DOCUMENT RESUME

ED 365 481 RC 019 423

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TITLE	Riding the Wind. Rural Leadership in Science and Mathematics Education.
INSTITUTION	Northwest Regional Educational Lab., Portland, Oreg.
SPONS AGENCY	Department of Education, Washington, DC.
PUB DATE	93
CONTRACT	R168D00183-92
NOTE	70p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Educational Innovation; Elementary Secondary Education; Higher Education; *Master Teachers; *Mathematics Education; Mathematics Teachers; Outdoor Education; Preservice Teacher Education; Rural Education; *Rural Schools; *Science Education; Science Teachers; *Small Schools; Student Teaching; Teacher Recruitment; Teaching Experience
IDENTIFIERS	*Teacher Initiated Activities; United States (Northwest)

ABSTRACT

This report tells the stories of 44 rural science and mathematics teachers who have been initiating and leading change in their classrooms and communities. Each has participated in the Science and Mathematics Academies for Rural Teachers (SMART), which: (1) recognizes and rewards outstanding science and mathematics teachers in small rural schools in Alaska, Idaho, Montana, Oregon, and Washington; (2) promotes exemplary field experiences for prospective science and mathematics teachers under the direction of these master teachers; and (3) enhances recruitment and induction of novice rural teachers through mentoring. Each chapter in this report discusses a major theme of the SMART program and presents teachers' perspectives on their experiences. Chapter 1 describes the challenges of teaching in rural areas, and the ways SMART teachers meet them. Chapter 2 discusses the need for rural field experiences for prospective teachers and describes SMART solutions: rural-advocacy presentations on campuses and short intensive rural exposure for student teachers. Chapters 3-6 examine teacher initiatives that increased teacher collaboration, collegiality, student mentoring, and community involvement; curriculum improvement efforts; 18 SMART class projects, many of which involved integration of math or science with other curriculum areas; and a variety of outdoor projects related to ecology and environmental protection. Chapter 7 describes efforts to disseminate SMART teachers' creative approaches to other rural teachers in the Pacific Northwest. An appendix includes names and addresses of SMART participants and a topical index of teacher projects. (SV)

RIDING THE WIND

RURAL LEADERSHIP IN SCIENCE AND MATHEMATICS EDUCATION

ANNE BATEY
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The contents of this publication were developed under Grant No. R168D00183-92 with the U.S. Department of Education, a total of $635,999 over a three-year period. However, the contents do not necessarily represent the policy of the Department of Education, and endorsement of the contents by the federal government should not be assumed.

This group of rural teachers continues to improve themselves. They admit that not all goes as planned, and they learn from their mistakes. Above all, they share their ideas and successes in spite of the changes in society, the lack of funding, and a general feeling that public schools are not doing the job. We are willing to go the extra mile to serve our students and community. The source of the energy to continue as we do comes from participating in projects like this. We charge our batteries and return to change our schools and communities. We do impact the future."

—Don Parker

In memory of Don Parker: rural teacher, friend, and longtime mayor of Prairie City, Oregon (1936-1993).

Amidst the flurry of educational reform and the skepticism about the quality of public education in the nation's schools, there are ordinary teachers doing extraordinary things. These are caring and competent individuals whose challenges and triumphs have often gone unnoticed. More than one-fourth of the nation's 79,037 school buildings are small and rural. The country school creates images for all of us which are largely mythical. Small, rural schools may be rich or poor, good or bad, growing or stagnant. Their diversity eludes generalization. It is more important to recognize that small, rural schools exist than to attempt to typify their existence. They educate 6.6 million of America's children every day—quietly and without fanfare.

Why would a report be written about the experiences of rural, secondary mathematics and science teachers in very small, rural schools? Why not a curriculum guide or a teacher education handbook or a set of small school assessment tools or teaching methods or content standards? The answer is because teaching is a very personal act, and improving one's profession takes place in a multiplicity of ways. Metaphorically, these teachers have learned from experience how to harness the resources of themselves and those around them to guide their way through change.

This report provides a valuable lesson in the importance of continuity, solidarity, and tenacity that is possible in the small, rural school.

Riding the Wind takes you on a journey into the hearts and minds of these rural teachers. It is a reminder of what the art of teaching still is and can be. It is a celebration of their own words and deeds undertaken for the sake of young learners. Rarely do we have the opportunity to recognize courage in common events, pride in everyday achievements. *Riding the Wind* is dedicated to all of those friends in small places doing their very best with what they have.

—Steve R. Nelson, Director
Rural Education Program, NWREL

You feel like you are getting into the wind, you are not just on the sideline watching what is happening on the mountainside. You are getting in there and trying to integrate some change that is needed. So you are "riding" the wind instead of feeling it across your face.

—JoAnn Arthur, Montana

This is the story of 44 rural science and mathematics teachers who have been "riding the wind," initiating and leading change in their rural classrooms, in their communities, and in the education of their students. Each of them has participated in the Science and Mathematics Academies for Rural Teachers (SMART) project which supported teachers who were seeking ways to stay in the forefront of their professions.

Their exemplary efforts to initiate education reforms in line with the recent national impetus for high standards in math and science curriculum serve as a beacon for the education community—teachers, administrators, policymakers, teacher educators, parents, students, and others. SMART participants took leadership roles in shaping curriculum, creating alliances between universities and rural schools, and offering structured support to colleagues through mentoring.

SMART began in the fall of 1990 with a grant from the Dwight D. Eisenhower National Mathematics and Science Education Program to the Northwest Regional Educational Laboratory, whose service region covers Alaska, Idaho, Montana, Oregon, and Washington. Its purpose was to (1) recognize and reward outstanding science and mathematics teachers in small, rural schools by providing them professionally renewing experiences and leadership roles, (2) promote exemplary field experiences for prospective science and mathematics teachers by enabling them to work under the direction of these master teachers dedicated to teaching in small, rural schools, and (3) enhance the recruitment and induction of novice teachers in rural settings through mentoring by these master teachers.

Five teacher education programs, one from each state and four public science and technology agencies, were central to the efforts of SMART. During the summer of 1991, representatives of this alliance and selected veteran teachers from the smallest rural schools of the five-state region spent two weeks together in an intensive professional development academy in Corvallis, Oregon. The academy offered professional renewal along with an opportunity for sharing successful practice and celebrating rural circumstances. Each teacher left the academy ready to launch an action plan for leadership. Each teacher education representative left with personal knowledge of 10 committed rural science and mathematics teachers eager to guide the field experiences of a student teacher.

Ongoing exchange of SMART teacher leadership projects have occurred in subsequent state-level planning seminars and academies. State teams of SMART teachers and the teacher education representative met twice each year during the final two years of the project to review student teacher placements, share progress, and coordinate state academies. During state academies, SMART teachers facilitated workshops and activities to present their innovations to their peers.

Riding the Wind furthers the SMART spirit of sharing and caring: In sharing, it illuminates how support for rural teacher leadership goes a long way toward changing the overall climate and specific practices of rural schooling; in caring, it advocates for rural schools.

At the final Washington SMART academy, teachers summed up their hope for *Riding the Wind*. "We have a deep commitment and love for rural areas and schools that must come out—what makes it so attractive and why we love it so much." This book is a tribute to their spirit, their profession, and their efforts on behalf of the children in the small towns and rural communities of the Pacific Northwest.

MOVING MOUNTAINS

I teach in a rural school because I love teaching. Nothing gives me greater pleasure than to see young people learn and become successful. I chose a rural school because I found that I can become more involved in the total process of the community and the school. There are fewer distractions and greater need for what I have to offer in the small, rural school. There's the challenge: to do well whatever I am called on and needed to do. — *Rich Stasenko, Alaska* —

"I believe that my students can achieve their potentials only as I achieve mine."

Kermit Tate, Idaho

Rural America is dominated by rugged mountains, untamed rivers, towering forests, windswept plains, and pristine lakes. For some, these natural wonders represent harsh barriers that can impede progress. For others, they represent stimulating challenges that bring out the best in the people who live, work, play, and learn in the remote and isolated reaches of our country.

For those who teach science and math in rural areas, this paradox of nature reflects the formidable challenge and enticing opportunity that rural education presents. This chapter describes some of the obstacles to teaching in rural areas, and the ways SMART teachers skillfully traverse them.

The Challenge to Offer Excellent Instruction

I believe that my students can achieve their potentials only as I achieve mine. The great variety in subjects and age-spread of students and the need for improvisation with limited resources all push me to my limits.
—Kermit Tate, Idaho

Rural teachers throughout the country find that leading by example is an invaluable tool in their efforts to help students reach their limits. Like the rugged terrain in his home school district, Tate's tough job assignment prods him to strive harder rather than give up. This is a common response to the dilemmas of rural teaching conditions. The challenges stimulate teachers to make admirable progress toward education reform instead of stopping them in their tracks.

"The most difficult challenge," says Terry Hurd, a math teacher in Ilwaco, Washington, "is the amount of work required to teach students ranging from first grade to college-bound seniors. One year I taught sixth-grade math, pre-calculus, biology, chemistry, and computer programming and worked with elementary students on computers. It's also difficult to remain current in all areas of math, science, and computers while I'm isolated from other math and science teachers."

Talk to rural teachers and you learn that it is common to prepare for five or six different classes a day, often in a variety of subjects and for a variety of grade levels. "Be prepared to teach all areas of science, not just your own particular favorite," says Wayne Mangold, a SMART teacher from rural Montana. "Rural high school teachers are expected to handle earth science, biology, physics, and chemistry for students from grades seven to 12."

Adds Maureen Michael, a seventh and eighth combination classroom teacher at Orient Elementary School in northeast Washington, "You might have six class periods, but as many as 10 preps because some of those are combination classes of different subjects, grades, and ability levels each period."

Extracurricular activities also are routine expectations in rural communities. The activities often go beyond the coaching or debate team coordinator roles common in larger districts. "Extracurricular duties will consume much of your free time, including weekends," says Joanne Morrow, a math teacher in St. Ignatius, Montana. "If you admit to athletic ability, chances are you will be coaching. If you don't coach, take your pick (if you have a choice) of yearbook, newspaper, drama, speech, pep club, honor society, student council, cheerleaders, ticket-taking, class sponsorship, or the Christmas play. You will probably be assigned two or more of these."

Colleges of education rarely—if ever—prepare students for the expanded duties and heavier loads of rural schools. "In college," notes Michael, "they didn't tell me that I was expected to go to all the (home) sports contests in the school as well as the away contests that were within 80 miles."

As hard as these demands on teachers' time and talents are, they have some positive effects in terms of quality teaching and community service. For example, teaching several subjects means branching out intellectually and seeing the connections among diverse areas of knowledge. "In many instances, rural teachers become generalists by necessity and are able to innovate and go beyond textbooks and worksheets to make learning meaningful and exciting," says Rich Stasenko, a SMART teacher in Shishmaref, Alaska.

Along with multiple preps come smaller class sizes where rural teachers can cultivate a closer relationship with students and learn more about their lives, their families, and their communities. Teaching some of the same individuals in several classes and/or for several years makes it easier to match instructional approaches to individual needs.

Small, rural schools often provide more opportunities for students to interact across grade levels and more one-on-one contact between students and teachers. "I balance full classroom projects with individualized exercises that will deliver the best learning experience for each child, give the students positive feelings about successfully completing programs, and ready them for ever-wider ranges of skills," notes Larry Preszler, a math, history, language arts, and business occupations teacher in Atka Island, Alaska. "I continually review, rework, patch together, throw out, alter, and otherwise build on basic programs to meet these individual needs."

Rural areas also provide a relaxed and nonregimented environment for living and teaching as well as an atmosphere that is ideal for honing fine instruction. "It is this atmosphere that makes teaching enjoyable," says Robert Emmons of Hysham, Montana. "One becomes more and more aware of this when meeting teachers from nonrural areas. It seems the urban school is more time-oriented. Lesson plans are not allowed to deviate much. This takes away from the freedom good education has to have. If it takes sometimes an extra hour or two—or even a day or two—to complete a lesson, so be it. The rural school is like a big family, and like most families it is adjustable."

The Challenge to Find Instructional Resources

The most significant obstacle I face is the lack of equipment and facilities to do classic science experiments. As a result, the students and I must invent new projects. When we know what stuff we need, we go out and get as much as we can from the community.

— Alex Rajala, Washington

Inadequate resources are a particularly thorny barrier to top-notch instruction in small schools. States and districts typically are reluctant to invest huge sums in equipment for only a few students. And, due to rural education's historically low profile, the pay-off for such investments (in terms of learning outcomes) is generally underrated. As a result, rural students are at risk of being left behind in the rapidly changing fields of science and math.

