WCER Highlights

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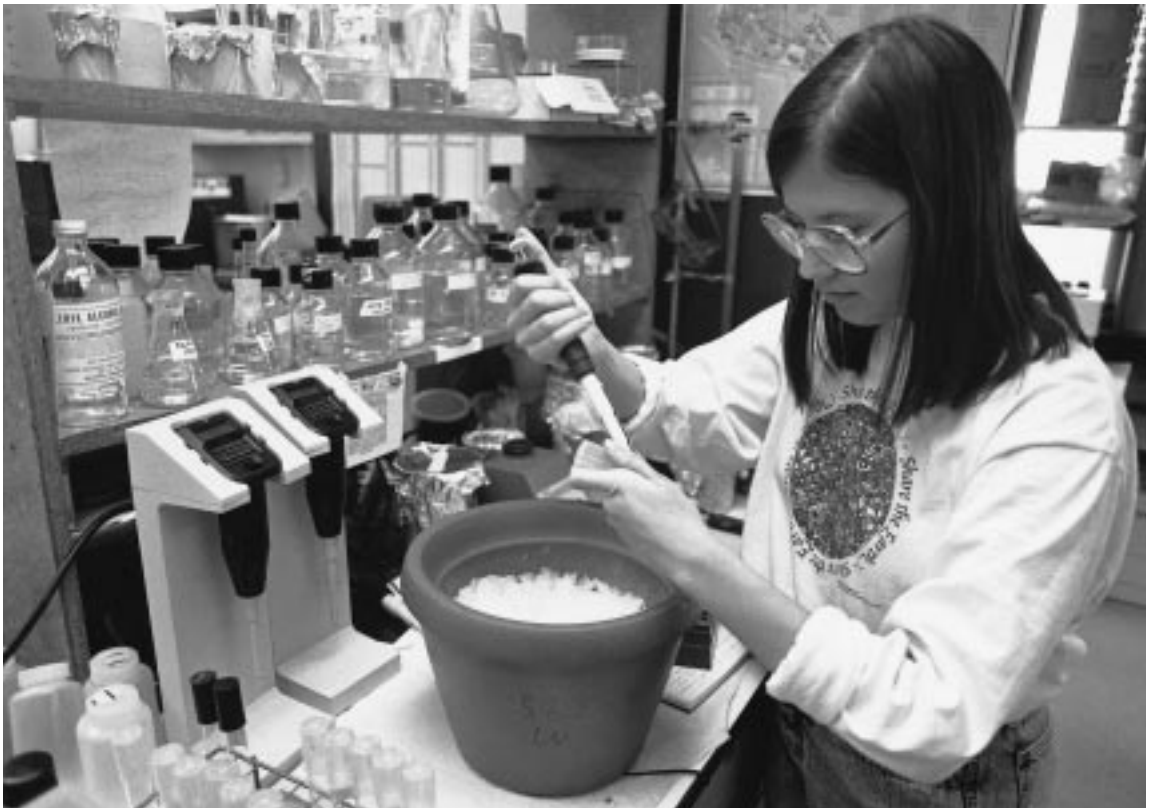
Math and science teachers deserve better professional development



JEFF MILLER

Science and mathematics teachers should experience for themselves the science and mathematics learning they will want their students to do.

Effective professional development is an essential part of helping teachers meet the challenges of teaching mathematics and science. Yet most current professional development programs are inadequate, say Susan Loucks-Horsley and colleagues at the National Institute for Science Education (NISE).

Many professional development programs are ill designed. They don't give teachers the knowledge and skills they need. Loucks-Horsley doesn't mince words: "Professional development that is confined to short, discrete events is usually a wasted effort. Professional development takes time. It requires teachers to be reflective about their practice."

Loucks-Horsley and the NISE Professional Development Team have accumulated and analyzed information about effective professional development practices, strategies, and structures for inservice staff development. The Team has developed case studies, synthe-

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From the Director

Shaping the reform of science education


JEFF MILLER

In this issue of *Highlights* we share more findings from the National Institute for Science Education, this time in the areas of professional development and the alignment of standards.

Few professional development programs give teachers the knowledge and skills they need to meet the challenges of teaching mathematics and science. Susan Loucks-Horsley and the NISE Professional Development Team have found that effective professional development happens in a community of learning. Just as students deepen their knowledge of science and mathematics through communication, their teachers learn through formulating, sharing, and challenging what they and their colleagues think they know.

