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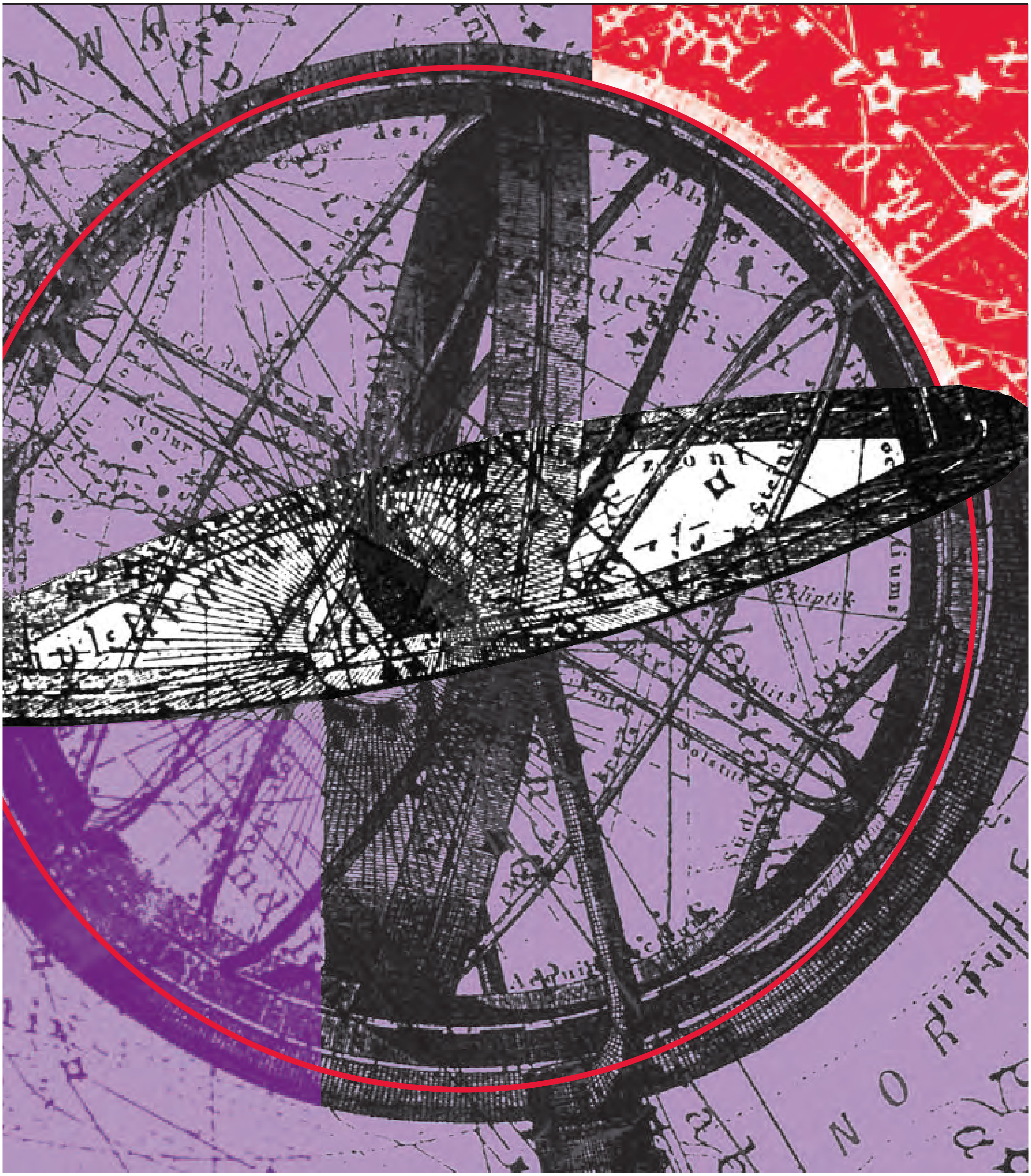

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When "One Shot" Is All You've Got:
Bringing Quality Professional Development to Rural Mathematics Teachers

