WCER Highlights

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What do science teachers teach?

What distinguishes one teacher's practice from another's is the point where a teacher either allows more leeway to students for making decisions or, conversely, steps in to clarify ambiguities.

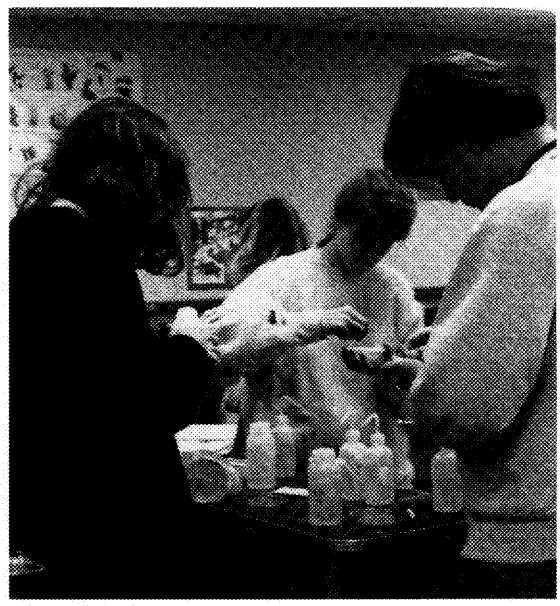
WCER Highlights

SUMMER 1994
Vol. 6, No. 3

Students of science learn that many important things in the world happen to be invisible. Science teachers are learning that the factors shaping the way they teach are sometimes invisible as well. Teachers' beliefs about science and teaching, whether conscious or not, influence how and what their students learn.

Project DISTIL, an acronym for Description and Interpretation of Science Teaching with Implications for Learning, has pinpointed teachers' underlying assumptions about content, learning, and teaching and how these beliefs influence their teaching. Principal investigators Peter Hewson and Robert Hollon recently studied the teaching practice and the underlying assumptions of 12 teachers of high school biology, chemistry, and physics. The National Science Foundation funded the project.

Project staff interviewed the science teachers on five occasions over the course of a school year, listening for statements that seemed to encapsulate the teachers' thoughts on the nature of science, learning, and instruction. They also visited the teachers' classrooms to observe how they taught. One particular point of interest was how the teachers conducted student laboratories. Educators have long believed that laboratory work is important for two reasons; it helps create a scientifically literate citizenry and it enables some students to pursue a science career.



Different teachers create different atmospheres in their classrooms.

JEWELL

Mr. Jewell rejects the role of teacher as an authority on content and instead delegates the responsibility of making meaning to the students. In Jewell's labs, students work in groups of three to four on a single project, for weeks at a time, with minimal teacher intervention. Jewell tells them that they may be frustrated and that they'll have to modify their projects repeatedly.

Jewell does not think in terms of there being a "central content" to his course; rather, "maybe what I want them to do is to use the physics formulas as tools" to come up with "some result that makes sense." He expects his students to work on tasks that entail a great deal of ambiguity, and he waits patiently as they occasionally flounder. Only toward the end of project activities did researchers see that Jewell eventually intervened to relieve students' struggles and to provide some clues.

SORENSON

Ms. Sorenson constructs students' physics lab responsibilities quite differently than Jewell does. She is concerned that students "do it right." "Read and follow directions; that is part of your job," she emphasizes. Sorenson assumes initially that classroom laboratory experimentation will speak for itself. Unlike Jewell, who denies the existence of any "central" science content, Sorenson expects the experiences and observations students make in her "hands-on" labs to lead to certain premises. Students' common-sense reasoning then should lead from these premises to accepted physics theory.

However, Sorenson does intervene to reinforce "necessary" conclusions from the context of preordained science content. This response to student performance in lab, however pragmatic, conflicts strongly with her belief that lab experimentation will speak for itself.

Sorenson wants her students to provide evidence to her that they have adopted the correct scientific explanations and conclusions during their labs. But when students' responses do not fulfill Sorenson's expectations, she provides the students with step-by-step instructions that will guarantee success.

Thinking and practice

Hewson and Hollon found that what shapes a science teacher's practice is not simply the *content* of the beliefs about practice but the *relationship among* those beliefs and their differing *relationships to practice.* It would be nice if teachers could sit in silence, engage in self-analysis, and produce an objective picture of their beliefs about practice. But it's unlikely that self-reflection would reveal these relationships, Hollon says, because most teachers work in isolation and have little help or incentive to engage in exploratory thinking and practices. Like most of us, they find reflection on their assumptions difficult.