Educators who recognize the need for major reform in K–12 mathematics and science curricula visualize ambitious content for all students. WCER researcher Norman Webb explains that significant reform must be based on the alignment of all components of an education system — curriculum, instruction, professional development, and assessments. All should work together to help students achieve higher levels of mathematical and scientific understanding.

School reform at the district and state levels has been of particular interest to WCER researchers Carolyn Kelley and Jean Protsik. As part of their work for the Consortium for Policy Research in Education, they studied Kentucky's Instructional Results Information System. Schools that successfully met student achievement goals in the state's accountability program had made considerable changes in curriculum and instruction.

You're invited to find out more about our research at the WCER web site *(www.wcer.wisc.edu)* and the NISE web site *(www.wcer.wisc.edu/nise)*.

Andy Porter

sized research, and assembled the experiences of seasoned professional developers to provide guidance about how mathematics and science teachers can best be assisted in their professional growth. The Team (including Peter Hewson, Nancy Love, and Kathy Stiles) recently published its findings in *Designing Professional Development for Teachers of Science and Mathematics* (Corwin Press, 1997). The book describes a framework for designing inservice professional development for K–12 science and mathematics teachers and includes descriptions and examples of 15 different professional development strategies, critical issues that all programs must address, and professional development programs that use the design framework for development and analysis.

"The national standards for science, mathematics, and professional development exhibit a strong knowledge base and a great deal of consensus about what constitutes effective professional development," the authors say. "Yet there's still a gap. There's a lack of rich description of effective programs that are constructed in various contexts and that address common challenges in unique ways. Nowhere is there accumulated the knowledge of effective professional development strategies and structures for teachers of mathematics and science. There's no guidance, in any one place, about how these teachers can best be assisted in their professional growth." *Designing Professional Development for Teachers of Science and Mathematics* aims to address these needs.

The authors insist that science and mathematics teachers need to experience for themselves the science and mathematics learning they will want their students to do. Learning about it in a vicarious manner is no substitute. Effective professional development happens in a community of learning. Just as students deepen their knowledge of science and mathematics through communication, so too do their teachers learn through formulating, sharing, and challenging what they and their colleagues think they know.

Professional development also must go beyond the needs of individual teachers to address entire school systems. "School systems can influence teaching in powerful ways," the authors say. "They have a key role in developing leadership in their teachers." Systemwide influence occurs directly, through the nature of professional development that's offered and, indirectly, through the structures and policies that help or hinder a teacher's efforts.

A framework for designing professional development

Successful professional development planners use distinct but related kinds of knowledge in their work: (a) what is known about learners and learning in general, (b) what is known about teachers and teaching, (c) the nature of the disciplines of mathematics and science, (d) the principles of effective professional development, and (e) knowledge of change and the change process.

Designers of effective professional development filter knowledge through their own contexts to arrive at the most appropriate approach for a given setting. This knowledge includes strategies, critical issues, and beliefs. "As professional developers learn from their experiences, they become active contributors," the authors say. "And as their

needs and interests change, they look to research for new ideas. Beliefs change, too." When professional developers see the effects of their work, they begin to think differently about students, teachers, their disciplines, professional development, and change. Experience leads designers to consider new issues or gain deeper understanding of the ones they have grappled with. "Professional development is recursive and sometimes messy," Loucks-Horsley says. "It demands flexibility and continuous learning throughout the process."

Critical issues in designing professional development

Effective professional development programs support subcultures in which professional development can flourish. The need to create subcultures for high-quality professional development is more than instrumental, the authors say; it has a deeper significance. "The nature of the reform that is embodied in the mathematics and science standards will require a large number of teachers to keep changing and learning," says Loucks-Horsley. "It also implies a different intellectual culture for schools than is typical. So schools need to build capacity not only for teachers to reflect on their own teaching, but for the culture of teaching and schooling itself to change."

Viewing reform as a cultural matter as well as an individual psychological one opens new avenues, says Loucks-Horsley. "If we created supportive subcultures in different parts of the system we would begin the process of cultural change. Researchers would then have the opportunity to study the nature of such cultures." Building capacity means initiating, developing, and supporting teacher subcultures at social and organizational levels that will complement efforts designed to build capacity at individual levels.

Public support for professional development is intimately related to public support for science and mathematics reform. Professional developers can garner public support for science and mathematics education reform and for teacher professional development. They can do so, the authors say, by paying attention to three areas:

- increasing awareness of the importance of effective teaching and learning of science and mathematics, as well as effective professional development—and what they look like;
- involving the public in learning situations (those of both students and teachers); and
- gathering and publicizing the results of teaching and professional development.