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ABSTRACT:
Criteria for "powerful" professional development in mathematics have been well documented by researchers and organizations. Unfortunately, barriers of distance, time, and expense impede rural teachers from attending conferences, workshops, and college courses built on these recommendations. This paper proposes a professional development model that has successfully addressed these criteria, resulting in change in teacher knowledge, skill, and practice, with positive results for student learning. In particular, the model is analyzed against five curricular and structural criteria identified by research as essential for effective professional development: a focus on ***content knowledge****, the use of* ***active learning*** *strategies,* ***coherence*** *with other learning experiences, sufficient* ***duration*** *of the experience, and* ***collective participation*** *by teachers.*

The defining characteristics of "ideal" or "powerful" professional development in mathematics and science have been well-documented by researchers and organizations who publish recommendations for high-quality professional development (Easton, 2005; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Schwan Smith, 2001). These characteristics have in some cases been identified through repeated experience and hands-on expertise, while others arise from research efforts ranging from case studies to meta-analyses of dozens of programs. Often, an underlying goal of these recommendations is the establishment of an embedded culture of professional development based on the individual school climate; enacting this culture frequently depends on ongoing collaboration among teacher groups (Easton, 2005).

In an urban or suburban school district, it is possible to embed professional development if teachers, administrators, and professional development designers and facilitators commit to creating and following through on appropriate experiences. But what if the district in question includes only one school? What if that school employs only one or two secondary mathematics teachers? What if the nearest colleague of similar discipline and grade level is fifty miles away, as is the case in many rural schools? Ensuring collective participation and ongoing collaboration among teachers within a content area becomes not merely challenging, but nearly impossible. The questions posed above suggest the need for an alternative model that incorporates the key characteristics of effective professional development while respecting the limitations and restrictions imposed by rural realities. This paper proposes a professional development model that has successfully addressed these characteristics, resulting in change in teacher knowledge, skill, and practice, with positive results for student learning.

In 1999, reviewers for the National Research Council called for research to "determine the efficacy of various types of professional development activities, including pre-service and in-service seminars, workshops, and summer institutes....[in] order to identify the processes and mechanisms that contribute to the development of teachers' learning communities" (Bransford, Brown, & Cocking, 1999, p. 240). In response, Garet, Porter, Desimone, Birman, and Yoon (2001) conducted a large-scale study of over 1,000 teacher participants in Eisenhower-funded professional development programs. Five characteristics of professional development emerged that have "significant positive effects on teachers' self-reported increases in knowledge and skills and changes in classroom practice" (p. 916).

The first three characteristics, related to the professional development curriculum, include a focus on *content knowledge*, the use of *active learning* strategies, and *coherence* with other learning experiences. In addition, the researchers identified key structural aspects that contribute to the success of professional development activities. These include the *duration* of the activity (in terms of both contact hours and span over time) as well as the "*collective participation* of groups of teachers from the same school, department, or grade level, as opposed to the participation of individual teachers from many schools" (Garet et al., 2001, p. 920).

Rural Realities

Loucks-Horsley et al. (1998) consider "equal access for all teachers to quality professional development" (p. 192) to be a critical issue. They note that equity in professional development is not merely about offering equal access to opportunities; equity also encompasses the design and content of professional development experiences. High-quality professional development ensures that all teachers are fully engaged and learning and that ultimately they will be able to provide the same experiences for their students.

Unfortunately, district-wide staff development with a content focus is unrealistic in a small rural district where an entire content discipline at several grade levels may be covered by one teacher. The lone mathematics teacher may find support within her/his own building or district for everyday matters involving students, parents, classroom management, and general instructional practices. But guidance in the tasks of a mathematics educator—locating and designing worthwhile mathematical tasks, orchestrating meaningful discourse, analyzing students' mathematical thinking, and using tools and alternative methods to present concepts (National Council of Teachers of Mathematics, 1991)—is more difficult to find.

