform the work that is beginning in this country.
The Algebra Working Group’s role within the NCRMSE was to develop a range of practical recommendations for teacher educators and for developers of curricula and tools. One project within the Working Group aimed at reconceiving algebra in grades 6–12, based on the notion of function, and testing it with a small group of teachers. The resulting new curriculum builds from the position that the function is the primary and fundamental object of the subjects of algebra, trigonometry, probability and statistics, precalculus, and calculus. Existing algebra curricula may confuse students because they confound functions and relations, equations and expressions, and variables and unknowns. Students unfamiliar with functions find themselves crippled when they begin to learn calculus, which is fundamentally about the operations of differentiation and integration on functions as objects.

The reformed curriculum clarifies these relationships by relating them to the central notion of function. Working Group member Judah Schwartz and colleagues developed the curriculum (under independent funding) with help from teachers who discussed its design and field tested it. The team gathered evidence about the teachability of the curriculum through extended clinical discussions and observations with teachers and their students. The monograph, Spinning Wheels: An Analysis of Some of the Factors Contributing to the Unreasonableness of Asking Teachers to Weave the Strands of Mathematics Education Reform by Themselves, outlines the functions-based approach to algebra. It explains how teachers came to understand and use this approach as they participated in an 18-month series of programs with the Schwartz team.

Ideas into practice

During its five years of activity, the Algebra Working Group influenced policy development, research direction, and curriculum change across the nation:

- Besides circulating algebra research material, the Working Group grew to nearly 200 members. Kaput and team shared findings widely with graduate students, teachers, and other researchers. The group’s e-mail discussions, available online as an archive, supported researchers, teachers, and graduate students interested in curriculum change. It’s likely that several thousand people have come into direct contact with working group material in some form. High school teachers and curriculum developers have found the working group useful as a way to develop connections with researchers, something that might not have been easy otherwise. Faculty at two-year colleges and nonresearch institutions, whose heavy workloads limited their access to research seminars and conferences, found the working group discussions a bridge to the world of active research and development.
- The group’s findings are scheduled to appear in the Fall 1996 issues of the National Council of Supervisors of Mathematics newsletter and the Association of Mathematics Teacher Educators newsletter.
- The group’s Curriculum Futures Project examined new directions for the evolution of mathematical content for the next century, especially at the secondary level. It explored means for the continuing renewal of content in the future. Some of the features of this project have been incorporated into the agenda of WCER’s new School Mathematics and Science Achievement Center’s High School Design Collaborative.

For more information, see the Algebra Working Group postings at the Web site http://tango.mth.umassd.edu/AWG/WecomeAWG.html. NCRMSE research findings are posted on the UW–Madison’s gopher server, “WiscInfo,” under “Newsletters and Other Special Interest Publications,” and on the WCER Web site at http://www.wcer.wisc.edu.

The Working Group’s Web site provides archives of its products.
Recent school finance reform efforts in Kentucky, New Jersey, and Texas have led to significant, if not dramatic, improvement in the equity of their school finance structures, according to researchers at the Consortium for Policy Research in Education. CPRE studies of these statewide reform efforts were the first to look at the equity effect of finance reform that analyzed the structural reasons for inequity and ways to improve equity. Future research on these reforms will need to determine whether the equity gains are maintained, says Allan Odden, director of the CPRE Finance Center at WCER. Other states considering fundamental changes in finance policy may find helpful information in the full reports CPRE produced. The following summarizes what the researchers found.

Kentucky reduces revenue disparities

CPRE researchers Jacob Adams and William White* studied Kentucky’s reform of its school finance policy as mandated by the Kentucky Education Reform Act. KERA resulted in a more uniform school finance code and more equality of educational opportunity.