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Teachers are challenged to know their subjects more deeply and how to teach them to diverse learners.

The University of Washington's professional development project for elementary school teachers directly addressed the issue of garnering public support for science education.Teachers learned how to craft messages to address the questions and concerns of various audiences, for example, parents, principals, business executives, and city council members. They interacted with a panel representing these groups around the question, "What would motivate you to support science education?" They identified the common threads and the unique needs of the various groups.

For more information see *Designing Professional Development for Teachers of Science and Mathematics*, Corwin Press, 1997. The NISE Web site can be visited at *http://www.wcer.wisc.edu/nise.*

(Susan Loucks-Horsley is Team Leader for the NISE's Professional Development Team; Director of Outreach and Professional Development for the National Research Council's Center for Science, Mathematics, and Engineering Education, and a Program Director at WestEd, Tucson, AZ.)

Kentucky's school reform efforts bear fruit

A state-level accountability program can lead to significant improvement in school performance, according to recent studies by UW–Madison Education Professor Carolyn Kelley. She found that Kentucky schools successfully meeting student achievement goals in the state's school-based performance award program did so by making considerable changes in curriculum and instruction.

JEFF MILLER

A combination of rewards, sanctions, and developmental interventions seems to address barriers to successful organizational change.

Carolyn Kelley

Kelley found distinct differences between award-winning schools and non-award-winning schools in the Kentucky Accountability Program. She studied 16 schools, selected to represent elementary, middle, and high schools in various geographic regions and reaching various levels of success in their accountability goals (see sidebar).

Funding for the study was provided by the Pew Charitable Trusts and the U.S. Department of Education, Office of Educational Research and Improvement.

The Kentucky accountability program aims to produce school-level improvements in student performance on the state's authentic assessment instrument, the Kentucky Instructional Results Information System (KIRIS). Both the accountability program and the assessment instrument were created in 1990 as part of Kentucky's state education reforms.

The accountability program combines KIRIS results at the individual student and school levels with measures based on student attendance, dropout and retention rates, and transition to adult life.

Strategies for meeting accountability goals

Studying the 16 schools, Kelley wanted to determine what differentiated the award-winning schools from the non-award-winning ones, and how some schools that had received a poor score the first year changed to perform as successful schools the next year. Kelley found that the most successful schools:

- aligned curriculum with the assessment instrument;
- incorporated writing and other test-taking skills into the regular curriculum; and
- focused high-quality professional development activities on gaps in teacher knowledge and skills.

Principal leadership and a focus on achieving rewards were critical factors in achieving reward status, except in the highest achieving schools. In these schools exceptionally skilled and professionally connected teaching staffs worked with principals to focus the curriculum and instructional program. The schools receiving rewards in both the first and second cycles all had extraordinarily skilled teaching staffs and were professionally "in the loop." They had direct contacts with the state's accountability program through professional ties and as current or past members of state committees. As a result, these schools were more likely than others to know how to use and interpret the considerable amount of information the state issued as a guide to help schools improve practice.

They used draft curriculum guides and analyzed test results from previous assessments to modify their curriculum to address weak areas.

Although principal leadership was not a major characteristic of the schools receiving awards in both years, it was an important characteristic of other successful schools. One explanation for this, Kelley says, is that the schools receiving awards both years had such strong teaching staffs that the principal could function as a facilitator rather than as a director.

The low success schools lacked the characteristics and strategies of high success schools. For example, the elementary school in reward status the first year but in decline the next did not incorporate KIRIS goals into its curriculum program. Teacher leaders in this school made no attempt to modify curriculum and instruction to KIRIS goals. The principal was more a nurturing figure than a strong instructional leader and chose not to exercise leadership to overcome teacher preferences for more traditional curriculum and instructional approaches.

The reward/decline middle school had a stronger professional culture, but had several major educational reform initiatives underway that competed with KIRIS and absorbed the attention of teachers in the school.

Some poorly performing schools were able to achieve reward status in the second cycle. They did so by implementing an accountability program with a strong developmental intervention. Schools identified as in decline received financial resources and were assigned a Distinguished Educator who provided developmental guidance. The combination of rewards, sanctions, and developmental interventions seems to provide a powerful package that has the potential to address organizational and individual barriers to successful organizational change, Kelley says.