Again, though, a paradox in rural education arises. While rural teachers lament the dearth of equipment and inadequate facilities, they also create opportunities for themselves and their students. They find that their physical surroundings—the creek that runs in back of the school, the spring flowers that muscle their way through the permafrost, or the caribou that migrate seasonally—provide a real-life learning laboratory.

"I personally would prefer more control of students," admits Alex Rajala, a teacher of science and math in Pe Ell, Washington. "But in the interest of education, they are off at the creek plumbing its depths, out on the field shooting rockets and measuring angles of elevation (for the trig students to calculate), or engaged in other activities all at the same time. I personally don't like to teach in a barnyard, but the students in biology benefit from having animals around—so we have lots of them."

Rural teachers grow resourceful and

One of every six students in the United States attends rural schools.

inventive when it comes to equipping the laboratory. "You will probably have to make some of your own lab equipment, devise or substitute chemicals for other chemicals that are not readily available, and look for alternative labs that are affordable to a sometimes tight rural budget," says Mangold.

Local residents can also play vital roles in rural classrooms and should not be overlooked by rural teachers. "There is a need for more awareness of our own elders' knowledge in using and living in our land," says Anna Angaiak, a teacher in Tununak, a subsistence community on Nelson Island along the Bering Sea in southwest Alaska. "My students (to my surprise) were enthusiastic about gathering local data rather than just dispassionately receiving a conglomeration of various facts from distant places."

The Challenge to Know the Whole Student

My most difficult challenge can also be my most rewarding: You get to know students real well in a rural school. Sometimes, I think, too well. I find myself wanting to help all students and not let any slip away. I have often come home with student problems on my mind that I have no control over. I have met this challenge by reminding myself that parents are responsible for their children and by making my classes ones that students want to come to school for.

—Karma Goodwin, Washington

Rural teachers, more than their urban counterparts, get to know their students in many contexts and for many years. While teachers' relationships with their wards grow with time and contact, so does the burden of responsibility for guiding them well.

Sometimes the same students will be in a rural teacher's classes for six consecutive years. "You must feel, as I feel, a love for them akin to the love of a parent for a child," says Rajala. "You must want

to hear about their projects and problems. You may be the most stable influence available."

Positive interpersonal relationships fuel quality education. SMART teachers concur that such relationships are crucial in rural areas, where teachers become involved in the many aspects of their students' development aside from the academic. "I prefer the family atmosphere over the more impersonal setting of a larger school," says Morrow. Adds Tate, "I am convinced that the science teacher in a small school can do a better job of educating the whole person than teachers in larger schools can."

Rural areas not only make it fairly easy for teachers to get to know their students, but they offer the youth themselves certain life experiences that bolster good science and math education. Although rural students may lack experiences that urban kids take for granted (and to which teacher training and materials are geared), country life offers experiences with nature, agriculture, and small communities that youth in cities miss.

"I feel the most important element of teaching in a rural area is the profound impact I can have on the students," says Ward Bond, a ninth- through 12th-grade teacher in Tuntutuliak, Alaska. "They are quite willing to learn, and they present me with a unique challenge to satisfy their needs. I will always cherish the relationships created with the students and the community people. As a teacher, I have the opportunity to observe directly the success and improvement within each student, which in turn motivates me to work hard and provide a quality education for each individual."

The Challenge to Extend Professional Relationships

Professional isolation is the toughest thing to deal with. If I'm struggling with a math problem, there is no one to ask for help. The first year I taught, I worked on one problem set for two weeks before finally contacting a teacher in a nearby town. He told me I was doing it fine—the answer key was wrong!

—Pam Koterba, Montana

Distance from urban centers isolates rural teachers from professional colleagues. This cloud casts at least two shadows over teachers' work. For one, it creates the need for ties to faraway colleagues in education and specialized teaching areas; secondly, it creates job pressure that results from the small numbers of teachers, specialists, substitutes, and administrators to share the workload. "You will be alone, the only math teacher in the building," cautions Ed Armbrust of Rainier High School in Washington. "Probably no one else will think like you."

Similarly, when there is only a single voice of authority on a given topic, people look to that person as a font of wisdom. "Being the science authority for an entire school district is a heavy burden," Tate says. "Students, parents, and colleagues alike expect me to know the latest about every aspect of science."

However, this cloud also has a silver lining: Rural teachers enjoy a relatively high degree of autonomy, which encourages, motivates, and stimulates them to provide innovative learning opportunities for their students. So the same teachers who bemoan their isolation also extol certain advantages of it.

"Rural schools can make educational reform decisions more easily than larger school districts can," says Jim Warren of Midvale, Idaho. "The organizational bureaucracy is much less complex in nonurban situations," adds Karen Garrison, also of Idaho.

Even the large staff turnover in rural districts can work to the advantage of those teachers who commit to life in rural areas. "Our schools have large staff turnovers every few years," says Michele Bifelt, a teacher at the Jimmy Huntington School in Huslia, Alaska. "This year, 50 percent of our staff was new. So those of us who stay have a large hand in guiding the local program.

"Since I have worked in the district for 12 years, I have been obliged to take a leadership role," she continues. "The challenge is to get all the staff to participate, but once I've done that I have a built-in audience. There are many ways to accomplish educational goals. You don't have to have a lot of money or a big staff to work wonders. Small schools have untapped resources. We tap them."

FORGING PROFESSIONAL TIES

SMART teachers reach out to other educators in the vicinity to forge professional ties and stimulate professional growth. "It is essential not only to attend professional meetings, such as the Montana Council of Teachers of Mathematics, but also to get to know fellow teachers at home," Koterba says. "This professional support and networking have made an enormous difference for me."

Remember, too, that even though other teachers may not teach the same subjects, they are in similar situations, SMART teachers say. Get to know other staff members and forge ties with them. "If you don't get along with other faculty, you will have a lonely life and, as a result, difficulty teaching effectively," says Angaiak.

Team teaching, collaborative projects,

Almost 30 percent of the nation's public schools are rural.

and other partnerships also help to break down barriers and diminish isolation. "Balance between individual and team work are critical," says Bifelt. "It doesn't pay to shoulder the entire burden of the school's functioning, but neither can you isolate yourself in the classroom."

Distance from urban centers need not limit teachers' contact with colleagues. Kimberley Girard, a math teacher in Glasgow, Montana, learned to actively forge long-distance ties by reading and attending conferences. Those activities have long-term payoffs in the classroom and among people in the community.

For example, Girard first had to establish a stable mathematics program by convincing students and their parents about the importance of mathematics. Now, she is involved in revising the curriculum. "De-emphasis of computation, whether arithmetic or algebraic, is necessary, but it requires much decisionmaking," she says. "In meeting both challenges, I read all I can in professional publications and attend conferences to exchange ideas and stay on top of what is happening in mathematics education."

Extracurricular activities also provide an excellent opportunity for rural teachers to meet their colleagues in neighboring communities. "The most interesting job I do is chaperoning a group of students to nearby villages for sports," says Angaiak. "It's always a challenge to chaperone because you are entirely responsible for all the students. But chaperoning is a great way to meet other teachers in the district."

Several SMART teachers suggest that one way to diminish the effects of isolation is through new communication technologies. Electronic mail (E-mail) is available to some teachers already. Partners range from district colleagues who know but don't often see each other to unacquainted science and math educators around the world. Courses beamed from satellites provide opportunities for teacher, student, community, and even student/teacher education.

With the advanced technologies in communications, many of the disadvantages of rural teaching are now advantages. Satellite communication enables teachers to continue their professional education through college credit courses and inservice and information programs at less than the cost of on-campus courses—and they can still be home with their families.

"Satellite courses can fill a large gap in the curriculum of small schools and offer the community the opportunity for academic as well as technical education," says Don Parker, a teacher in Prairie City, Oregon. "Thus the community and school become as close academically as they have been socially and athletically."

With all the demands on a rural teacher's time and expertise, it is also crucial that they find time for themselves and their families. "Build quality in your home life as well as your classroom environment," advises Preszler. Balance is important, emphasizes Bifelt. "Remember that you have a life outside the school," she says. "Save time for being part of the community and time for yourself."

And don't let the burden of being the local expert go to your head, Tate says. "Be honest: If you make a mistake, admit it." Remember, too, that friendships are forged outside the classroom as well as in it. "Every once in a while, tell a joke, bet a soda on the game, have fun. You will last longer if you like what you are doing."

The Challenge to Build Community Life

In a small community people really know a teacher's every move. At first this bothered me. But now it means that I never have to cook dinner anymore.

—Ward Bond, Alaska

The small population, distance from large cities, and intimacy of small towns are both benefit and bane for rural teachers. Lack of privacy makes many feel they are in a fishbowl. In addition, the rural setting means no large museums to take students to, no libraries for extra books to supplement a tiny school library or refresh one's knowledge, no universities for evening classes, and no conferences within easy driving distance.

SMART teachers acclaim the valuable reward which accompanies these trials: membership in a small community. Their consensus is that the course to professional success and personal happiness in rural education requires embracing local social opportunities.

Since this social world is a major asset of the environment, learning about it is crucial for one's well-being. "If a person grows up in a metropolitan area and subsequently signs that first contract with a rural school district, the culture could drive them out of teaching altogether," Koterba says. "Rural schools and towns are wonderful, but they are different from the cities."

Well-intentioned teachers who do not take the time to learn about local customs, culture, history, and ways of being can unwittingly sabotage the chances they have to succeed. Students from different cultures also may learn in different ways that must be respected and nurtured. Angaiak, a native Yup'ik Eskimo, exemplifies the way knowledge of the local culture—their uses of language and visualization in learning—allows a teacher to understand her students' ways of learning.

"The most difficult challenge I face is attempting to teach an abstract concept that is nonexistent in my students' lives," she says. "Examples are universe, hypothesis, animal kingdom, religion, or democracy. The majority of my students have difficulty comprehending math concepts because, in our culture, we don't use exact numbers, whereas math books tend to require answers that are very specific and precise. The basic methods I use to face such a challenge are to take advantage of my Yup'ik language. When I explain an abstract concept, I translate the English version into Yup'ik. That makes a tremendous difference. I also do a lot of showing. I show pictures, words, ideas. My students are highly visual. Since they don't quite understand what is being lectured to them in English, seeing what they are hearing about usually helps them to comprehend."

INTERACTING WITH THE COMMUNITY TO BUILD SUPPORT

Just as understanding the local way of life pays off in terms of instructional effectiveness, wholehearted participation bolsters classroom efforts. Colette Cozort of Kendrick, Idaho, describes how she strived to join community activities and accrued the benefits for her students. "The initial challenge when I moved to Kendrick was to earn the respect of the district's patrons and their children. In an effort to gain that respect, I went to all of the ball games, took tickets, and attended concerts and all other extracurricular events that I could.

"I introduced myself to parents and commented on the students' performances in school the next day. I joined the local rock club and invited members to help with the earth science class. I went to church and trained to be a local emergency medical technician. In class, I set high academic and behavioral standards. I spent extra hours at home studying my texts and trying to keep up with journals. I encouraged students to be real scientists as they participated in the reinstituted local science fair. I organized and chaperoned field trips to the Oregon coast, Canada, and wilderness areas. I called parents with positive feedback on students' daily work and encouraged them to come in for extra help before and after school.

"Through the years, I developed enough rapport with the students, parents, and administration that I had the support to build an admirable science program. SRA and SAT scores zoomed: The majority of our students receive their highest scores in the science category."

The school and its teachers play an important role in the lives of rural communities. The proverbial interest by small towns in their high school football team is just one part of this. Teachers' academic decisions and extracurricular activities are high profile, and citizens are not reluctant to request that faculty extend their services outside the school.

Melvin Henning, a math and science teacher in Whittier, Alaska, found that the isolated community he taught in brought a high expectation for local involvement. "In my situation, the school and town are not accessible by road—only by train," he says. "Therefore, folks in the community are very much affected by school programs, and the teacher spends a large portion of his or her time directly involved in community efforts."

Teachers experience the satisfaction of close communities. Turning to neighbors and local festivities and issues, they find alternatives to urban life that fulfill their needs and alter their interests. "Forge your relationship to the community," Henning says. "Find out right away what they expect from you as a new member, and blend into it a bit—be willing to change."

Another key to survival: Do not judge. "Learn about and accept the culture of the community and avoid imposing your own cultural values," says Don Lewis, a teacher from Carey, Idaho.