Prior to reform, per-pupil property wealth varied across Kentucky school districts by a factor of nearly 10, from $39,138 to $341,707. Levied equivalent tax rates varied by a factor of nearly five, from 2.29 mills to 11.19 mills. Locally generated revenues varied by a factor of more than 40, from $80 per pupil to $3,716 per pupil; at the same time, state per-pupil revenue varied from $1,750 to $2,753. Allocation of state aid was insensitive to variations in property wealth across school districts, resulting in a wide and constitutionally unacceptable variation in total revenues available per pupil. The Kentucky Supreme Court also found a correlation between per-pupil revenue and student achievement: Put simply, the quality of a child’s education in Kentucky depended on the local availability of education money.

In 1990, the Kentucky legislature stepped in to reinvent the state’s school system. The Kentucky Education Reform Act (KERA) mandated that state aid become sensitive to variation in local wealth. Resulting changes led to a diminished relationship between per-pupil revenue and property wealth. Disparity in the distribution of pupil revenue still existed but, to an extent, this disparity was intentional, allowing for the exercise of local discretion. KERA allowed Kentucky to move its schools closer to the efficient system envisioned in the state constitution, as interpreted by the state Supreme Court in 1989.

Although Kentucky’s school finance system is now more uniform and provides more equal educational opportunity than previously, CPRE researchers Adams and White say that future analysis will need to determine whether the disparity in pupil revenue affects the adequacy of the state school system. Kentucky policymakers may choose to seek additional gains in system equity, and marginal gains are possible. The amount of the base guarantee funding (a state-guaranteed minimum revenue per pupil) would need to be adjusted. Changing the base guarantee, however, would involve substantial additional cost. More cost effective equity improvements may be found in other attributes of the system.

Texas equalizes tax rate

Unlike the overwhelming and rapid effects of KERA, school finance reform in Texas has resulted from a lengthy series of legal battles, according to CPRE researcher Lawrence Picus.*

In 1984 a group of poor school districts in Texas, including the Edgewood Independent School District, filed a lawsuit in state court alleging that expenditure differences among districts violated their rights under the Texas constitution. In response, the state legislature enacted House Bill 72, which included a number of significant improvements in the equity of the school funding system. Despite the resulting improvements, the plaintiffs refiled the suit in 1985. In June 1987, a district court ruled the state’s public school finance system unconstitutional.

The Texas school finance formula now has two tiers. Tier I, a typical foundation program, allots a district’s funds according to the number of students attending, $2,000 per pupil, for example. Tier II is a guaranteed yield program through which the state offers districts a guaranteed revenue based on each penny of local property tax raised (for example, $22.50 per pupil for each penny of tax effort). In the past, districts were allowed to levy taxes beyond the tax rate guaran-

*C. Jacob Adams, Jr., and William E. White II are based at Vanderbilt University. Lawrence O. Picus is based at the Center for Research in Education Finance, School of Education, University of Southern California. Margaret E. Goertz is Professor and Senior Research Fellow at the Eagleton Institute of Politics, Rutgers University.
ted by the state in the second tier. This yield was not equalized.

For 1988–89 and 1989–90, the Tier I tax rate that districts were required to levy to receive the basic allotment was estimated on the basis of a calculation determined by a “local share” parameter established in the statute. For 1990–91 and subsequent years, the Tier I tax rate was made explicit in the statutes governing the distribution of funds to schools. The Tier I tax rate increased substantially, from 31.5 cents per hundred dollars of assessed value in 1988–89 to 86 cents per hundred in 1993–94, an increase of 273 percent.

From 1989–90 through 1993–94, dramatic changes occurred in the equalized tax rate and the amount of revenue available to Texas's 1,044 local school districts. Along the way, some districts were forced to make dramatic program cuts while other districts saw their per-pupil revenues increase by as much as $1,000 per pupil from one year to the next.