What motivated teachers

In 1993–94 the maximum cash bonus paid to teachers in reward schools was $2,600 per teacher, with the minimum award set at $1,300. For most teachers in reward schools, the cash bonus was a nice acknowledgment of work well done, but not an incentive that drove their behavior. At the same time, the cash award has an important indirect effect on motivation, given the level of attention to the accountability program and the level of attention paid to achieving reward status. The bonus seemed to provide an important signal to teachers, principals, district administrators, and the public about what educational goals the accountability program valued. (Kentucky spent $26 million to $27 million in each of the two award cycles to pay for bonus awards. In 1997 the Kentucky Education Association decided to oppose the funding of bonus awards and to recommend funneling that money into professional development activities.)

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The success of elementary schools was generally due to the smaller structure, the cross-disciplinary nature, and teachers' willingness to try new things.

Teachers were also motivated to avoid sanctions for their schools (having to submit a transformation plan to the state and being assigned a Distinguished Educator) because of the resulting

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"Reward" schools exceed their accountability targets and receive a pool of reward funds that are distributed to teachers for any purpose, including salary bonuses.

"Successful" schools meet their target but receive neither bonuses nor sanctions.

"Improving" schools improve over their baseline but fail to reach the target. They must submit a transformation plan to the state, detailing how they will meet their achievement goal in the future.

"Decline" schools drop below their baseline. They are assigned a Distinguished Educator and some improvement funds and must submit a transformation plan.

"Crisis" schools drop more than five points below baseline. They are assigned a Distinguished Educator who is given broad powers to terminate teachers and override school site council decisions if necessary.

Alignment critical to successful reform

Just as a schooner's speed increases when its sails are set properly, alignment among the policy elements of an education system will strengthen that system and improve what the system is able to attain.

Norman Webb, a senior researcher with the National Institute for Science Education, uses this image to illustrate the importance of aligning the elements of systemic reform in mathematics and science education.

Among the states and school districts trying to boost student achievement in mathematics and science, some are seeking deep, lasting changes in how students learn these critical subjects. Improved student learning will be easier to attain if expectations and assessments are in agreement. Webb's work aims to help educators think more clearly about the concept of alignment and to examine what it means for expectations and assessments to be in agreement. "The major elements of the education system must work together to help students achieve at higher levels of mathematical and scientific understanding," Webb says. "If instruction and assessment are not aligned, the education system will be fragmented and ineffective." Alignment, or agreement, needs to occur across criteria and across grade levels.

Norman Webb

Agreement across criteria

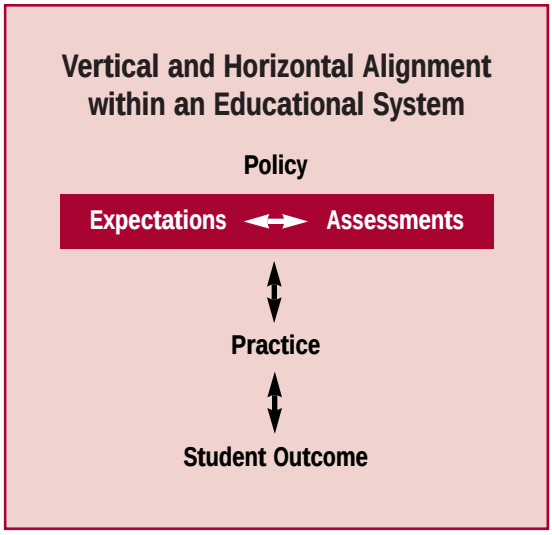
When educators look at alignment between expectations and assessments of student achievement, assessments should agree with expectations (i.e., content standards and curriculum frameworks) in their focus on developing students' knowledge of mathematics and science. Specifically, expectations and assessments should share the following attributes:

- The same *categories* of content should appear in expectations and assessment. For example, for an assessment to agree with the *National Science Education Standards*, its content topics would include science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and social perspectives, and the history and nature of science.
- Expectations and assessments should require students to know the same *level* of information, to be able to transfer this knowledge to different contexts, and to have the same prerequisite knowledge.
- Expectations and assessments should cover a comparable span of topics and ideas within categories.
- Expectations and assessments should agree on the underlying concepts of science and mathematics, and what it means to "know" these concepts.
- Expectations and assessments should give similar highlight to content topics, instructional activities, and tasks.
- When expectations include more than learning concepts, procedures, and their applications, such as molding student attitudes and beliefs about science and mathematics, assessments also should support that broader vision.

As students mature, their knowledge of mathematics and science grows. For expectations and assessments to be aligned, Webb says, they should agree on how students develop and how best to help them learn at different developmental stages. In addition, expectations and assessments should agree on the underlying concepts of mathematics and science and what it means to "know" these concepts. Aligned expectations and assessments describe and represent, in complementary fashion, how students link concepts and how their instructional experiences should be organized.