Residents in rural communities are used to knowing their neighbors and willing to lend a helping hand. Bond emphasizes the need for teachers to show the same spirit by involving the community in the education of its students. "Community members can be wonderful resources for mathematics and science in the local setting," he says. "This kind of communication with the community deepens students' respect for you."

Finally, we end this chapter where we began—with the notion of role models and partnerships among rural teachers, their students, and their neighbors. "Be a fine role model on and off the job," says Cozort. "Unless you establish yourself as a caring citizen, it doesn't matter what knowledge you have to share."

FRAGILE ALLIES

Large school districts have a multitude of applicants for every teaching position, while smaller districts scramble to find qualified teachers for some positions. By experiencing what a small, rural school is really like, some prospective teachers may be more open to exploring those options and applying for the rural jobs. Seeing firsthand how to turn some of the "minuses" into "pluses" would be invaluable. — *Pam Koterba, Montana*—

SMART teachers began the project fully expecting to guide a student teacher, a fragile ally, through the challenges and the benefits of rural teaching. The difficulties facing such placements are significant, and during the project only five student teachers apprenticed in SMART classrooms. However, a partnership between teacher education programs and rural SMART teachers, another fragile alliance, produced several alternatives that addressed the challenge of rural placements at perhaps more fundamental levels.

The Need for Rural Field Experiences

The supply of well-prepared science and mathematics teachers is chronically low for both rural and urban schools. But even a well-prepared teacher is not necessarily well prepared for rural teaching. The transition to a rural school can be an overwhelming adjustment to a new teacher prepared in larger, nonrural schools.

"My student teaching was done in a large, urban middle school," says Terry Hurd, a math teacher in Ilwaco, Washington. "All of my experience since then has been in small, rural schools. The differences between the two are many and varied. I was unprepared for rural teaching. It takes a special sort of person to excel at teaching in a rural school."

Even seemingly rural districts appear big to those who venture into the more isolated communities along the back roads of the Pacific Northwest. "Our new science teacher is a first-year teacher," notes Rod Patten of Sherman Union High School in Moro, a community in the heart of central Oregon's rolling wheat country. "She has commented several times that this teaching experience is nothing like her student teaching experience at all. Some might think that Philomath [where she student taught] is pretty small and rural. It is not small, nor rural compared to Sherman County. They are just two different worlds."

And Alaska, with its "last frontier" image, presents unique challenges to those who venture north to the "land of the midnight sun." In many of Alaska's rural communities, there are no roads connecting residents to the outside world. Travel year-round is limited to airplanes for some, while others may be served by train and boat as well. But the long, harsh winters will occasionally close off these communities from all transportation options.

"We saw many teachers blow out at schools where they have had nobody to talk to and no way of picking up the model of rural teaching that can be successful in Alaska," notes Morgan Gray of Chignik Lake on the eastern end of the Alaska peninsula, about 250 miles southwest of Kodiak Island. "They are being hired at job fairs from the lower 48 with no experience in rural teaching, and being put in situations where not only are they isolated from other teachers, they are isolated from any familiar cultural experiences, and maybe foods they are used to eating."

Such culture shock leads to a high rate of turnover—as much as 25 percent don't get through their first year and 50 percent leave at the end of the year, Gray says.

Early preparation and a broad range of skills can pay handsome dividends for rural teachers. "I student taught in a big school and they thought I was crazy wanting to teach in math and English," says Mel McWhorter of Waitsburg, Washington. "But it served me well: I knew I might end up teaching both subjects in a small school."

The Challenge of Rural Field Placement

When the five teacher education members of the SMART alliance met for the first time in the fall of 1990, they talked about the significant challenge of field preparation and induction of teachers in rural settings. Teacher education programs do not promote rural student teaching experiences because such placements require extra effort and special arrangements.

There are extra costs to provide supervision of student teachers placed at greater distance from the institution. Even in instances where teacher education programs have a network of qualified off-campus supervisors, they may not be available to visit remote locations as often as necessary. Finding qualified and willing classroom teachers in schools that are also well run is an ongoing challenge for a teacher education program, even in nearby communities. It takes an unusual commitment and effort by a teacher education program to find and maintain good rural placements in remote locations.

Factors associated with the teacher candidates themselves create additional difficulties. Few teacher candidates request a rural placement. The exception is the prospective teacher who grew up in rural areas and attended rural schools. Candidates from nonrural schools may never have considered rural teaching as an option. They need a balanced exposure to the benefits and demands of rural teaching. Even with recruitment, an interest in a rural placement may not outweigh a student's desire to stay close to campus and friends during the last months of college years. It is also less expensive to remain near campus and may not require a move. Temporary housing arrangements in some rural communities may mean one extra hurdle for an interested candidate—rental housing may not be available.

The SMART Solution

During the SMART Academy, two sessions focused on the planned rural student teaching component of the project. The first, led by Dr. William Hall of Montana State University, explored the skills of an effective cooperating teacher. Using a problem-solving/brainstorming approach, SMART teachers developed guidelines to enhance the field experience for both the student and themselves as cooperating teachers.

Dr. Maggie Niess from Oregon State University facilitated a second session. In it, participants explored the potential for partnerships between veteran rural teachers and teacher education. When challenged to consider alternatives within this partnership, five SMART teachers, with support from the teacher education representatives, applied creativity and resourcefulness in fashioning projects to address them. They broadened the perspective of this partnership beyond student teaching opportunities to include advocacy for rural teaching on campuses and shorter practicums in rural settings.

TAKE THE COUNTRY TO THE CAMPUS

Two SMART teachers developed projects that brought the rural perspective to science and mathematics methods courses on campuses: Don Parker, science teacher and mayor of Prairie City, Oregon, and Joanne Morrow, mathematics teacher from St. Ignatius, Montana.

Road Show for Rural Schools. Parker developed a slide presentation and took it on the road to several methods classes at campuses in Oregon and Idaho. "Future teachers are not aware of the many opportunities that are available in the rural areas," Parker says. "I hoped to dispel the image of the poor rural school with no equipment isolated from the world and culturally deprived. Basically, the project was designed as a recruiting tool to entice student teachers to accept positions in rural areas. However, I feel that the project has also made teachers more aware of the community/school relationship and the need for teachers to be involved in community affairs anywhere."

Parker emphasizes four advantages of rural teaching:

1. Bureaucratic processes are at a minimum; you have direct contact with administration, which allows more spontaneity, creativity, and flexibility.

2. Class size is an obvious positive, but also creates unusual situations where a

Two percent of rural secondary schools enroll more than 1,200 students.

teacher has some students for many classes over several years.

3. Students' antisocial behavior is not a major problem.

4. Outdoor field trips are much more easily arranged and generally involve less travel.

Parker shares his answers to the teacher candidates' three most consistently asked questions:

Teacher Candidate: How do you survive six different preparations a day?

Parker: Stick close to the text in all classes and venture out to try new ideas in one class at a time.

Teacher Candidate: How do you grade all that homework?

Parker: You don't grade every question or problem. Use a quality control method, as in production. Collect all homework and check two to four questions.

Teacher Candidate: How do you have a social life in such a small town?

Parker: In a rural setting, teachers are held in high regard; there are opportunities to be a leader in community affairs, including PTA, service clubs, and other activities for keeping a viable community.

Math Methods (for Small Schools) $M^2(4S^2)$. Morrow prepared a unit about teaching mathematics in small schools that she presented to preservice secondary mathematics teachers. She developed handouts on the demographics of Montana's small schools, small school myths, small school life (pros, cons, and recommendations), creative classroom activities, and professional organizations as resources.

In the first year of the project, Morrow gave two presentations—one to a methods class and one to a graduate-level seminar at Montana State University. Coincidentally, Morrow was the first SMART teacher to have a student teacher: Lisa Shute joined Morrow and added an important perspective as a student teacher who had chosen a rural placement. In the second year of the project, Morrow and Shute again teamed up to present the unit at three different campuses with three more scheduled for the following year.

Morrow reported that all presentations were well received, with obvious influence on those students who had some interest in rural teaching. "It seems that most students were very interested to learn about small school life, especially after discovering just how many small high schools there are in Montana," Morrow says. "Our presentation was beneficial to them."

COMING INTO THE COUNTRY

Pam Koterba and Morgan Gray created opportunities for preservice teachers to have short field experiences in small schools. They reasoned that even short, intensive exposure to life in rural schools would give a new teacher valuable experience that might support a future rural teaching decision.

A Network of Field Sites for Rural Experiences. Koterba is a 15-year veteran of rural teaching, all but two of them at Ryegate High School in central Montana. She designed a one-credit class for preservice teachers to experience teaching in a small, rural school for one week. The class was offered as an option in conjunction with a secondary methods course for math teachers during fall semesters at Montana State University.

"Even a week's experience would make students more aware of some of the advantages and drawbacks of a rural setting, as well as the adjustments that must be made to have a successful teaching experience," Koterba says. Koterba contacted 17 math and science teachers around the state who agreed to sponsor education students for up to one week, providing room, board, and mentoring at no cost to the student. Two MSU students took part in the program. Both felt it was a positive experience, commenting favorably on the family atmosphere and the tremendous involvement of students and teachers.

Although Koterba was discouraged by the low student turnout for these rural ex-

periences, she reported on the professional boost for the teachers who were asked to serve as mentors and hosts. "Teachers in rural situations are rarely acknowledged for their expertise," she says. "The two teachers who hosted students not only contributed to teacher training, but also gained something for themselves. Being asked for your opinion makes you feel good and raises your self-confidence. That, in turn, gives you the push to keep taking the chances that make for a good teacher."

Short Practicum in a Remote Village School. In spring of 1992, Morgan and Pam Gray were a teaching couple in the school at Chignik Lake, an Aleut community of about 100 on the Alaska peninsula. Morgan taught all subjects to 10 secondary students while Pam taught grades 4-8. They hosted a short two-day observational practicum for six University of Alaska methods students enrolled in Dr. Nancy Murphy's course on preparing for small school, multigrade teaching.

Arriving early one afternoon at Chignik Lake, the group was given a community tour by students in the 4-8 grade classroom. "The tour took us through the old village, into the new government-funded housing, around the lake shore, past the wolf carcass, into the landfill, around the bear carcass, into the wetlands, over the stream (we built a small footbridge), past the teachers' house, past two dog carcasses, back to the first fishnet set of the season (the ice was just melting off the lake), beyond the satellite dish, and back to the school," Murphy recalls. "All the while, young students were eagerly finding old stone oil lamps, mammal jaws and teeth, fossils, and other relics and giving them to the wide-eyed and appreciative practicum students."

The remainder of the day and most of the following day were spent observing Morgan Gray's secondary students as they pursued individual and small group projects integrating language arts, social studies, and science. Murphy's practicum students were impressed by what they observed.

"I haven't really seen a school that's as consistently well-rounded in terms of the academic success of the students and the relationship that the teachers have," noted one university student. "It really motivates me to realize what's possible, what you can do in a small district that doesn't really have a lot of money. It's very inspirational."

Another participant was struck by the "amount of time teachers need to gear up, to get organized, to get a couple of years of experience so they know what works, what doesn't work, and to get their own kind of curriculum set up."

One student who visited Chignik Lake sensed the camaraderie and community that develops in a remote school. "It's like everybody here is working together toward the same goals instead of a couple of people trying to coerce a whole bunch of kids into working, doing tasks. They're really motivated, and everybody's kind of going for it. It's not an artificial rapport with any of the students."

The practicum, Murphy says, left strong impressions on the university students. "Although I did not attempt to quantify changes in perceptions, it was clear to me that these new professionals were inspired and relieved that they now had a positive image of personal and professional growth within a small, rural

Seventy-four percent of rural secondary schools enroll fewer than 400 students.

school. They left with a realistic appraisal about the discrete role of a white teacher in a native school and the tremendous impact any individual teacher can have upon individual students and the attitude of a community toward education."

Murphy says the experience reinforced her belief in rotating students "through our most masterful rural teachers' classrooms, even if they don't have the lengthy opportunity to participate in the teaching. The visions that become ingrained after this quick immersion can help these preservice teachers accommodate new images as they are exposed to the latest strategies during methods classes and provide a common reference point for future discussions. I intend to lobby now for shorter but more selective and required rural placements for all of our students at the beginning of the methods semester."

STUDENT TEACHERS TRY COUNTRY

Five student teachers were placed with SMART teachers over two years. The SMART teachers indicated that student teachers provide unanticipated opportunities for professional growth even when the experiences were challenging.