But it's these assumptions that control how classrooms work. Even when they're addressing the same core content, different teachers create different atmospheres and activities in their classrooms, based on their underlying beliefs about what students should learn. The instances where teachers choose to intervene in student lab work reveal teachers' conceptions about what constitutes appropriate actions both on the part of the students and on their own part. The DISTIL study

reveals that teachers' practices can be distinguished at the points where they either allow more leeway to students for making decisions or, conversely, step in to clarify ambiguities. Mr. Jewell (a pseudonym), for example, intervenes only minimally, while Ms. Sorenson stresses the importance of "doing it right" (see sidebars).

One particular point of interest distinguishes Sorenson's practice from that of the other two teachers mentioned here. During the year of observations and interviews, Sorenson was initiating a change from a "mathematical" to a "conceptual" approach to teaching physics. She introduced a new textbook and many new tasks for students. Her practice, and particularly lab activities, needed to be interpreted within a context of significant transition.

In her classroom, the successful learner was one who in the end demonstrated his or her conformance to the structure of preordained physics content. On the other hand, Sorenson believed that students will learn better if they figure it out for themselves. Yet when she acted on this belief in the classroom, the students' responses often did not fulfill her expectations.

When lab experiences failed to bring the students to the correct conclusions, Hewson relates, Sorenson verbally cajoled them to proffer agreement with the official physics version of what happened. Her classroom discourse reflected both her dedication to, and her frustration with, convincing the students that the physics concept should have been accepted by them. Sorenson created some tension in the classroom by alternatively leading students by algorithmic instruction and then allowing them to work independently, Hollon says. But this is consistent with a period of significant change in Sorenson's approach to teaching.

Hewson and Hollon make the results of the DISTIL study available to teachers and preservice teachers in the form of individual case studies. This series of documents provides a library of professional responses to common classroom situations. "Each case study profiles a teacher's practice and represents the explicit and implicit beliefs that shape that practice," says Hewson. Examining these case studies should spur experienced teachers and preservice teachers to think and discuss teaching strategies. Reading analyses of science teachers' thinking and actions should give preservice teachers themes that can be used to construct teaching practices. They'll also get a glimpse into the complexity of constructing a teaching practice, says Hewson. The case studies may prompt experienced teachers to examine their own thinking and how they might make classroom experiences more meaningful for their students.

For more information about Project DISTIL or the resulting case studies, contact Peter Hewson at WCER, 1025 W. Johnson St., Madison, WI 53706, (608) 263–9250.

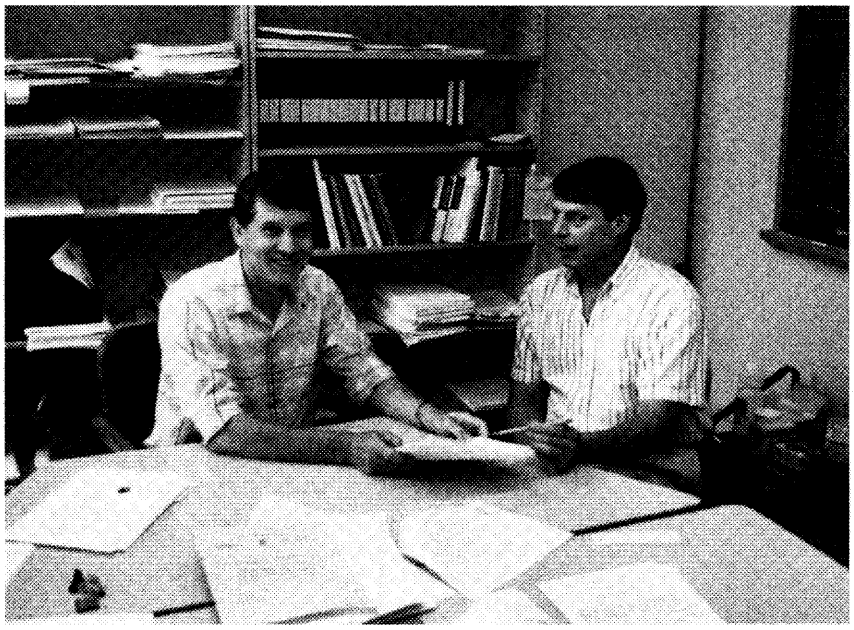
DODGSON

Mr. Dodgson, unlike Sorenson, does not expect his students to discover the principles of science from experience. Also, unlike Jewell, he does not largely ignore his students. Rather, he states the accepted principles explicitly and then expects his students to work out how to apply them in an experiment.