Seeking out such guidance and accessing outside resources presents another challenge. Barriers of distance, time, and expense impede rural teachers from attending conferences, workshops, and college courses offered in more populated areas. Furthermore, whereas new ideas and practices adopted by teachers in larger districts tend to "trickle down" into the awareness of their colleagues through casual conversation or formal dissemination, there is no such potential for the lone rural teacher.

Colorado is a prime example of a state caught in a rural-urban tension. Based on 2000 census estimates, nearly 80% of the state's population of more than four million resides in the counties that include the Denver metro area and the satellite cities stretching from Fort Collins to Pueblo. The remaining 20% are spread across vast reaches of mountains, prairies, and near-desert terrain. The urban center of Colorado offers multiple opportunities for teachers to increase their mathematics content knowledge, experience new instructional and assessment strategies, and learn how to implement new curricula. However, teachers in rural regions can rarely afford the time or expense of participating in site-based urban opportunities.

Professional development in Colorado became a critical issue in the late 1990s as the state formally implemented a new testing and accountability system based on recently revised standards. Along with defining a body of required content knowledge, the Colorado State Assessment Program (CSAP) called for assessment of students' mathematics knowledge through open-ended problems and performance tasks. Teachers across the state became concerned about teaching appropriate content and emphasizing reasoning, problem solving, and communication. In order for new standards to make a difference, they must be accompanied by professional development that focuses on procedures for implementing standards (Guskey, 2005). The inception of the CSAP served as a powerful impetus to develop and deliver professional development built around the new standards and assessment criteria.

The five largest universities in Colorado are all located in the highly populated north-south corridor bracketing Denver. Given that the majority of the teacher population is located within commuting distance, outreach to rural communities has not been a primary focus of those institutions. Mathematics educators at the University of Northern Colorado in Greeley (UNC) were concerned about including rural mathematics teachers in the reform efforts sweeping the state. UNC had previously experienced success in working at a distance with rural mathematics teachers in northeastern Colorado. As an experiment, two faculty members (the author and a colleague) determined to improve upon those efforts by bringing on-site professional development to teachers in the mountain and mesa communities of western Colorado. The result was the Western Slope Project (WSP), a two-year program for rural mathematics teachers designed to enhance their content knowledge, improve their ability to recognize and integrate mathematical processes, and provide them with alternative assessment strategies. Supported by higher education Eisenhower funds, the project ultimately sought to improve students' learning experiences and prepare them for success on the CSAP exam.

A Professional Development Model for Rural Mathematics Teachers

As an intervention directed specifically at rural mathematics teachers, the Western Slope Project (WSP) was challenged to creatively incorporate research-identified criteria of high-quality professional development in a setting that resists implementation of those criteria. On a more practical note, the first design challenge was to find a way to assemble a group of isolated teachers whose districts spanned half the state of Colorado. Our solution was to bring the program to the teachers. Rather than housing WSP at the University of Northern Colorado, we collaborated with the privately operated Colorado Mountain College system to provide dormitory rooms, meals, and classroom and computer lab space at its Leadville and Glenwood Springs campuses, both in rural western Colorado and over 150 miles from our home campus.

At those locations and with the assistance of Colorado Mountain College staff, we offered credit-earning courses during a two-week summer institute and two academic year workshops. Many professional development experiences have been similarly structured; the Western Slope Project was unique in the demographics of our audience and the framework we created to address their needs, maximize their engagement, and embed accountability into their experience. One of the critical issues in designing professional development is the need to "recognize, study, and apply the knowledge base of professional development theory and practice" (Loucks-Horsley et al., 1998, p. 206). The following discussion matches key components of the Western Slope Project against the criteria for effective professional development identified through research by Garet et al. (2001) and describes the means by which we adapted these general recommendations to a rural context.

CRITERION 1: CONTENT KNOWLEDGE

Research has consistently confirmed the importance of a content focus in effective professional development (Cohen & Hill, 1998; Garet et al., 2001; Kennedy, 1998). This finding is reflected in the professional development standards of national organizations. Cohen and Hill (1998) promote the use of curricular materials in professional development experiences as one way to directly affect teacher content knowledge and enhance student learning. Such efforts also enhance teachers' pedagogical content knowledge, or "knowledge about how students learn subject matter knowledge" (Kennedy, 1999, p. 4). Furthermore, Kennedy claims that "programs that focus on subject matter knowledge and on student learning of particular subject matter knowledge are likely to have larger positive benefits for student learning" (1999, p. 4).