The Texas Supreme Court’s ruling in a case known as Edgewood IV ended the state’s round of school finance litigation. Picus says it may have precluded a number of potential future lawsuits as well. The wealth restrictions of the resulting Senate Bill 7 will dramatically limit the revenue potential of the wealthiest districts, forcing reductions in their spending. Picus concludes that the Legislature might want to consider reductions in the $600 funding gap that exists between poor districts (those with wealth of $205,000 per pupil or less) and districts with a wealth of $280,000 per pupil.

New Jersey institutes Quality Education Act

In contrast to a relatively equitable system in Texas, most equity measures rank low in New Jersey, despite an infusion of one billion dollars in state aid, according to CPRE researcher Margaret Goertz. In February 1981 the Newark-based public interest law firm Education Law Center filed a complaint in New Jersey Superior Court on behalf of children attending public schools in Camden, East Orange, Irvington, and Jersey City. The plaintiffs contended that New Jersey’s guaranteed tax base system of funding education caused significant disparities in educational expenditures and programs between poor urban and wealthy suburban school districts. These disparities left poor urban districts unable to meet their students’ educational needs.

The Court ruled in favor of the plaintiffs, finding that the poorer the district, and the greater its need, the less money available, and the worse education. The Court then spelled out the state’s obligation to educate students in poorer urban districts. The Quality Education Act, implemented in 1991–92, (1) changed the formula for distributing state education aid to local school districts from a guaranteed tax base to a foundation formula, (2) redefined the property wealth measure (used to allocate aid) to include an income factor, (3) replaced the compensatory education categorical aid program with a program of aid for “at-risk” students, (4) eliminated the payment of minimum aid to wealthy school districts, and (5) changed transportation aid from a reimbursement to an expected cost basis.

State education aid increased $1.02 billion in the three-year period 1989–90 to 1992–93. Of this amount, aid for the “regular education” program—foundation aid—increased $631.5 million, and aid for categorical programs—special education, bilingual education, at-risk aid, and transportation aid—grew $470 million. Statewide, the gap in regular education spending did not narrow, and the correlation between education spending and wealth did not change. Goertz found evidence of some increase in spending among the bottom half of the districts and variation in spending around the mean narrowed slightly.

Although the Quality Education Act replaced a guaranteed tax base system with a new foundation aid program and increased categorical aid for students with special needs, it did little to increase the equity of regular education spending, Goertz says, and the results fall well short of meeting the Court’s mandate of parity. In spite of an infusion of one billion dollars in state aid, however, New Jersey ranks low on most equity measures.

Goertz concludes that the designers of a new aid formula will face three challenges: (1) a lack of consensus on what a “thorough and efficient” education entails and how much it costs; (2) a need to design a school funding formula that will win the support of a broad coalition in the state; and (3) a need to find ways to fund that formula.

At modest cost, Kentucky and Texas could have provided significant additional fiscal equity, or fiscal neutrality, by increasing the guaranteed tax base level of the second tier of the formulas, Odden says. Adding such a tier in New Jersey would have improved equity, but the cost would be much higher.

For more information about the experiences of the states profiled here, contact Odden at odden@macc.wisc.edu, (608) 263–4260.
For example, fourth graders who were studying ecology were assigned to write letters to a state legislator. They were to express an opinion about what should be done to save threatened eagles along the Mississippi River. Students were to ask each other to read their letters and offer constructive criticism. When the students were satisfied with their letters, they were to send them. This task challenged students to meet a number of the standards of intellectual quality for tasks. They had to organize information to address a problem, communicate knowledge and opinion effectively, and address their communication to an actual audience beyond the school in an attempt to influence a public issue.

The CORS study of 24 restructured schools found that, while all schools studied demonstrated clear progress in organizational restructuring, they varied substantially in their success on the standards for authentic pedagogy. “Some teachers and schools have been reasonably successful, signaling hope that authentic pedagogy is achievable,” Newmann says. “But overall levels of authentic pedagogy remain low according to CORS standards, even in highly restructured schools, and some teachers and schools have barely begun the journey toward authentic pedagogy.”