His students engage in a process that follows the thinking and actions of scientists in making sense of a complex world using a set of physics tools.

Mr. Dodgson remains purposefully vague with his students about what procedures they should employ during labs. Instead, he coaxes students in the direction of how they need to think about the experiment in order to "write the procedure [and] make it clear to the reader what you did to maintain control." He wants them to maintain control of critical variables, but he does not tell them so outright.

Dodgson does, however, interrupt procedures with comments meant to make students aware of their own thinking and actions. Toward the end of the lab period Dodgson intervenes by modeling thinking that includes a specific instruction.



WCER researchers Peter Hewson and Robert Hollon examine some case studies.

New math courses help more kids

The self-fulfilling prophecy is played out in far too many mathematics classrooms. Students know that they're facing a dead end. Their mathematics courses set low expectations for them. Students learn to hold low expectations for themselves, and their performance then further reduces their teachers' expectations. The courses are known as general math, fundamental math, and the lower track.

Some educators began to realize that ninth-grade general math students almost never reached the college-preparatory sequence, regardless of their abilities. To break this vicious cycle, some schools in California and New York offer innovative math courses known as "bridge" courses or "transitional" courses. Students and teachers involved in the courses are noticing a difference. Students have expressed enthusiasm for the courses and they are going on to take higher level math courses that might not otherwise have been available to them.

Math A has inspired students to read the newspaper and to try to make sense of statistics, charts and graphs.

To determine how and why these courses work, the Policy Center of the Consortium for Policy Research in Education (CPRE) analyzed California's "Math A" and New York's "Stretch" Regents courses. CPRE's ongoing analysis, based at WCER, studies course content and curriculum, student attitudes and achievement, and student attendance and mobility.

New York State's Regents, a college preparatory math program, integrates algebra, geometry, trigonometry, problem solving, and statistics. To open the door for students not qualifying to take the Regents course, some schools offer what's called the "Stretch" Regents sequence, which covers the same material, but stretches it over two years. The slower pace allows students to take math that's not only more challenging than fundamental math but also increases the students' chances of going to college.

On the other side of the continent, a similar project is underway in California. The Math A program serves as an entry course for students who are not ready for a college preparatory program, but who show readiness to learn content beyond the K–8 curriculum. Math A replaces lower level math courses and serves as a bridge to college preparatory courses.

Educators in New York and California developed the transitional courses because the traditional math curricula were not equitable. Students enrolled in the general math track were not taking or learning as much math as they needed and seemed capable of taking.

WCER researcher Paula White says that the knowledge gained from studying these two innovative programs can help other schools and districts develop math curricula that will enable more kids to take more meaningful math.

The CPRE research team examined New York students' chances of success in mathematics, conditional on their eighth-grade math grades. Overall, students' chances of success depended on their math performance as well as on their track levels ("general" or "college preparatory"). However, students enrolled in general math in ninth grade almost never reached the college-preparatory sequence, *regardless of their early capacity*.

Statistics from New York painted a bleak picture. A student who made an 'A' in eighth-grade math and who took college-preparatory math in ninth grade had a 96% chance of completing Regents math or the equivalent. But an 'A' student who took general math, by contrast, had only a 4% chance of completing Regents Math or the equivalent. An 'A' student taking the "Stretch" Regents transitional course had a 43% chance of completing the Regents sequence or equivalent.

The upshot? Although the general math track allowed students to acquire the math credits needed to graduate, it effectively *prevented* them from taking college-prep math. The transition math courses, by contrast, were found to improve students' chances of completing college-prep math.