Western Slope curriculum planning began with a needs assessment conducted with rural mathematics teachers in the target region, comprised of thirty-nine rural districts in western and southwestern Colorado. District superintendents and directors of rural BOCES (Boards of Cooperative Educational Services), sensitive to the limited professional development available locally for their mathematics teachers, enthusiastically supported our data collection efforts. As expected, concerns about imminent changes in state-mandated mathematics testing brought assessment to the top of the needs list. Other areas of need included appropriate use of technology; mathematical process skills (problem solving, reasoning, modeling/representation, and mathematical connections); geometry and spatial reasoning; and data analysis, statistics, and probability.

Experienced teachers (two middle school, two high school) from the Western Slope region were consulted to help convert the broad spectrum of identified needs into a manageable format. The program eventually emerged as a one-year professional development cycle launched by an intensive two-week summer institute designed to improve areas of weakness in content knowledge. Week One focused on statistics and probability, embedding the use of TI-83 calculators as a tool for data collection, analysis, and interpretation. In Week Two, a study of geometry and extensive use of Geometer's Sketchpad® software provided the context for developing problem solving skills and incorporating other mathematical processes into instruction. Performance assessment was also featured daily.

CRITERION 2: ACTIVE LEARNING

Teachers' classroom practice tends to reflect their own experiences as students; therefore, professional development needs to provide "the opportunity to experience firsthand a form of teaching that facilitates and supports learning" (Schwan-Smith, 2001, p. 43). This includes "posing worthwhile tasks, engaging teachers in discourse…and expecting and encouraging teachers to take intellectual risks" (NCTM, 1991, p. 127). Loucks-Horsley (1998) refers to "immersion in inquiry" as a means for teachers to "broaden their own understanding and knowledge of the content" and to be "better prepared to implement the practices in their classrooms" (p. 49), and Clarke (1994) considers it a basic principle of professional development that mathematics teachers experience model teaching strategies as active classroom participants.

The Western Slope summer institute modeled content delivery based on active learning and constructivist principles. Teachers worked in pairs and in groups on activities that called for the collection and interpretation of data, problem solving, and reasoning about geometry. Calculator and computer technology played a significant role throughout the two weeks. Many activities were drawn from modules in standards-based curricula (*Interactive Mathematics Program®* and *Connected Mathematics™*), allowing teachers to experience new approaches to teaching and to explore mathematical concepts through active learning as their own students might. They replicated these experiences in their classrooms and reported in their journals such successes as using software to teach lessons, changing questioning strategies to a more open-ended, probing style, and developing assessments in which their students had to explain their solutions in writing.

CRITERION 3: COHERENCE AND CONTEXT

Garet et al. (2001) identified three aspects of coherence: how new knowledge builds on previous knowledge; alignment of content and pedagogy with standards; and support for sustained, ongoing communication with like-minded colleagues. The National Resource Council observes that teachers bring "varying degrees of experience, professional expertise, and proficiency" to the table (1996, p. 70). In the context of rural professional development, each teacher also brings an entirely different school experience. Designers of effective professional development try to acknowledge the existing beliefs and practices of participants (Richardson, 2003) and take teachers' contexts into account (Schwan Smith, 2001). Consideration of school context, including availability of instructional resources, district and state mandates, and school structure, is essential in designing meaningful experiences for teachers (Loucks-Horsley et al., 1998).