Larry Brown of Cusick, Washington, appreciated the latest approaches and new realms in mathematics that his student teacher brought to both his students and his own repertoire. Mel McWhorter's student teacher was also an asset to his classroom. However, he acknowledged that he sacrificed progress on personal goals for his classroom during her tenure. "It made it difficult to make as much progress as I would have liked," he notes. "The emphasis was different when she was in the class."

Phillip Springer of Augusta, Montana, found that the two student teachers he mentored "allowed me to see the pitfalls I should try to avoid to remain as successful with student teachers as possible." Although one student teacher struggled at length with classroom management, he had impressive teaching abilities and brought refreshing new ideas to Springer's classes. The second student teacher was a struggle for Springer because of inadequate preparation for each day's classes. Springer had difficulty recommending him as a future teacher.

Joanne Morrow had nothing but raves for her experience with student teacher Lisa Shute. "This was the best part of SMART for me," she says. "My students and I were so lucky to have Lisa in our classroom. I learned so much about inner strength and perseverance from her."

Shute, a product of large schools, thought she would try a rural field experience because it might mean fewer discipline problems. She found that the benefits of teaching in a rural school far exceeded her expectations. "In a small school, no one can hide from you," she says. "You can assess needs and abilities of each student. No one gets lost in the crowd. You do a better job."

Shute also says that the sense of community that develops in rural areas is refreshing. "In a small school, you are part of a whole family unit instead of one little piece. You meet and get to know everyone even as a student teacher—the nurse, the counselor, the janitor—I mean, everybody."

Finally, Shute says, the teaching experience in a small, rural school is rich and provides a broad background for future teaching positions. "Most importantly, I got to teach all levels of mathematics," she says. "Before student teaching, I had a fear of teaching the upper-level classes like calculus. But by the time I finished, I was confident in my ability to teach all levels. I might not have had this if I was in a larger school."

Country and Campus, A True Two-Way Alliance

What makes a fragile alliance between teacher education and rural teachers work? Sustaining a partnership successfully over great distance and with infrequent communication requires extra time, effort, and expense. But when held together by commitment, the payoff may be bigger than expected.

SMART teachers have made lasting connections with teacher education professors who are now viewed as resources and professional partners. At the same time, the teacher education professors formed relationships with veteran rural teachers that are only beginning to bear fruit.

"I developed a professional and personal relationship with 10 talented rural teachers which enhances my knowledge and experience base, and in turn influences my teaching strategies with beginning teachers," says Murphy. "This is my chance to hear what's really happening and translate that into my classes at the university. I really noticed this year how often I was referring back to their stories and how much my students needed it."

Dr. Thel Pearson of Boise State University says that participation in the SMART project opened the door for future teacher candidates to student teach in rural areas. "During these three years, there has been a gradual change in attitude toward allowing students to go to the rural schools, to the point of facilitating such opportunities," she says. "The influence of the SMART project has already resulted in several different ways of utilizing veteran rural teachers within our teacher education programs."

For example, rural teachers have been invited to the university to participate in methods classes, have served as team teachers with the regular university faculty for workshops and inservice programs, and have been classified as adjunct faculty who can then conduct workshops and courses for credit on their own through continuing education.

Dr. William Hall of Montana State University says his university places relatively few teacher candidates in remote rural schools, a situation he expects to see change in the future. "We have placed three and will continue to seek student teacher placements with SMART teachers," he says. "Very little has been done to expand collaboration across teacher education institutions to promote rural schools. However, I have requested that all student teaching directors have names and addresses of SMART teachers. I anticipate that in time student teachers from other institutions in Montana will eventually be placed with SMART teachers."

In Washington, two major inservice projects are under way for rural teachers. "SMART provided a model that we could follow...showed us how beneficial such partnerships can be," says Dr. Donald Orlich of Washington State University. "Rural science and mathematics teachers represent a great untapped natural resource. Their willingness to share ideas and to establish mutually supporting networks is a real plus."

ACTS OF KINDNESS

We are more willing to bounce ideas off of each other. I hope we have broken through the barriers created by their thinking of me as the high school math teacher who teaches "the hard math" and the elementary teachers as those who teach "the easy math."

—*Carla Pfeifle, Montana*—

"The best period for our relationship was when four teachers rode together to a 10-week college class 40 miles away. It turned out to be a way for us to get to know each other away from school."

Kimberley Girard, Montana

Many SMART participants designed projects for extending expertise and support to teachers and other community members. Their immediate aims were to achieve specific improvements. For example, Kimberley Girard, math teacher from Glasgow, Montana, helped a colleague adopt an inductive, cooperative group approach to teaching geometry in conjunction with a new text.

But teachers' acts of kindness have effects beyond their immediate aims: Helping others achieve their education goals creates a climate conducive to continual educational improvement. In the SMART project, teachers reached out to new and experienced colleagues as well as community members. They also provided opportunities for their students to serve as mentors. These acts of kindness served as a jumping-off point for building a support system for curriculum reform.

Mentoring Fellow Teachers

Several SMART teachers offered assistance by mentoring colleagues on a one-to-one basis. Each mentor emphasized a different aspect of the role: lending a sympathetic ear, demonstrating confidence and competence, or consulting on pressing daily issues.

A Sympathetic Ear. Kimberley Girard fostered two mentor relationships during her first year at a new school. When she started the SMART project, Girard taught at the 65-student Nashua High School in northeast Montana. Now, she teaches at the 290-student Glasgow High School 14 miles west of Nashua.

Girard mentored the first-year teacher who replaced her at Nashua High. Before leaving the district, she explained her idea to the superintendent and left a letter for the new teacher. Two weeks into the year, Girard and the new teacher met and discussed how the relationship should develop. The mentor's primary role, in Girard's view, is to help the newcomer feel at home and grow in her role as teacher. She offered to meet with the new teacher at school, contact her by phone each week, send her friendly notes (one with a book of inspirational quotes for teachers), and encourage her to join professional organizations.

Girard says that mentors must be sensitive to the role of the new teacher and respect her need to develop rapport with faculty and establish relationships with students. She learned that it is best to meet with the replacement teacher away from the school. "The new teacher's students had been 'mine' the year before," Girard says. "Whenever I visited, they sought me out to talk. I should have set up our meetings when no students were around."

Girard also accepted that mentors can't fix everything. When she sensed that her replacement was having difficulty establishing rapport with her colleagues, Girard realized that some things just take time. "This was one area I was not prepared to help her with," Girard says.

Informal gatherings and communication are also beneficial. "The best period for our relationship," says Girard, "was when four teachers rode together to a 10-week college class 40 miles away. I had contacted the new teacher about the opportunity and asked the principal to encourage her to enroll. It turned out to be a way for us to get to know each other away from school and for her to talk with other math people, both in the car and the class."

Girard also mentored a colleague in her new school who was implementing an innovative geometry text after using the standard text for 16 years. Because Girard had used the text and its approach for two years, she was well-prepared to support his venture into new territory and material. They arranged their schedules so Girard's colleague could sit in during her geometry class and observe. The observer-teacher often pitched in on the management of the class while he assimilated new methods. Girard feels that her colleague's teaching became less traditional over the year. "The best outcome has been the way the changes in his geometry class spill over into his other classes," she says. "He's becoming a teacher of the '90s rather than the lecture-only type."

A Demonstration of Security, Confidence, and Friendliness. In his role as mentor, Leonard Pratt of Huntington, Oregon, found that "sharing my own experiences and knowledge helps new teachers jump the hurdles to success." What are the hurdles and the boosts he provides for getting over them?

"One common hurdle is the number of interruptions in the school week," Pratt says. "Often a new teacher gets quite frustrated when his lesson plans have not been completed. I have helped with organization and planning of the school week so that an interruption can be dealt with and the new teacher can feel good about his students' progress.

"Another hurdle is the numerous times that situations with students get out of hand. I defuse the conflict and give constructive guidance, as a friend. Strong mentoring like this means a new teacher is able to do his job with the security of knowing that there is a caring individual to lean on during stormy times. The most important role of a mentor teacher is to demonstrate security, confidence, and friendliness."

A Valuable Consulting Relationship. Wayne Mangold teaches an array of sciences—earth science, chemistry, physics, and biology—to high school students in Plevna, Montana. His broad knowledge of science and his 17 years of experience teaching in rural schools make him a resource for the entire district, especially elementary teachers. "Because they must have skills in all academic disciplines, science often is not one of their areas of expertise," he says.

Mangold honed a system for helping elementary teachers keep current in science. First, he cultivated a relationship with them by holding one-on-one conversations and monthly group meetings. Through these regular, informal meetings, Mangold educates teachers about science concepts. Participants use these sessions for chatting about science news, devising science experiments for kids, and taking on the issues of science curriculum. He also provides teachers a tour of the high school lab, an inventory of district equipment, and assistance in ordering additional supplies. "I try to help teachers with any aspect of science education that comes up," Mangold says. "I talk with each teacher individually about what's going on in the classroom. At times I'm able to solve a problem or give an idea that might help. In addition, I provide information about upcoming science conferences and workshops and encourage elementary folks to attend."

Listening carefully to elementary teachers' concerns develops valuable consulting relationships. The elementary teachers gain expert advice on science instruction, and the high school teacher becomes more involved in the science curriculum across the grades. "I am even able to spend time with the elementary students as they develop their projects for the Science Fair and help them set it up," Mangold says. "The project has opened lines of communication across the district."

Offering Access to Information

In an attempt to strengthen teachers' collaboration and knowledge about their teaching environments, one SMART project established an electronic mail network for teachers, and two others created written descriptions of rural sites.

A Computer Network of Trained Science Teachers. In the Lake and Peninsula School District of Alaska, Morgan Gray's students enjoyed exchanging mail with other schools through the University of Alaska's computer mail system. They suggested that a similar districtwide E-mail system be established for teachers. Gray formed the Science Teachers Network and offered training to teach staff how to use E-mail. This training enabled science teachers across 14 remote districts on the Alaskan Peninsula to share scientific data on diverse environments,

In 1988, 92 percent of rural eighth-grade students in the United States were enrolled in regular or advanced math, more than either urban or suburban students.

exchange information on teaching resources, and coordinate district curriculum development.

An Idea of What They're Getting Into. Teachers' success and commitment in a rural school depend on smooth transition into their jobs. Induction can be less traumatic if teachers have an idea of what they are getting into, says JoAnn Arthur, a SMART teacher from Richey, Montana. "Many first-year teachers start their careers in small classes, yet may not have ever lived or worked in a small community. They need information on such communities, their schools, and the characteristic needs of their students."

With this need in mind, Arthur wrote a guide to teaching in rural schools designed for preservice and novice teachers. She gathered information for the guide through surveys of experienced rural teachers from surrounding schools in the eastern reaches of Montana. She complemented the guide with a video of her rural school and community which included teachers, administrators, and community members discussing the school. The guide has been used during several presentations to preservice teachers in sessions at math conferences in Montana.

Site Portfolios. Anna Angaiak had another idea for sharing information that would ease novices' transitions into rural teaching—a "site portfolio" describing schools and communities in Alaska's Lower Kuskokwim District. By learning from the portfolio what a place is like, a newcomer can avoid some aspects of culture shock and function more effectively at the outset.

Angaiak's plan involved the development of 22 site portfolios with science and math classes gathering data in their communities. Portfolios would include physical descriptions of village locations and information on demographics, school, transportation, weather, water and food sources, and social activities. In addition, students would interview villagers for comments on what they like about their village and their expectations for education.

Angaiak mailed letters describing the project and soliciting involvement to science and math teachers in the other communities in the Lower Kuskokwim District. Although not everyone responded, Angaiak says she has "made a link with other teachers in the district who don't have ample opportunities to meet each other, even if only by name and on paper."

Angaiak says she also saw an increase in her own students' awareness of science related to the local environment as well as relying on their elders' knowledge in using and living in their land. "In many hidden ways," she says, "the elders used science to survive in this vast and sometimes harsh environment."

Introducing Student Mentors

With ideas about innovative practices and extra energy for trying them out, staff interaction flourishes. Some SMART participants have supplied fresh ideas and energy by guiding older students to extend a helping hand to the lower grades. These projects are described below.

SMART Approaches with Student Mentors

The Science Mentor Project. Kermit Tate, Jr., a teacher in Bruneau, Idaho, based his SMART project on the principle that rural secondary teachers *and their students* can become links in a learning chain which stretches from teacher to older students to younger students. Tate selected high school juniors and seniors who had demonstrated competence in chemistry and physics, as well as good character and communication skills, to become mentors.