Equity and fairness

Expectations and assessments should demand equally high learning standards for all students, while providing fair means for all students to demonstrate the expected level of learning. Expectations and assessments will be better aligned and more equitable if multiple forms of assessment are used. Why? Because students' ability to perform well on an assessment can depend on a number of factors in addition to their knowledge. These factors include students' culture, social background, and experiences. "The challenge," Webb says, "is to develop and maintain an aligned system with a



variety of means of assessment that function together to reflect accurately what students know and can do."

For the near future, Webb says, it may be difficult to gauge the alignment of expectations and assessments on equity and fairness. Consistently low scores on an assessment of a particular learning goal may be the result of many factors, including misplaced expectations, rather than poor instruction or students' lack of effort. Students may be developmentally unprepared to attain a particular expectation without previous experiences, for example.

Implications for teaching

Expectations and assessments should send consistent messages to teachers about appropriate teaching and should strongly affect classroom practices. Judging the alignment of expectations and assessments therefore requires considering the likely implications for classroom practice. Meaningful analyses have been done, for example, by asking teachers how they interpret expectations and assessments and how their classroom practices fit with them.

The true benefit of alignment, Webb says, is what happens in the classroom. Educators are now paying increased attention to the importance of involving students in scientific inquiry, hands-on learning, and "authentic" instruction. Assessments that reflect a passive type of instruction would be less aligned with those expectations. Likewise, expectations that students should perform scientific inquiry through actively constructing ideas and explanations will lack full alignment with assessments that test only whether students have memorized canonical ideas and explanations. Such instances of lack of alignment may result in less positive influences upon classroom instruction.

Although expectations and assessments should seek to encourage high student performance, they also need to form the basis for a program that is realistic and manageable. Local policy elements must be in a form that teachers and administrators can use in a day-to-day setting. Also, the public must feel that these elements are credible and that they are aimed at getting students to learn important and useful mathematics and science content.

Reviewing alignment

When using these criteria to judge the alignment of a system's expectations and assessments, one needs to maintain a sense of reality, Webb says. The available resources, the amount of time available, legislative mandates, and other factors will influence how well alignment can be realized.

In approaching reform, Webb says, the consideration of alignment cannot come too soon. And just as educators need to ensure alignment from the very beginning of a reform initiative, they also should review the alignment among major policy elements as new policies are instituted, new administrative rules are imposed, and system needs are changed.

Just as that schooner needs constant attention to be sure that it's making the best use of the available wind, education systems require continuing review and adjusting to make sure all policy elements work together to enhance student achievement.

For more information see Webb, Norman L., *Criteria for Alignment of Frameworks, Standards and Student Assessments for Mathematics and Science Education,* a joint publication of the National Institute for Science Education and the Council of Chief State School Officers. For more information, visit the NISE Web site at *http://www.wcer.wisc.edu/nise.*

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negative publicity. This motivation was particularly strong in rural areas, where school news dominates newspaper coverage. A few teachers and principals also said they were motivated by fears of losing professional autonomy or job security. But many were motivated by professional pride; they wanted positive public recognition and they wanted to see their students achieve.

Kelley found that elementary schools were significantly more successful in achieving reward status than were middle and high schools. In the first accountability cycle, most of the reward winners were elementary schools, followed by middle and then high schools. In the second cycle, most of the reward winners were again elementary schools, followed by high schools and then middle schools. "In general," says Kelley, "the success of elementary schools was due to the smaller organizational structure, the cross-disciplinary nature, and teachers' greater malleability and willingness to try new things."

Implications

The Kentucky Accountability Program created a crisis or galvanizing event that research suggests is needed for meaningful organizational change to occur, Kelley says. Her research provides important information on the responses of teachers and schools to the accountability program. The program provided teachers with clear, specific, and challenging goals to strive for and enabled them to focus curriculum and instruction on these goals rather than any of the other myriad possible goals. The program outcomes that provided a meaningful incentive for teachers included fear of negative publicity, a desire for positive public recognition growing out of a sense of professional pride, intrinsic rewards associated with seeing students achieve and, for a smaller proportion of teachers, a fear of loss of professional autonomy from having a Distinguished Educator assigned, and a fear of job loss.

Several other studies of various aspects of Kentucky education reforms provide support to suggest that the findings here may be generalizable within Kentucky.

For more information contact Kelley at kelley@mail.soemadison.wisc.edu or visit the CPRE web site at *http://www.wcer.wisc.edu/cpre.*

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