Western Slope teachers were challenged to link new ideas to old as they were confronted with new approaches to teaching and learning content during the summer institute. During the institute, teachers matched the content they were learning to state content standards and experienced how content can be introduced through activities that incorporate mathematical processes and different ways of thinking. During Week Two, aligning standards and assessment became the unifying theme as teachers became familiar with alternate ways to assess students' conceptual understanding through the use of performance tasks and open-ended problems. Teachers carried this knowledge into the classroom and reported on efforts to implement it:

> "Designing a performance assessment forces me to use the standards as a guide. Hopefully, this helps students meet the standards in a hands-on applied setting… Designing a performance assessment with a rubric was challenging for me. I wanted to make sure I was measuring the right things… It's challenging to ask questions that foster problem solving, and it's difficult for students to justify solutions to problems."

Creating a climate of sustained, ongoing communication after the summer institute proved to be a challenge. The limited availability of technology in some rural schools made us wary of depending on Web-based communication. Likewise, expecting teachers from more than a dozen different schools to collaborate on projects outside of the summer institute seemed unfeasible. Instead, participants created individual action plans for the academic year, and made a commitment to carry out and report on their activities. Teachers kept journals and submitted samples of student work, and each cadre met twice during the academic year to report on their action plans and share progress. As another measure, all participants were required to share Western Slope assessment materials with one district or regional colleague and to mentor one less experienced teacher in their schools or districts. These "second tier" teachers reported that mentoring by Western Slope participants helped them in areas of content, assessment, and technology. One wrote: "My mentor provided much needed information on CSAP-type questions, which is lacking in our Saxon textbooks. Also, her enthusiasm about your program and about teaching math based on standards has been inspiring!"

CRITERION 4: DURATION

Teacher growth requires time, and effective professional development must be of sufficient duration, both in terms of total contact hours and the length of time spanning those hours. In a report to the Glenn Commission, Susan Loucks-Horsley advocated for a process that is "continuous and sustained over time" with "adequate amount of time for teachers to learn and make meaningful changes in their practices" (Kimmelman, 2003, p. 2). She further noted that up to 100 hours of contact is desirable for a high-quality experience. In a review of 93 studies of professional development effectiveness, Kennedy (1999) observed that total contact hours appeared to be unrelated to student benefits, while distribution of time did appear to matter. In general, however, researchers agree that sustained and extended experiences are most effective (Garet et al., 2001; Richardson, 2003; Sparks, 2002).

Building in sufficient contact hours was not a problem for the Western Slope Project. Our choice to host the summer institutes in-residence at small, local campuses rather than through classes offered at the University of Northern Colorado allowed us to make maximum use of time. Besides meeting formally for eight hours each day, the Western Slope teachers spent two weeks establishing lasting professional and personal relationships through shared meals, recreational activities, and organized social events.

Professional development that continues over time requires a new model for rural teachers from far-flung rural schools who cannot be expected to meet together regularly. To compensate, WSP built in assignments with academic year follow-up to keep participants focused on the project goals. Teachers were asked to design an enrichment unit or series of activities to be integrated into an existing course. The activities and their assessments had to incorporate problem solving, statistics, and/or geometry and align with Colorado and NCTM standards. At an October face-to-face meeting, teachers presented their action plans for implementing new technology, teaching problem solving skills, and/or introducing new statistics and geometry concepts in their classrooms. As a group, they also selected a set of performance assessment tasks to administer and score for later comparison. In April, they reconvened to analyze their students' work on those tasks and to report progress on their action plans.

The academic year sessions also provided a forum for teachers to share classroom "success stories." Most evident among the teachers' self-reports were a significant increase in problem solving activities, greater emphasis on written responses and explanations from students, better understanding of statistics concepts, and instructional use of Geometer's Sketchpad®. One teacher shared that he was teaching more statistical analysis and problem solving, adding "I've become well versed on State Standard #3! I feel more confident!" Another came to the summer institute with a goal "to start using the *Connected Mathematics*™ series with my 8th graders." WSP gave him confidence to try a standards-based unit in his regular curriculum. By spring, he had used several *Connected Mathematics*™ modules in 7th and 8th grade. He later reported that his students did exceptionally well on the CSAP exam. "I have used the knowledge I've learned about performance assessment and scoring to set up the tests I've given… Because of this, I'm more aware of the way that I am teaching—so that I teach in a way to help them be successful on the assessment."