"The problem we have is not what to buy, but how to show some of the elementary staff, who have never been able to buy their own science equipment, how to use the secondary staff's equipment," Tate says. "In order for us all to get the most out of the district's apparatus, we secondary science teachers need to give the elementary faculty a chance to get comfortable with it. How to address this problem? Enter the science mentors."

Mentors worked in groups to develop lab activities that illustrated basic physical and chemical concepts and presented them to younger classes. The exercises capitalized on the "gee whiz" factor to get attention, but also laid the groundwork for grasping concepts.

"For example," Tate says, "using a Van de Graff generator to make someone's hair stand straight up is a real crowd-pleaser; then the crowd can go on to learn the *reason* this happens." The high school aides gave written descriptions of their presentations to the elementary teachers so that they could recreate them in subsequent years.

Science Kits. While teaching high school science and math in Parma, Idaho, Don Lewis designed a project in which his students provided "good science on request" to elementary students. First he and advanced students created and catalogued kits to structure hands-on science activities for elementary students. Lewis did not merely announce their availability to elementary staff, but trained high school students to help the teachers use them. In the first year, there were 22 requests for demonstrations and lessons.

Science Fun and Awareness. Robert Emmons, who teaches seven science subjects in Hysham, Montana, led the elementary staff to set aside an afternoon for fourth-, fifth-, and sixth-graders to do science experiments in their classrooms. Emmons taught six upper-class high school students how to lead these classes, with such positive results that the principal invited him to adapt the project for the first three grades.

"The coordination of all the project elements was at times numbing, but in the end rewarding," Emmons says. "One of the rewards was the kinship that it opened between myself and the high school teaching aides."

The Master Science Project. In Brookings, Oregon, Rick Foster designed a mentoring project that involved middle school science students. The students interviewed elementary teachers about their needs for support in science education. Based on this needs assessment, the students, with help from Foster, created half-hour science presentations. The elementary teachers previewed these presentations before the students viewed them.

Foster, like other SMART teachers, makes no bones about the fact that taking the leadership of this project involved burdens as well as rewards. One difficulty was finding time to teach the master science tutors as well as teach his regular classes. But the increased awareness of elementary teachers' science needs—and the ability to help fulfill their needs—more than compensated for the burdens.

Stupendous Cooperation in Applied Math (SCAM). Karma Goodwin's advanced algebra students prepared and led engaging math activities for elementary students. "In preparation, algebra students identified and pilot-tested appropriate activities for elementary students: tangrams, word puzzles, star cut-outs, problem solving, and games requiring addition, subtraction, multiplication, and division," says the Northport, Washington, teacher. "Once they could run the games smoothly, they invited each elementary grade to the high school multipurpose room for 20 minutes. There, elementary students roamed from one game to another. At each game an advanced algebra student was ready to help the kids while teachers stood back and watched the fun."

Goodwin observed positive responses to the activities. "The project brought excitement into my advanced algebra classroom—my students were amazed at the amount of math in the games and enjoyed the boisterous afternoon with young children. Since all my advanced algebra students also take chemistry, next time we are going to put on a science show for the elementary grades."

"The project brought excitement into my advanced algebra classroom—my students were amazed at the amount of math in the games and enjoyed the boisterous afternoon with young children."

Karma Goodwin, Washington

The Contributions of Student Mentoring Programs

Preparing and guiding older students to demonstrate, tutor, share, and care eases the teaching and learning trail for younger children and their teenage helpers, as well as teachers of both these age groups. It also builds cross-grade support for innovation throughout the staff.

Student Self-Esteem. Goodwin says she saw self-esteem soar for older and younger students: "My advanced algebra students are the cream of the crop, superb role models. They usually are individuals who elementary students often see during athletic competitions and other school events. During a SCAM, one elementary student saw Jason, a starter for our basketball team, and ran to his table and stayed there for the rest of the SCAM. Later he told his teacher that he got to sit with Jason and that Jason told him he was good at math. This student struggled with math and had very low self-esteem. For 20 minutes one afternoon, he was on top of the world. Many of my algebra students later told me that they did not realize what an impact they could have on younger students and said that they felt like celebrities. I told them they were. It is clear that self-esteem was being built at all grade levels."

Learning Outcomes. Academic outcomes of such projects are also evident. For the upper-grade students, mentoring reinforces knowledge and adds understanding of teaching and learning. "The high school kids get excited about going into the elementary classroom," Foster says. "They learn basic concepts in a new way because they must be able to present their ideas to the elementary kids. They must have a solid grasp of the concepts—everything from how gears work to electricity, static, and AC and DC currents."

Teaching Outcomes. Student mentoring projects made it clear that working with more mature students to prepare activities for younger ones advances teachers' skills for instructing and relating to students. Teachers involved in mentoring projects found that helping secondary students to articulate basic concepts, select appealing activities, and relate to younger children illuminated their own classroom teaching.

Staff Collaboration. The staff as a whole gains from the introduction of older students as helpers. "Such programs increase communication among teachers about the math program, thus establishing ties for future curriculum efforts," Goodwin says.

Establishing Community-Oriented Events

SMART teachers prove that math and science can be useful and fun in a variety of settings. A number of their projects established community-oriented events to increase public awareness by breaking down traditional barriers that separate young and old, instruction and daily life, academics and social activity. These projects were also a strategy for developing community involvement in education.

"The time has come to improve the working relationship between the school and the community," says Ward Bond, music, math, and computer teacher in Tuntutuliak, Alaska. "Parents, other community members, and school staff are eager to work on committees and assist students in every way possible."

The Tuntutuliak community's enthusiastic response to Bond's rally was echoed in other communities where SMART teachers extended the concept of schooling in similar ways. Teachers' suggestions for widening participation include:

- Create special and festive events
- Invite people not usually involved in instructional activities
- Design activities for maximum motivation and learning

Local Science and Math Olympics. Extending already established events is one route to increase participation. For example, Karen Withrow, formerly a seventh- through 12th-grade teacher in Mt.Vernon, Oregon, recognized the value of Science and Math Olympiads for her community. At the same time, she regretted that it was often difficult for rural schools to send students to distant competitions. "In any case," she says, "only the top students are involved."

Local Olympic-like events (in non-rural as well as rural areas) have the advantage of being closer to home and including more students. Withrow, along with a team of science teachers from 10 schools in two rural eastern Oregon counties, simply adapted a Science and Math Olympics for local rural schools.

Math Fun Night. Other SMART projects created local events from the ground up. The Yup'ik Eskimo village of Tuntutuliak is located about 30 miles from where the Kuskokwim River empties into the Bering Sea. Ward Bond teaches math at the K-12 school, serving 90 students. The Tuntutuliak Committee for Involvement and Improvement in Mathematics, led by Bond, instituted a monthly Math Fun Night for students and community members.

At this math celebration, families spend the evening cooperating on math activities designed to increase their awareness of the role mathematics plays in local life. Each month the Math Fun Night committee selects a community member who uses math extensively in daily life to be the Mystery Math Person. On Math Fun Night, participants receive clues to this individual's identity, and the first to figure out "who this person is who uses so much math in our village" gets an award. A handout provides clues to help students figure out the individual's identity.

On one night, the handout for the village electrical meter reader, Gabe Olick, read, "In my work, I visit your house. I do not go in but I am there each month. I add and subtract, multiply and divide, but reading a code is my specialty. Who am I?"

"The number of students involved in the monthly gatherings has been remarkable," Bond says. "They obviously enjoy the sessions tremendously and keep asking 'When will the next session be held?' and 'Why not sooner?'

"In the classroom, I have noticed considerable improvement with the students' desire to learn mathematics. Having been exposed to the ways adults routinely use this valuable tool here in the village, the young people come to realize its importance in their own lives and their need for a strong math background. In fact, everyone who attends Math Fun Night—adult guides and student learners—expands his or her knowledge."

Math Camp. Another way to break down barriers surrounding traditional math curriculum is to offer it as an extracurricular activity. Carla Pfeifle of Power, Montana, took care to design a math camp for fifth- through eighth-grade students in her community that furthered the National Council of Teachers of Mathematics (NCTM) standards. The standards emphasize the crucial need for students to understand mathematical concepts, know how to apply them, and feel confident in their own abilities.

Recognizing these standards as she selected activities, Pfeifle emphasized "pattern recognition and strategy. Rather than elaborate board games, we chose simple games using manipulatives like beans, dice, egg cartons, and golf tees."

"One of our most challenging activities was the town survey," Pfeifle says. "The students paired up and went out to survey every household in town (there are 58 homes). Once back at camp, they compiled the results and drew bar graphs representing the information. We'll display these next fall for others to see and study."

Pfeifle says high school students who helped plan and run the activities showed "patience and empathy" as they worked with younger students. "They have come to view themselves as role models," she adds. "Often my best helpers are my poorest, most struggling math students. When we discuss our observations on the day following a Math Camp, they are the ones who pick right up on the different learning styles exhibited by the elementary students."

As a result of the activities, Pfeifle says

"They have come to view themselves as role models. Often my best helpers are my poorest, most struggling math students."

Carla Pfeifle, Montana

she developed a kinship with the fifth- through eighth-grade students. "They often drop by my room or stop me in the hall to ask when our next Math Camp will be," she says. "Better yet, they tell me how they showed their parents what they learned and ask me what the activities will be next time. They see mathematics in a whole new light, and are looking forward to continuing their involvement in mathematics."

Japanese/Alaskan Student Exchange Program. One SMART project suggests that community boundaries may be far-flung. The town of Shishmaref, Alaska, planned to reach out from its sand spit on the coast of the Chukchi Sea (100 miles north of Nome, and 100 miles west of the coast of Siberian Russia) to its sister city, Nakagawa, Japan.

"Shishmaref is an Eskimo community of 450 people whose economy relies on traditional Eskimo hunting, fishing, and handicrafts," says SMART teacher Rich Stasenko, who led the attempt to bring Japanese visitors to Shishmaref.

The idea, he notes, was to bring a different culture to his students, thereby opening new ideas and levels of understanding to them. "Through this contact with Japan, village students would learn about an unfamiliar geographical area and its inhabitants' diet, dress, and points of view," he says. "Existing pen-pal relationships between Shishmaref and Japanese youth would take on deeper meaning through face-to-face interaction."

Stasenko made detailed plans and preparations, learned and observed cultural protocols, coordinated home stays for the Japanese students in Anchorage and Shishmaref, and initiated fund-raising events and community donations.

Several months into the effort, Stasenko received word from the mayor of Nakagawa that they would like to visit in early August instead of late spring. "This proposal stymied me," says Stasenko. "Our school starts in late August and the community would be scattered in the country picking berries and gathering fish for drying. How could I possibly generate funds for a trip that occurred outside the school year?"

Not ready to give up, Stasenko tried again the following year, only to have the invitation declined. Stasenko continues to be optimistic, grateful that the correspondence program with the Japanese students survives, and hopeful of initiating an exchange with a Russian school in the future.

SEEDS OF CHANGE

In some ways, rural teachers are on the cutting edge of education.

Rural education can be a great place to put sound ideas into practice.

—Rich Stasenko, Alaska—

For many SMART teachers, the seeds of change have been cultivated through nationwide efforts such as the development of the NCTM *Curriculum and Evaluation Standards for Mathematics* and the American Association for the Advancement of Science (AAAS) Project 2061. Some of the curriculum improvement efforts of SMART teachers are featured in this chapter.

Spreading the Word for Reform

Terry Hurd and Colette Cozort are concerned that the national efforts at science and mathematics reform will follow the route of an educational bandwagon that disappears in a cloud of dust. Hurd and Cozort worked to bring the word about reform to rural teachers in addition to implementing the ideas of reform in their own classrooms.

Hurd, formerly with Endicott and St. John school districts in eastern Washington, calls upon all mathematics teachers to begin the real work of the mathematics standards—implementation. "It is the responsibility of all teachers who believe the standards are a tool to improve mathematics education to acquaint their colleagues with the standards," he says. "I fear that advocates will lose their momentum unless there is a grass-roots movement by each and every one of us to promote the standards."

This is not a responsibility that can be taken lightly or carried out by just a few teachers. Implementation begins in each teacher's classroom. "If you wait for your school board, administration, curriculum supervisor, or department head to start the ball rolling, you will have a long wait," Hurd says. "You must provide the impetus to begin and you must persevere in your efforts if mathematics education is to be improved."