Courses make a difference

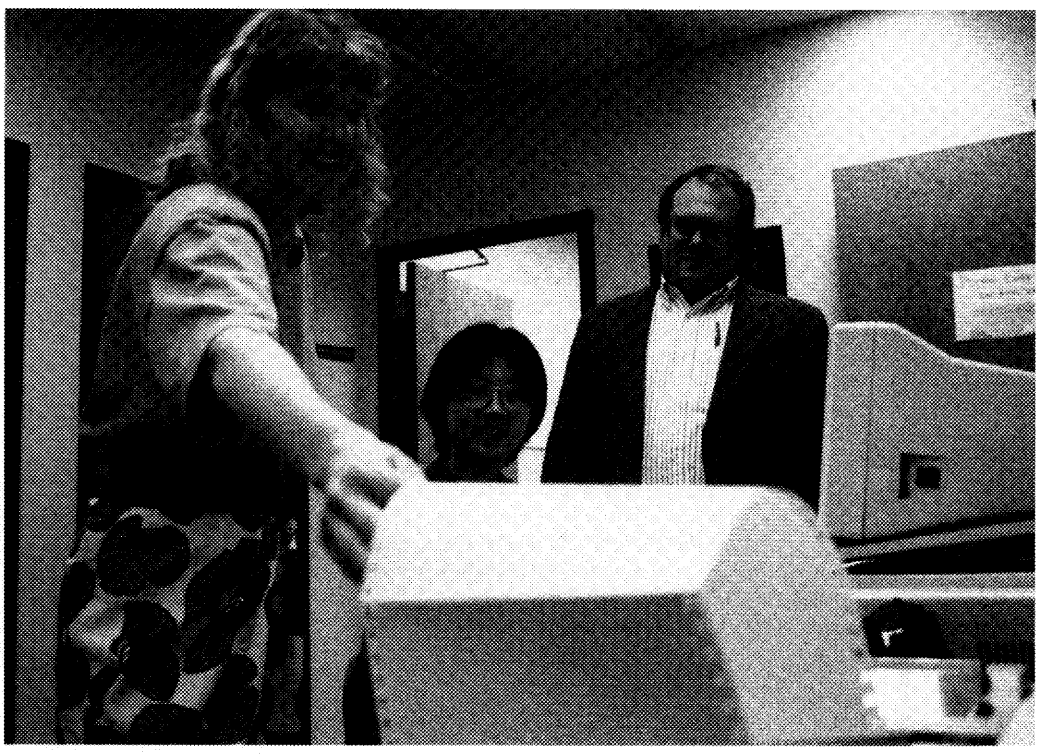
The transitional math courses resulted in several key improvements for students, the CPRE study found.

In each of the seven high schools studied, more students take more worthwhile math. Six of the schools have eliminated lower-level math courses, resulting in more students taking college-preparatory math.

One Rochester teacher says, "You get a lot more students through [with "Stretch" Regents] that would never have gotten through Regents math otherwise." The "Stretch" Regents course

gives students "a better chance of doing math and not getting discouraged and giving up, which is typical of the kids we deal with," says another teacher. And "Stretch" Regents students are proud that they use the same textbook as students in the one-year Regents courses.

Similarly, in California, students taking Math A have a better opinion of math and learn more than students taking general math. One Math A teacher says math no longer frightens her students. As researcher White explains, "Kids who thought they were poor math students now see that they can do these things. They're finding they have a talent for it." San Francisco and San Diego teachers say that Math A students have a better image of themselves as math learners and enjoy getting away from mindless drill and practice. Math A's emphasis on cooperative learning enables students to learn concepts from their peers.



Students enrolled in the general math track were not learning as much math as they needed and were capable of learning, says WCER researcher Paula White (left).

The course material emphasizes practical problems relevant to real life. Math A's problem-solving, hands-on activities have inspired students to read the newspaper and to try to make sense of statistics, charts and graphs. One Math A teacher says, "Anything could happen. You drop the bomb and the students have to find ways to solve it. It's hard. It's drastically different from the old-fashioned way."

The courses benefit teachers, too. California teachers say that Math A empowers them. Although the state department of education compiled the Math A units, teachers may choose which units they cover and the exams and materials they use.

Change isn't easy

Because reform initiatives met with initial resistance in both states, changing the curriculum required some politicking and readjustment. In California, for example, some teachers complained about the lack of a textbook for the Math A course and the amount of additional preparation required to teach it.

Teachers also seem to be shooting at a moving target. In the schools studied, teachers face high rates of student mobility and student absenteeism. High percentages of students transfer in and out of the schools, so that teachers must work with different subsets of students in the same semester, complicating attempts to prepare students for the next course in the sequence. Teachers also report that chronically absent students tend to be enrolled in the transition courses—Rochester teachers estimate a 20% to 25% daily absenteeism rate.

Another problem compromises the success of transitional math programs. The CPRE research team found that some transition courses are used as "dumping grounds" for students coming from different math backgrounds. Some upper-level students take the transition math courses only because they need to earn an additional math credit. This practice was more common in the Rochester and San Diego school districts, which require students to have three math credits to graduate, in comparison to two credits in Buffalo and San Francisco. Some California juniors and seniors who had already taken algebra and/or geometry, but were not ready for advanced algebra, were placed in Math A to satisfy their third district math credit requirement.