CRITERION 5: COLLECTIVE PARTICIPATION AND COMMUNITY OF LEARNERS

Collaboration among teacher learners has been found to positively affect teacher outcomes (Garet et al., 2001; WestEd, 2000), and is accordingly given high priority in nationally recognized professional development guidelines and standards (Loucks-Horsley et al., 1998; National Research Council, 1996; National Staff Development Council, 2001; Schwan Smith, 2001). Schwan Smith (2001) cites research suggesting that participation in "communities of collaborative practice where teachers are able to work with colleagues toward shared goals" provides valuable support to teachers in terms of their own practice (p. 45). The issues of collaboration and community building have also received significant attention in the distance learning literature (Berge & Mrozowski, 2001).

Teachers in the Western Slope Project experienced a two-week immersion not only in worthwhile mathematics and high-quality instruction, but also in the company of like-minded professionals. The context of preparing students to succeed on the standards-based state assessment provided a shared goal. Participants from some small districts expressed excitement about their first-ever collegial experience with other mathematics teachers, even though they came from different schools. Two weeks of working together, eating together, living together, and sharing leisure activities established a professional learning community in a way no summer course on a university campus ever could. Permanent relationships were forged—in fact, one couple became engaged in the year after they met through the Western Slope Project!

Results

The Western Slope Project directly served 37 secondary mathematics teachers from rural western Colorado (18 in the first cadre, 19 in the second), while other teachers were reached indirectly through the mentoring component. Most of the participants worked in communities of less than 5,000. More than half of them were responsible for teaching the entire mathematics curriculum for grades 9-12. Roughly one-fourth were in their first or second year of teaching.

A substantial body of data collected over the two-year life of the project documents success in increasing the participants' content knowledge, influencing their classroom practice, and improving their ability to assess achievement of standards.

Quantitative data were drawn from pre- and post-tests based on content learned during the summer institute and from pre- and post-surveys of perceived preparedness to teach mathematics. The content test consisted of ten multiple-choice items on statistics and probability and ten open-ended items on geometry and problem solving, compiled from text sources and released assessment items. Open-ended problems were scored using a rubric (1.0 = meets expectations, 0.5 = partially proficient, 0 = unsatisfactory or blank); multiple choice problems were worth one point. Mean scores for the 35 participants who completed both pre- and post-tests increased from 5.64 to 7.70 for the data/probability portion, and from 5.76 to 7.79 for the open-ended portion. The pre- and post-tests revealed significant gains in the form of large and medium effect sizes for statistics/probability, geometry, and the use of technology.

The preparedness survey was adapted from a 1999 teacher enhancement instrument designed by Horizon Research, Inc. Using a Likert scale, teachers were asked to rank their preparedness level along ten dimensions of pedagogy relevant to mathematics. Calculation of effect sizes on subscales of the survey revealed the largest gains in teachers' preparedness to develop their students' problem solving skills.

Qualitative data included journal entries submitted by participants throughout the academic year as well as self-reports and feedback forms indicating changes in practice and observed effects on student behavior and performance. Analysis of the textual data indicates that teachers applied their newly obtained content knowledge and skills, made substantial changes in classroom practice, and witnessed improvements in their students' conceptual understanding and ability to communicate ideas. Self-reports from 29 of the teachers indicated that all but one had transformed knowledge gained from the Western Slope Project into classroom practice. Significant practices included teaching problem solving processes and skills, using technology more effectively, and actively preparing students for the constructed-response items on the CSAP (e.g., assigning open-ended problems, scoring with rubrics, and asking students to explain their thinking).

Conclusion

Although obstacles still exist, it is possible to design "powerful" professional development for isolated rural teachers. The key characteristics of effective programs can be adapted for the unique context of rural mathematics teaching, with positive results for classrooms and students. The outcomes are further enhanced when teachers who work as individuals in their profession, but share similar contexts and experiences, are brought together in an immersion experience that allows them to share stories, learn from each other, and form professional bonds. The Western Slope Project motivated many teachers to make substantive changes in their classroom practice, with documented effects on student learning:

- "I am making a special attempt to incorporate technology, which I haven't done in the past. I am also having my kids practice for the CSAP, and they are assessing each others' work; this way they'll have an idea how they will be graded."