Math for the 21st Century. Hurd aspires to better prepare students for life in the 21st century by improving their education in mathematics. He recognizes the vision for math education presented in the *Curriculum and Evaluation Standards for Mathematics* as essential for a young person's productive participation in the 21st century. He is concerned that the standards find their way into all classrooms and reach all students. With a goal of "presenting the standards to all persons involved in math instruction in the Endicott and St. John school districts," Hurd developed a workshop for K-8 teachers. It focused on examples of the kinds of mathematics instruction the standards recommend.

To meet the challenge of teachers who did not show an interest in the class, Hurd tried other less-direct approaches. "This has forced me to alter the delivery system of my material," he says. "Since I cannot force teachers to come to me, I am going to them by distributing written materials in their mail boxes. While this has not caused any of them to be willing to spend the time to attend a class or workshop, I have been asked for more material by a few. They are willing to look at the material on their own schedule, but do not have the time to commit to regular class attendance."

Perhaps the most compelling reason for any teacher reaching out to encourage others to change is Hurd's own awareness of change in himself. "The more I worked on my project, the more I found myself modeling the behavior suggested by the standards," he says.

Kisser to Kicker for Science Reform. Colette Cozort, a science teacher at Kendrick High School in the panhandle of Idaho, created the Kendrick Initiative for Science Reform (KISR). Cozort began her project by reviewing several publications from nationally recognized science reform projects, among them: *Science for All Americans* from the American Association for the Advancement of Science (AAAS) Project 2061, and *The Content Core*, Volume I of the Scope, Sequence and Coordination Project of the National Science Teachers Association.

"Small, rural schools are particularly suited for pilot programs involving articulation precisely because there are fewer parts to coordinate," Cozort says. "It is quite possible that rural programs may surprise everyone with new models."

Cozort's first priority was to create better communication among rural science teachers about reform initiatives. She conducted two surveys to determine the level of awareness and the interest in science education reform among rural teachers, and she presented science reform ideas to her own school board and district administration.

Cozort distributed surveys at two science and math conferences attended by mostly rural Idaho science teachers. She had about a 45 percent return rate. The results indicated that there is work to be done in spreading the word, but that there was an interest and willingness to change. "The most disheartening aspect of the surveys is that only a third of the respondents had heard specifically of the new math and science standards," Cozort says. "Mere awareness of the standards seems to be more common than familiarity; individuals often knew about reforms but were unaware of district plans. The good news is that 66 percent of the fall respondents and 75 percent of the spring respondents thought they would be willing to make time for reform efforts."

Cozort then experimented with reform-inspired strategies in her own classroom and building. She increased contact with the elementary classes, which included hands-on labs led by her secondary students. She also increased classroom dialog about science, using questioning strategies to integrate science concepts.

In one new strategy designed to draw out student interests, students selected special projects for 10 percent of their grade. These projects went beyond the typical science fair experiments. For example, some students conducted research for the local community development committee.

Cozort was sufficiently inspired by her KISR to continue her efforts under a new label, the Kendrick Initiative for Continuous Reform (KICR).

Curriculum Coordination Throughout a County

Many rural secondary schools are served by several elementary schools that are located in separate communities, often in separate districts, and sometimes at great distance from the high school. Schools in these dispersed systems face problems of coordinating and sequencing a curriculum. Rod Patten of Moro, Oregon, and Susan Wallace of Somers, Montana, developed new communication avenues among several rural districts and the high school, each hoping to improve coordination of curriculum, reduce redundancy, and align with state guidelines and national reform directions.

Sherman County Coordinates Mathematics Instruction. Rod Patten teaches mathematics at Sherman County Union High School, which serves three different K-8 districts in north central Oregon. He organized a local network of mathematics teachers that meets monthly. Attendance numbers have ranged from five to ten participants, with each of the four schools in the county represented at any meeting.

"Gaining countywide support was not as difficult as had originally been anticipated," Patten says. "By first soliciting the support and assistance of those persons known to favor the formation of the network, we were able to obtain the enthusiastic participation of all four school districts. At present, we have no problem obtaining release time for our meetings."

Patten's network made substantial progress toward the goal of coordinated mathematics instruction: There is now a list of skills necessary for success in mathematics at each level, elementary and secondary; they have reviewed current curriculum for compliance with the Oregon Common Curriculum Goals; they have investigated evaluation procedures under state guidelines; and they have prioritized problem areas in the mathematics curriculum to address in the future.

"The most significant outcome of this project has been that a medium of communication has been formed and main-

In 1988, almost 41 percent of secondary rural teachers in the United States reported having a great deal of influence over school curriculum policy compared to 36 percent for nonrural teachers.

tained," Patten says. "Each of the participants anticipates the next meeting and willingly shares concerns and successes. I have learned that my fellow math teachers were just as eager to share their concerns and ideas with me as I was to share mine with them. I now consider as friends those colleagues whom I really did not know nine months ago."

Patten also has seen direct and immediate benefits for his students. "Since I have a better understanding of the backgrounds with which my students enter my classes, I have been better able to shape my curricula to fit their needs," he says. "Previously, communication between the grade schools and the high school was so poor that I did not know exactly what material my students had covered before I received them. Now I have a direct line to their former teachers, and can check with them when I am in doubt."

Grade Level and Subject Sharing (GLASS). Susan Wallace teaches seventh- and eighth-grade science at one of 14 single-school elementary districts in Flathead County, Montana. Students from these K-8 schools will go on to Flathead High School in Kalispell. Wallace addressed countywide communication with a needs assessment, sharing sessions among the seventh- and eighth-grade teachers, and tours of the high school. During the first year, teachers from seven of the schools participated in tours and sharing sessions. Each of the 14 schools received GLASS updates from Wallace, which were distributed by the county curriculum coordinator.

Wallace extended GLASS in the second year of the project to address the persistent rural science teacher problem: access to resources. "My most consistent and difficult challenge has been a lack of supplies, equipment, and space," she notes. "This problem plagues those of us who use hands-on methods in developing math and science concepts. I have spent a lot of time searching for activities that require little in the areas of materials, time, and space. I call my method of teaching 'science, plain and simple.' "

Wallace reasoned that a thorough, well-organized inventory of science resources would support efficient sharing among teachers. She developed a communitywide science resource database. It included local science talent and school-owned science equipment with clear information on location and procedures for using student helpers to gather and return equipment. "Although the community talent response was not great in numbers, it was rich in gifted speakers," she says.

Wallace says that communication among teachers improved as a result of the activity. "GLASS has opened doors to allow a comfortable exchange of ideas and resources," she says. "Local rural teachers are eager for exchange. Unlike other professions, where the best ideas are trade secrets or ideas are sold for profit, the materials, resources, and ideas of the best teachers are shared. There is a wealth of ideas to share; teachers are willing to share. All that was needed was an opportunity."

District Coordination of Reform

Three SMART teachers from Idaho—Angie Lakey-Campbell of Cambridge, Kermit Tate, Jr., of Rimrock, and Karen Garrison of Castleford—led efforts to develop coherence across grades K-12 in their respective math, science, and technology programs. Each was challenged by varying levels of discontinuity in their programs and found that increased communication is often the richest reward when teachers work together across the grade levels.

A New Guide Improves Math in Cambridge. When Lakey-Campbell, a secondary math teacher, was asked by her principal to present new materials from a national math conference to the district's elementary teachers, she was surprised to find that only two of the seven elementary teachers present considered themselves math teachers. "I vowed to help our mathematics program at Cambridge find some direction," she says.

Lakey-Campbell began by coordinating an effort to develop a curriculum guide. She chaired a committee composed of two elementary teachers and the principal. Together, they wrote goals; researched sample curricula, state guidelines, and the mathematics standards; and wrote the curriculum guide. The curriculum was piloted and revised. The input from all the faculty has given direction for current and future activity: development of a quick reference guide, a companion scope and sequence, and grade-by-grade objectives.

In addition to the need for greater continuity in the mathematics department, Lakey-Campbell hoped to improve professional cooperation between elementary and secondary faculty. She credits a supportive principal for allowing release time to observe elementary teachers. "I now believe that if curriculum development is taking place, teachers should be given professional leave for visitation, even within the district," she says. "Many times, teachers feel they must go outside their district for professional leave and forget about the good teachers in their own backyard. Observing any good teacher is beneficial. I learned many things by watching a kindergarten teacher explain the concept of addition using colored beans. I presume the benefits of an elementary teacher visiting a secondary classroom would be just as great."

Lakey-Campbell had originally intended to have the school board adopt the revised curriculum, but feared that the process of communicating and sharing a vision for mathematics education might cease with adoption. "It will be more beneficial to our students if the curriculum is not adopted," she says. "Adopting the curriculum implies evaluation is complete. Because the needs of our students are continually changing, the curriculum must be continually evaluated. Constant evaluation will lead to more self-evaluation, reflection, and communication among teachers."

Rimrock Has a New Science Curriculum. Rimrock Junior-Senior High School is located in the Snake River Valley of southwest Idaho. According to science teacher Kermit Tate, the school is "nine miles from nowhere in either direction." When the communities of Bruneau and Grand View (serious rivals, 18 miles apart) consolidated to form a single school district, they were unable to agree on a site for the new school. As a result, they built it halfway between the two communities.

The science curriculum in Tate's district needed an overhaul. "Our science program was patchwork, dependent on individual instructors to develop programs," Tate says. "This led to gaps and overlaps in covering different areas of science. It made selection of text materials more difficult. It placed a large burden on teachers who were non-science specialists."

Tate chaired the science curriculum committee that developed a fully articulated K-12 science curriculum. "The two most important factors in producing a workable document," he says, "were the close cooperation and respect among members of the curriculum-writing committee, and the active support and encouragement of our administrators at both district and building levels."

It is essential, Tate says, that elementary and secondary staff "develop an atmosphere of mutual trust and support, preferably before attempting to construct the curriculum."

Technology Gets Integrated into School and Community. Karen Garrison grew up in Castleford, Idaho, just north of the Nevada border and close to Balanced Rock, a distinctive landmark and tourist attraction. She now teaches math at the only school in Castleford, serving nearly 350 K-12 students.

Garrison found that the district's sizable investment in high-tech equipment was underutilized. "Despite incredible technological advances in equipment and the availability of high-quality, inexpensive software in virtually every subject

"Because the needs of our students are continually changing, the curriculum must be continually evaluated. Constant evaluation will lead to more self-evaluation, reflection, and communication among teachers."

Angie Lakey-Campbell, Idaho

area, the computers in our schools still tend to be used in isolation—mostly as word processors or for programming by a small, select group of students," she says.

Garrison also was bothered that a satellite delivery system, in place for several years, was rarely used in the school and never used by the community even though there was interest and need for distance courses.

Garrison began a program of organization and awareness focusing on a well-run computer lab in the first year and a full complement of satellite-delivered courses during the second. She surveyed teachers, students, and the community for software, school-related inservice, and community-education needs; catalogued and organized existing software and related print materials; and purchased additional equipment.

To increase awareness and use of the computer lab, she presented a school-wide half-day inservice with follow-up practice sessions for the faculty. Each student was also trained in basic computer operations as well as lab procedures. Garrison also conducted a community open house, and made a presentation to the school board to increase community awareness of the lab and the distance delivery opportunities.

Garrison's efforts have brought results. "Increased use of the computer lab by students and teachers is notable," she says. "It has been used by students in many different subject areas. I would bet that the lab was used more this year alone than in its previous four-year history. The school board has been so impressed by comments from staff, students, and parents that they voted to remodel the lab, enlarging it so that more students can use it next year."

Garrison reports some success with identifying teleconferences and courses of interest to the community. At least one group, the Quick Response Medical Unit, is ready to schedule classes.

New Courses for All Learners

To respond to the diversity of learning needs of their students, three SMART teachers developed new science or math classes. In small classes, individual differences in background, ability, and learning style are not subsumed in large numbers of students. The differences are pronounced and demand multiple approaches to instruction which often require teachers to customize or create a new course. That's just what Paul Dunster, Patrick White, and Leonard Pratt have done.

An Activity-Based Course for Grades Five and Six. Washtucna is located in the dry wheat farming country of central Washington about 80 miles southwest of Spokane. Paul Dunster has taught most of the science and some of the math for grades seven to 12 at the 45-student Washtucna High School.

When faced with teaching a semester-long science course to a combined fifth- and sixth-grade class at Washtucna Elementary School, he decided to make some changes. The traditional presentation method, structured around an elementary science text, was mildly successful.