School scheduling issues, rather than choices made by teachers or students, sometimes dictate student placement. In Rochester, placement in ninth-grade courses supposedly depends on students' grades in eighth-grade math. The CPRE

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Shaping a call to action

The Kentucky state supreme court in 1989 declared the state's educational system unconstitutional because of inequities in opportunity to learn. At that point, the state realized that it had two big jobs on its hands. One was to redesign the state's system of funding school districts. The other, equally important, was to explain to state residents the need for reform and how it was going to be accomplished.

The state launched a well-planned publicity campaign. It developed and distributed a 62–page guidebook explaining the Kentucky Education Reform Act (KERA). A series of brochures addressed specific parts of KERA—extended school services, the new primary school program, school-based decision-making, preschool and special needs services, and the new assessment system.

Helping then, and now, in the public information effort is the Partnership for Kentucky School Reform. The Partnership is a nonpartisan coalition of public and private leaders from business, civic, governmental, and education organizations that promotes public understanding and support for KERA's ten-year implementation. Other help has come from the daily Louisville *Courier-Journal*, which ran a three-day series of articles on KERA in August 1992 and provides reprints for wider distribution. To help finance the campaign to promote public understanding of the reform act, three private corporations belonging to the national Business Roundtable committed $1 million a year for three years.

Public information activities such as these constitute an important part of restructuring K–12 schools across the nation, says WCER Director Andrew Porter. "Restructuring will not happen on any scale unless there is first a massive shift in beliefs about what schools can and should accomplish, and about how schools should proceed," Porter says. Efforts to change public opinion must occur at the federal, state, and district levels.

WCER Director Andrew Porter

Education research exemplifies the government's strategy for creating a general press for school restructuring.

The federal level: Creating a general press

The lack of public acceptance of the need to change presents one of the greatest obstacles to fundamental change in K–12 education, says Porter. At one level, teachers and the public believe schools need to change to improve, yet teachers tend to consider their own practice acceptable and parents tend to give good marks to the schools their children attend.

To help resolve this inconsistency and to increase public awareness of the need for reform, the federal government has published reports and developed initiatives. The 1983 publication *A Nation at Risk* was effective for a number of reasons, says Eric Osthoff, a research assistant at the Center on Organization and Restructuring of Schools. The report was short and to the point and was written for a general audience. It was promoted through a professionally orchestrated national publicity campaign.

The National Education Goals, another Federal initiative, were announced in 1990 during the Bush administration. The President of the United States rarely has been directly and personally involved in education reform, Porter notes; of those rare times, the National Education Goals provide the best example. "As with *A Nation At Risk*, the Goals do not specifically call for school restructuring," Porter says, "but they do preview several major themes included in most definitions of school restructuring. The goals have stimulated schools to restructure learning environments and to better coordinate with community resources."

Education research also has a place in the government's strategy for creating a general press for school restructuring. The National Assessment of Educational Progress (NAEP), begun in 1970, has since been referred to as "the nation's report card." NAEP assessments of student achievement in core academic areas have provided the best source of data for monitoring the outputs of schooling at the national level, says Osthoff. Data are universally cited in arguments that schools must be improved. Additionally, federally supported U.S. participation in international comparisons of academic achievement has uncovered our nation's relatively weak standing among the world's developed countries. These international comparisons were especially influential with the National Commission on Excellence in Education, Osthoff says, and are now routinely reported by the National Center for Education Statistics in its publication, *The Condition of Education*.

State-level campaigns to change public opinion

Complementing these federal strategies are the states, which recognize the important role public opinion plays in school reform. To accomplish fundamental and comprehensive change of schooling, those who pay the bills will need to be convinced of the need to change and that the proposed changes offer promise, says Porter. Such persuasion will not happen easily. Porter cites studies by the National Governors' Association, polls, and focus groups that repeatedly show that, while governors, other policymakers, and educators talk of higher standards and a richer curriculum, the public yearns for "a return to the basics and the old-fashioned discipline."

Further, many reforms require increased expenditures on education, yet three-fourths of voting adults in the U.S. do not have children in the public schools. This overwhelming majority of voters needs to see that public education remains an issue of importance to them. Osthoff says that carefully structured and well-financed public opinion campaigns offer a promising but relatively new strategy for supporting school restructuring. A campaign to change public opinion can be designed to either initiate or support school restructuring (see sidebars).