- "It has made a difference in the way I teach and assess students. Lessons are more activity-oriented and students are more interested and engaged."

- "I have been focusing on students constructing their own understanding. I have been using problem solving daily and working on my questioning techniques and requiring…written explanations/responses that explain their strategies or 'why.'"

- "I have implemented the problem solving strategies …with much success. The students are writing in words the strategies and steps used to solve certain problems."

The Western Slope model bears replicating, and indeed is now being implemented in a Montana Mathematics and Science Partnership project funded by the U.S.

Department of Education. Similar in structure but of larger scope, the COMET Project serves 70 teachers from across the state, roughly two-thirds from distinctly rural communities. Three grade band groups (K-5, 6-8, and 9-12) attended a two-week residential summer institute in 2005. Following the Western Slope model, teachers set goals and wrote action plans for the following academic year, and attended two academic year workshops. In an extension of the model beyond teaching mathematics content and modeling appropriate pedagogical approaches, COMET is also educating participants about how to use self-assessment and reflection to improve instruction. Teachers were introduced to a set of observation instruments at the summer institute and are expected to videotape and assess their own teaching throughout the year; some of these tapes will later be shared and analyzed with other participants. Reflection will be the centerpiece of another week-long summer institute in 2006, along with continued expansion of content knowledge. The Montana project has shown great promise in its first several months. We encourage others to adapt and report on similar models for rural professional development.

References

Berge, Z. & Mrozowski, S. (2001). Review of research in distance education, 1990 to 1999. *The American Journal of Distance Education*, 15(3), 5-19.

Bransford, J.D., Brown, A.L., & Cocking, R.R. (Eds.) (1999). *How people learn: Brain, mind, experience, and school.* Washington, D.C.: National Academies Press.

Clarke, D. (1994). Ten key principles for research for the professional development of mathematics teachers. In D.B. Aichele & A.F. Coxford (Eds.), *Professional development for teachers of mathematics: 1994 yearbook* (pp. 37-48). Reston, VA: National Council of Teachers of Mathematics.

Cohen, D. K. & Hill, H. C. (1998, January). Instructional policy and classroom performance: The mathematics reform in California [Electronic version]. *Policy Briefs, RB-23*. Philadelphia: Consortium for Policy Research in Education.

Easton, L.B. (2004). Power plays: proven methods of professional learning pack a force. *Journal of Staff Development*, 26(2), 54-57.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Education Research Journal*, 38, 915-945.

Guskey, T.R. (2005). Five key concepts kick off the process: Professional development provides the power to implement standards. *Journal of Staff Development* (26)1, 36-40.

Kennedy, M. M. (1999, November). Form and substance in mathematics and science professional development [Electronic version]. *NISE Brief, 3(2)*.

Kennedy, M.M. (1998). *Form and substance in in-service teacher education.* (Research monograph No. 13). Arlington, VA: National Science Foundation.

Kimmelman, P. (n.d.) *The Glenn Commission and professional development.* Retrieved January 21, 2003 from http://www.enc.org/focus/pd/document.shtm?input=FOC-002605-index

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., Hewson, P. W. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

National Council of Teachers of Mathematics (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Research Council (1996). *National science education standards.* Washington, D.C.: National Academy Press.

National Staff Development Council (2001). *NSDC standards for staff development.* Retrieved January 15, 2002, from http://www.nsdc.org/library/standards2001.html

Richardson, V. (2003). The dilemmas of professional development [Electronic version]. *Phi Delta Kappan, 84,* 401-406.

Schwan Smith, M. (2001). *Practice-based professional development for teachers of mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Sparks, D. (2002). Designing Powerful Professional Development for Teachers and Principals. Oxford, OH: National Staff Development Council

WestEd (2000). *Teachers who learn, kids who achieve: A look at schools with model professional development* [Electronic version]. San Francisco: Author.