However, Dunster sensed that for many students, curiosity and interest in science was low and frustration was high. He also knew that the group demonstrated variety in learning styles and comprehension ability. He decided to offer an activity-based course that emphasized doing rather than learning about science.

Dunster chose a sequence of topics for the semester, sought out resources and ideas for activities to address the topics, and customized the activities to fit with available resources and local interests. He also encouraged greater parent involvement through take-home projects, science fair projects, and two science camps scheduled in conjunction with swimming lessons at the beginning of summer.

"Student interest in this program was rewarding," Dunster says. "Most of the class enjoyed doing the activities and appreciated not using the textbook. Many students tried extensions of the activities at home and I never heard 'I hate science' from the group."

However, he was concerned that students would not link activities successfully to underlying scientific concepts. The first weeks served as a test of his reservations. "My concerns," he reports, "proved valid in that the students, in general, did not draw correct conclusions about the phenomena they were observing."

Dunster began to supplement with reading and questioning activities. Student responses to questions began to demonstrate understanding of the basic ideas and also produced "spontaneous elaborations on topics," which Dunster described as "entertaining and ingenious."

"I have no doubt the class was valuable to most and any missing concepts will be picked up easily later on," Dunster says.

A Practical Physical Science Course. At best, students in small, rural schools are offered the typical complement of four high school science courses: earth science, biology, chemistry, and physics. In Idaho, a recent increase in graduation credits requires all college-bound students to take a third year of science, which means either chemistry or physics in a rural school.

The requirement concerns Patrick White, math teacher at Clark Fork High School in northern Idaho. "Many of these students are not intending to pursue careers or vocations that require a math-based college preparatory chemistry or physics course nor do they have the math background required for those courses," he says. "Therefore, they are in a situation in which they may very well fail the course or pass with a charity grade given by a teacher who knows they need the credit for college admission."

White worries that such students "not only put in a great deal of time and effort with little to show for it, they may have also come to think of themselves as failures in the field of science." White proposed a new course, Practical Physical Science, which integrates chemistry and physics and focuses on science literacy as laid out in the recommendations of Project 2061. He emphasized application and processes with students working in cooperative groups to discover the concepts of physical science.

When the district withdrew support for purchasing a text and materials, White proceeded with the course anyway. "I had to improvise, borrow, and buy materials for the many experiments and hands-on activities we have done," he says.

His reward was results. "Several students have shown an increased interest in science. Two students, in particular, are taking a much more serious approach to the class. They often take home the experiments we do in class to show to their parents and seem to take a great deal of pride in doing so."

At the end of the year, White faced a dilemma. "Without a textbook, you have more freedom to be creative and try innovative ways of teaching," he says. But he paid a price. "Without some sort of guide or long experience teaching a class, preparation time increases dramatically. I had five other different classes to teach, and this class took more preparation time than the five others combined." The

Every state has rural schools, ranging from South Dakota with 76 percent rural schools to Rhode Island with 4 percent rural schools.

price was too high and White did not offer the course the following year.

Multicourse Classes. Leonard Pratt of Huntington, Oregon, has taught mathematics for 30 years in rural schools. In that time he has taught several classes where multiple math courses are offered during a single class period. This is a common phenomenon in very small schools where perhaps 10 or fewer students need advanced math courses. In such a class, there are, for example, a few students taking algebra II, a few taking trigonometry, and a few taking pre-calculus. The math teacher structures activities that alternate interaction with the teacher with individual and student group work.

Over the years, Pratt has observed that students in his multicourse classes are able to learn many topics from courses other than those in which they are enrolled. Therefore, once they are formally enrolled, they already know many topics for that course quite well. Pratt is concerned that traditional enrollment constrains students from getting credit for learning material in this way and does not allow them to progress without repeating learned material or waiting a year for the next course.

Pratt has devised a system of grouping courses into levels that can be learned together. Students choose, complete, and challenge courses in the same level before they can move on to another. They take whatever math course they feel they are ready for, not necessarily in a traditional sequence, and some at the same time. One of his students, for example, took both pre-calculus and analytic geometry during the same time. To meet state requirements, the student challenged the analytic geometry course.

Pratt finds the method works well for students. "They prefer to choose their own courses in order to fulfill a goal," he says. "They have no time to get bored."

Initially, some students are confused or need to learn what is expected of them. "I had to emphasize to the student that I was not able to plan their future and that each student had to participate in the program knowing that his/her education would be more meaningful," Pratt says. "Such a plan as this just wouldn't work in the classes of more than 20 students—I'm doubtful that a class of 10 students would be very easy. My classes this year are all less than 10 in number."

EXPLORATION AND DISCOVERY

I could spend the entire school year on the DNA molecule, and Ph.D.'s spend their entire lifetime on it. So how, pray tell, can I teach all there is to know in biology, chemistry, physics, and all the other disciplines? There are some fundamental concepts that are integrated across the curriculum, and we can teach certain skills to students that will be life skills, if you like, so they will be able to go out and be successful people. —*Don Parker, Oregon*—

SMART teachers found the going rough at times, but their disappointments were offset by the adventure, risk-taking, and unexpected discoveries inherent in their pursuits. In this chapter, we look at the progress students made in 18 SMART classroom projects. Eleven projects involved curriculum integration and seven focused on other means of improving classroom practice—graphing calculators in mathematics, portfolios for assessment of mathematics and science learning, and cooperative learning in science classrooms.

Project-Based Curriculum Integration

One of the most natural and effective ways to integrate curricula is to center learning around a practical project. When students have authentic interest and exercise significant choice in project activities, they are motivated to seek and apply knowledge and skills in many disciplines. Three SMART teachers used student projects in this way. One of these projects employed a traditional art form, quilting. Another used a more modern art form, video production. And the third resulted in theater productions.

Blanket of Success. Shirley Preszler taught math, science, and other subjects to fourth- through 12th-graders on Atka, an island in the Aleutian chain off the coast of Alaska. The island's 90 residents rely on subsistence and commercial fishing, reindeer hunting, and about eight wage-earning positions. Preszler sought to involve the community in education and create new occupational possibilities for their youth. Preszler created the Blanket of Success, a student-quilting project that enabled her to further these aims.

In Preszler's classroom, the Blanket of Success became a learning laboratory of activities that lasted the school year. Students learned to apply the knowledge of measurement, fractions, angles, and geometric forms in the quilt design phase. A unit on materials science addressed the properties of fiber, fabric, dye, and detergent as well as weaving patterns and construction techniques. Students also gathered their own materials and learned how to use sewing machines. Throughout the year, students generated personal portfolios, including cost analyses, project reports, photographs of finished quilts, and other items depicting their learning. Preszler tracked their grasp of computation and design concepts through journal entries.

The project also built relationships between the classroom and the community. Preszler presented the project idea to the Aleutian Region School Board and the Atka community, and built initial public support through newsletters and posters. Students presented progress on the Blanket of Success to the community during an open house at the school.

Community participation in such an unconventional school activity opened debate about new educational ideas. "Many parents need to see students 'suffer in the text' through traditional teaching techniques," Preszler says. "This need can lead to an unsure feeling among community members even when they are delighted at public displays of final projects. But with continued efforts and open parent/school communication, I believe parents will become more comfortable with cooperative and holistic educational methods."

Preszler's students noticeably improved their standardized test scores after less than a year of the Blanket of Success project. Special needs students were particularly enthusiastic and determined to complete their blocks in the quilt.

The project's successes may have been due to the integration of subjects and application of knowledge to practical activities. Or perhaps motivational forces—the use of peer tutors and volunteers, along with the teacher's excitement about leading a new kind of learning—ushered in the advances.

The Blanket of Success convinced Preszler to use a project-based approach in other areas as well. "It lessened my fear of straying off-text, and encouraged me to teach thematically throughout the year," she says. "In English, reading, literature, mathematics, health and safety, science, and study hall, I now teach thematic cross-curricular units on wolves, whales, body organs, drug and alcohol abuse, mountain building, earthquakes, and volcanoes."

Music Video Production for Teaching Science. Jim Warren teaches elementary and advanced sciences in Midvale Junior-Senior High, Idaho's smallest school (enrollment: 50). Warren and a group of his physics students had previously created a music video to illustrate a science concept. He was impressed with the level of student motivation and understanding of critical science concepts when they developed their own video. He decided to extend the approach with his junior high students with hopes that high student interest would insure success for the low performers in the group.

Student teams began by choosing from a list of topics, such as muscles or circulation. To develop the concept, students combined taped segments of student demonstrations, existing video footage, titles, graphs, and narration. Student teams were responsible for outlines, scripts, and conferences with Warren as their project progressed. "No longer did they come to class asking, 'What are we doing today?' " Warren says. "Instead, they came prepared to work. Students were spending three to four hours after school, weekends, and vacation time setting up experiments and demonstrations to film, gathering existing video footage, and editing their music videos without prompting or prodding. And their work was creative. They even invented new editing and titling methods."

The activities transformed student learning into a form of personal art. "Some students became very possessive of their projects, even resenting my suggestions," Warren says. "I had become the resource person—not the traditional teacher."

Integrating Science and Math and Theater Arts. Ed Armbrust has taught mathematics for 26 years at Rainier High School, located 45 miles west of Mt. Rainier in Washington. A graduate student researching educational theater joined the staff to complete her thesis and teamed up with Armbrust, the science teacher, and the drama class to create a half-hour assembly for upper elementary students.

The fourth-, fifth-, and sixth-grade teachers submitted a list of possible topics to the drama students, who then selected five: Brownian movement, Bernoulli's Principle, territory/aggression, mitosis, and recycling. Teams of students researched a topic, created and wrote a skit, found props, and selected music. Armbrust and the science teacher served as consultants for students who usually remembered learning about the topic ("Didn't we learn this last year?"), but needed deeper comprehension to design a dramatic portrayal.

The final production was called *Wayne's World of Science*, a take off on popular television and movie characters Wayne and Garth. It presented five segments with Wayne and Garth as narrators and a special guest appearance by pop singer Madonna's mom. The young students enjoyed the show as much as the older students enjoyed presenting it. The elementary students retained a surprising amount of content, as shown in their responses to a follow-up worksheet. The following year, students presented an adaptation of *The Three Little Pigs* with math content.

Inspired by the success of educational theater, Armbrust experimented with another form of artistic expression called sculpturing. Classmates serve as the materials for a sculpture, which depicts mathematical concepts such as random, order, proper fraction, and others. The sculptor selects and places people to express a concept, then explains how the sculpture represents the concept. Other students may modify the sculpture and embellish the meaning. Armbrust has experimented with variations, such as placing all stu-

In 1988, 97 percent of rural eighth-graders were enrolled in science classes, more than either urban or suburban students.

dents in a sculpture to depict perimeter vs. area of a square. He thinks that for certain learning styles such tangible and kinesthetic experiences lead to a better understanding of concepts.

Integration of Curriculum Around Themes

Students engaged in a project-based approach focus on a product, performance, or service. In contrast, those following a thematic approach select activities to illuminate a concept or topic. Three SMART projects based innovative instruction on themes. In one, students investigated penicillin. In another, they looked at presidential elections. And in the third, themes were used throughout the school and across the grades.

The Story of Penicillin. At the head of the John Day River Valley in Prairie City, Oregon, Don Parker teaches all science classes, from kindergarten through 12th grade. Taking a leadership role in the integration of science with other subjects, Parker shaped a thematic unit combining the study of the history and biology of the antibiotic penicillin.

"In order to make informed decisions, students need to know how past discoveries of science and math changed the moral, ethical, political, and social structure," he says. The way to teach this, Parker believes, is to show how one specific case—the discovery and medical use of penicillin, for example—had far-reaching effects on human welfare.

The sequence of activities Parker used for exploring the development of penicillin followed Benjamin Bloom's taxonomy of thinking skills, proceeding from lower- to higher-order cognitive processes. Students first received information on the story of penicillin: then they synthesized it, applied it to other contexts, and analyzed it. Finally, they evaluated the historical decisions regarding the development and use of penicillin and related their conclusions to similar issues in medical research (and new scientific knowledge, in general) today.

The Mathematics and History of U.S. Presidential Elections. Alex Rajala teaches high school math and science in Pe Ell, Washington, a small timber town about 120 miles southwest of Seattle. Rajala combined math and social studies in his SMART project, which focused on the theme of elections.