District-level projects

In many ways, districts are especially well positioned to stimulate and support the restructuring of schools, says Osthoff. Their proximity and first-hand knowledge of people and conditions (not enjoyed by states and federal agencies) allow them to tailor strategies to local circumstances. Osthoff cites Dade County (FL), Chicago (IL), and Jefferson County (KY) as making "especially strong efforts" to initiate and support school restructuring.

In September 1987 the Dade County Public Schools began a restructuring project that introduced school-based management and shared decision-making. Thirty-three schools began making their own decisions rather than following the traditional reporting procedures to school administrators or area offices. The new arrangement gave teachers and administrators the opportunity to voice and implement their own ideas of how students should be taught.

To explain the benefits of such reform and to spur public interest, Dade County Public Schools and United Teachers of Dade (the teachers' union) jointly publish "The Innovator" newsletter and a 24–page brochure called "Renaissance in Education." The newsletter takes its readers inside various schools to explain how shared decision-making works, and how the county's Partners in Education program links 11 schools. The brochure explains how the school system is being restructured by the system's Professionalization of Teaching/Education movement.

Serving as contact people for county residents are officials from the teachers' union and representatives of the county public school system.

Several hundred miles north of Dade County, statewide reforms are well

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Oklahoma

Antitax groups in Oklahoma were able to get a repeal question on the ballot to negate the state's 1991 Comprehensive Education Act. The Act included a number of school reform initiatives and increased funding. The governor, however, launched a successful campaign against the repeal initiative, using $1.5 million of private funding and strong support from two of the state's largest circulation newspapers.

An expertly organized statewide pubic information campaign involved a coalition of citizens—business and labor, urban and rural, teachers and parents. Pro-reform citizens formed "Growth Oklahoma" as a political action committee. Volunteers received copies of a kit that included sample speeches, background papers, and fact sheets. A 200–page notebook explained how to organize a public relations campaign, including structure, strategies, and activities. The notebook also provided resource materials including brochures, display ads, legal guidelines for fund raising, and the 100–page text of the Comprehensive Education Act.

In a special election, the largest in state history, the bill was upheld and the repeal was defeated by a 54% to 46% margin. The campaign had worked.

Vermont

Vermont's reform initiative, the Green Mountain Challenge, held more than 50 forums, involving more than 4,000 citizens, to communicate in plain language the need for reform and how schools could change. The forums provided an opportunity for the public to share their concerns and suggestions. The Challenge, based on four state education goals, was developed by 250 Vermonters and adopted by the State Board of Education in 1989.

The state's public communications program involved several activities. In addition to the forums, many communities sponsored Annual School Report Nights. Every superintendent, principal, and school board chair in Vermont receives a copy of the Commissioner's monthly Report to the State Board.

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WCER Highlights is published four 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.

ISSN 1074–1832
Vol. 6, No. 3
Summer 1994

Math

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team found that about 35% of students, however, were not placed in accordance with these rules. About half were "above" and half were "below" their expected positions in one school, and more students were above than below in another school.

Although responsibility for placing students in the various math courses generally lies with counselors, respondents from each of the schools indicated that counselors were not following math department guidelines. One counselor said that information provided by middle schools is "not always sufficient to make those kinds of decisions, so you really kind of play it by ear." Counselors often were said to know very little about the content of the math courses, and teachers and counselors in each district admitted that student placement was more random than systematic.

Problems such as these need to be monitored. As they are addressed, even more students will benefit from the bridge math courses. They'll take more meaningful mathematics and live up to higher expectations. As the CPRE study continues, more detailed information about the effectiveness of these courses will become available.

For more information about this study, contact Paula White at CPRE, 1025 W. Johnson St., Madison, WI 53706, (608) 263–4353.

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underway in Kentucky. Convincing state residents that reform is worth the expense and trouble has proven to be an ongoing challenge. Supporters of reform must keep making their pitch, even as anti-reform groups keep making theirs.

Kentucky's bottom-up reform is unique, yet many states have set ambitious agendas for themselves. State, district, and federal efforts to persuade taxpayers in all states of the importance of reform will continue to play an important part in their success.

This article was adapted from a paper written by Andrew Porter and Eric Osthoff for the Center on Organization and Restructuring of Schools. For more information about the paper, contact Porter or Osthoff at WCER, 1025 W. Johnson St., Madison, WI 53706, (608) 263–4200.

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