In 1992, the year of the Bush/Clinton presidential campaign, Rajala's students studied and simulated 12 other U.S. presidential campaigns. Students worked in teams and applied their knowledge of mathematics and U.S. history to bid points (representing time, money, and influence) in their attempt to win party nomination and the presidency. They learned the principles of electoral methods through simulated primaries and caucuses, party conventions, and general elections. For example, they learned about proportional and winner-take-all systems, and the differences between primary and general elections and a plurality system. The system itself, they learned, can lead to dramatic differences in electoral outcomes.

"In my algebra and logic classes, we campaigned under several different sets of rules," Rajala says. "It startled students to see that different counting methods could give victory to different candidates." In calculating simulated election results and tracking real ones, students grasped the way successful campaigning in states rich in electoral votes can pay off more than dedicating equal campaign time and dollars to all states.

"As they began to understand a winning strategy, they wanted to redo several stages of the campaign," Rajala says. "Another suggestion was to run a student convention modeled on the party convention during which a candidate would attempt to form a winning coalition. That one sounded like a good exercise for my speech class."

Schoolwide Themes. Maureen Michael has coordinated a schoolwide theme approach which runs throughout the year in her K-8 school in Orient, Washington. The entire staff selects a series of themes

for the year and each classroom develops projects and activities around the theme. For example, for the first theme, each classroom completed a project on patterns. "All the work was displayed on the walls of the school for all to enjoy," Michael says. "This ran from simple repeated patterns and growth patterns through tessellations."

Michael says students benefit from the research at various levels. "They can see that at each grade level you can learn even more about a given subject," she says. "They are actively involved and excited about seeing their work on the walls of the school."

In addition, the teaching staff can address broad goals for all students in a coherent fashion. For example, older students are enhancing their communication skills by learning to present material about their projects in front of others. "I think the overall benefits have been in the increased interest in science and math and continued growth and confidence in those areas," Michael says.

Teacher Teams for Math and Science Integration

In many cases, a small school staff presents an opportunity to integrate math and science curricula that may not be present in larger schools. Teachers may already teach several subjects and have their interrelationships in sight, and they may teach the same students in several different classes. As a result, relaxing traditional constraints to merge classes and relate their content to real-world needs may be relatively easy. The logistics of teamwork also may be simpler for people who already live and work in close proximity.

Field Study and Analysis of Data on Rodent Population. The advantages of a small school staff operated for SMART math teacher JoAnn Arthur in Richey, Montana, as she collaborated with a science teacher in her school to design and lead student research on the rodent population. The AP biology class established a web of 100 small mammal traps in an area at the edge of Richey. For five consecutive mornings, students ventured onto the grassy plains of northeastern Montana, checked the traps, and marked any captured rodents by clipping their toe nails. The data included total caught each day and the number recaptured, or marked.

Arthur and the science teacher had arranged the schedule so their advanced classes met at the same time. During the unit, they combined four advanced science or math classes for a two-hour block. Arthur guided the students' statistical analysis using chi square and measures of variance. "The students felt like they were truly applying math and science," she says. Students extended their research into several additional disciplines as they took photographs of the rodents, wrote final reports, and prepared an article on their findings.

The Adventures of Jasper Woodbury. When Kay Wright and Norman Palmer at Pleasant View Middle School in Milton-Freewater, Oregon, teamed up for a SMART project on problem solving, they used "The Adventures of Jasper Woodbury." The video-disk series dramatizes complex, realistic problems that require the application of a variety of thinking skills. For example, "The Big Splash" episode challenges students to figure out a cost-effective way to use a dunk tank for a fund raiser.

After showing each episode to their eighth-grade math and science students. they grouped students into teams to solve problems. Groups often took up to a week to reach their solutions before presenting them for teacher review and suggestions. In conjunction with the program, Palmer and Wright taught strategies for both cooperative learning and problem solving. Students kept journals on their problem-solving processes and reactions to the class.

Student response was enthusiastic. Although they appreciated the freedom to explore the problems independently, the main draw seemed to be the intellectual challenge of the problems themselves. One student judged the material difficult "because you had to have taken great notes and you had to have well-used mathematical brain waves."

A Snow Job. SMART teachers Karen Withrow and Diana Prichard in Sisters. Oregon, conducted a parallel design and construction activity in two separate classes. The project. called A Snow Job. brought home the importance of science and mathematics in students' lives.

During the winter of 1992-93. an unusually heavy snowfall severely damaged sections of overhanging eaves on the new Sisters High School. Withrow and Prichard saw learning opportunities in the misfortune. "This winter has shown us the importance of buildings being designed to hold a heavy snow load." they wrote in an assignment sheet for A Snow Job. "The purpose of this project is to design a model that will hold the maximum snow weight."

Withrow and Prichard established guidelines for the type of structure and materials. and the students applied the principles of math. science. and technology as they diagrammed. built. and tested their structures. Students also wrote about their efforts and insights and presented them orally in a formal competition.

Finding time for collaboration on this project posed a challenge for Withrow and Prichard. who had to solicit materials donations from community businesses. consult with the school's technology teacher. and set grading criteria. They also needed to coordinate their class schedules and revise the curricula in order to incorporate the new instruction. Most of their project meetings had to be squeezed in after school or on weekends. Occasionally, they moved the project along through phone calls.

But Withrow and Prichard have no regrets about the collaborative effort they invested in A Snow Job. "Students enjoyed the project." Withrow says. "Final evaluations showed that they did apply all three areas of knowledge, showed real learning, used thinking skills in creating and evaluating the structures. and could see the application of this activity to the real world. The project was a valuable addition to the curriculum."

Technology Curriculum to Integrate Science and Math

Technology curriculum encompasses several domains where science and math are applied. including principles of engineering and design. Such curriculum offers high motivation for students to use and apply science and mathematics principles. in addition to integrating science and mathematics in a natural and relevant way. Three SMART teachers in Alaska developed and implemented technology curriculum units in their schools.

Cube Cove Careers in Engineering. Joe Quinn. math and science teacher in Cube Cove. Alaska. had his upper-class students engineer a section of road near their town. The goal of this SMART project was to provide students with real-life applications and problems. By working as apprentices to professional engineers. the students explored career options and opened opportunities for summer internships.

The context of real work held advantages for academic and practical learning. One advantage was the authentic feedback on the quality of student work. "The section of road they are working on needs to be completed by mid-summer, so they'll be able to see if their work is satisfactory before school is out," Quinn notes. "The problems my students dealt with while working with the engineer were sometimes the very same type as our class work."

Quinn recalls the complex skills students applied in the vocational context: "The first step in Cube Cove Careers was to learn how to read aerial photographs," he says. "After this initial survey, the students went to the road site to collect data. Road material, grade, water run-off, and location are all critical elements that need careful attention before roads can be built. All road building begins with compass work: Each student has learned how to read and take headings using the compass."

This attempt to integrate subjects and apply them in a non-school setting met some resistance. "The camp boss was skeptical at first that the students would use their time wisely," Quinn says. "To assure him that they would truly benefit from this experience, the engineer and I wrote up an outline describing the plan of action for the students. After reading the outline, the camp boss was very positive about letting the students proceed."

Computer-Aided Design and Drafting. Melvin Henning teaches in Whittier, Alaska, a community where 80 percent of the population live in one 14-story building that formerly served as a U.S. Army barracks. The school offers few electives, and Henning is concerned about students' limited options in preparing for careers and college.

Henning, who has a background in engineering, has developed an up-to-date course in computer-aided design and drafting. The course helps some students develop skills that will be marketable in Whittier and prepares others for higher education in technology, materials science, computers, engineering, and related fields.

In planning his project, Henning took into account his students' characteristics and surroundings: "In Whittier," he notes, "students have shown a desire to work with their hands and to design and construct things. The perfect opportunity awaits those who can build aluminum boats. The town lies in a protected harbor with direct access to Prince William Sound. Aluminum welding and boat construction could be part of the overall program."

When school construction delayed student access to equipment for boat design and construction, Henning adapted the project by incorporating design for buildings in a new subdivision between Whittier and nearby Shotgun Cove. Students also learned how to produce logos for local businesses.

Henning found that the value of his instructional approach lay in its combination of practicality and idealism. "Whether they design boats or subdivisions, solve engineering problems or conduct scientific investigations, they inevitably involve themselves in socioeconomic and personal values with goals for success," he says.

Fundamental Materials Design Across the Curriculum. Larry Preszler, a teacher in Atka, Alaska, finds inspiration in the work and words of noted designer Buckminster Fuller. "Good design," said Fuller, "is an innovative, highly creative, cross-disciplinary tool responsive to the true needs of man."

Such thinking fueled Preszler's SMART project to teach upper elementary students materials design across the curriculum. "Design fundamentals can be taught in a cross-disciplinary manner to ready students for further study in higher math, graphing, drafting, materials science, and other technical applications," says Preszler.

A survey of parents in the Aleutian Region School District, Alaska's smallest district (30 students and 4 teachers), strengthened Preszler's resolve to teach materials design. Survey results pointed to inadequate opportunities for vocational education, a common need in small villages in Alaska, where equip-

Two out of five of the Northwest region's 1,306 districts are rural *and* isolated, located more than 30 miles from a town of 15,000 or more.

ment, facilities, materials, and skilled technical personnel are scarce.

"Students will learn to plan and construct projects that satisfy design criteria," he notes. "First they will construct simple items in two dimensions, using black and white paper only. Students and teachers will evaluate these early endeavors. More variables will be added to the next assignments: dimensions, colors, and materials. The early teacher-generated projects will be replaced first by projects determined through student and teacher collaboration, and later by student-generated designs. Students will record their decisions in a log, sketch and draft project designs, and, finally, combine these records in a poster along with pictures and video."

This project fulfills a long-harbored professional aim of Preszler's to start a cross-curricular program that takes advantage of several subject areas and combines them with physical talents and skills. "My difficulty had always been that I teach many grade levels at the same time, with many learning disabled and special education students in each," he says. "This bogged me down with regular classroom instruction to the near exclusion of cross-curricular innovations. After testing the waters slowly, I was able to meet my district curriculum requirements and combine elements of science, math, art, language arts, computer keyboarding, and basic construction techniques."

For Preszler and his students, curriculum integration paid off. "As the students' projects were completed, I began to see a structure emerging in my classroom that enhanced the pattern of students' regular classroom experience."

The project will influence Preszler's teaching on a long-term basis. "Now that I have used cross-curricular instruction to reinforce the teaching in each discrete subject area, I am much more comfortable about incorporating the techniques I have learned into my future teaching," he says.

Exploring New Approaches in the Classroom

Some SMART projects took a direct approach to reform by identifying teaching methods that yield positive results in classrooms around the country and honing them for rural science and math instruction. SMART teachers employed graphing calculators, cooperative learning, and portfolio assessment to enhance student learning.

Using Graphing Calculators to Teach Mathematics

"Scientific calculators with graphing capabilities soon will be available to all students at all times."

—National Council of Teachers of Mathematics

To an outsider, the 100-student school in Cordova, Alaska, where Dick Shellhorn teaches five high school math classes, may seem isolated. After all, there are no roads leading to Cordova, which is accessible only by plane and state ferry. But by carrying out a SMART project that recognized NCTM's expectation, Shellhorn has placed his students on the cutting edge of mathematics education.

Shellhorn incorporated the graphing calculator into each of his five classes. In his advanced math class, for example, he taught students how to program the calculator so they could see the effects of period, amplitude, phase shift, and vertical translation on sine and cosine curves flash across the screen. "They were awestruck to see asymptotes appear before their eyes and were soon predicting from the nature of the equation where asymptotes would occur," Shellhorn says.

"Each Cordova High math student can operate a graphics calculator," he adds. According to a student survey, each student also considers graphing ability to be valuable for problem solving.

Shellhorn's incorporation of graphing calculators also led to changes in other classroom practices. For example, to evaluate student progress, students worked cooperatively to solve problems both with and without calculators and write summaries of their processes and conclusions.

Cooperative Learning Structures in Biology. Mel McWhorter implemented cooperative learning structures in his science classes at Waitsburg High School, located in southeast Washington. McWhorter, who has taught in rural areas for 13 years, believes that cooperative learning helps students to:

- Participate actively in many types of science activities (rather than just laboratory sessions)
- Apply scientific concepts and vocabulary to realistic problem-solving assignments
- Develop communication skills through interaction focused on science
- Practice setting and achieving group goals for scientific endeavors
- Take responsibility for their individual work that is accomplished in cooperation with a group of scientific colleagues

McWhorter says that cooperative learning also emphasizes student-centered learning. When McWhorter's principal visited his room for an observation, the focus was clearly on student learning, he notes. "The principal entered my room, took out his notes, and prepared to observe the teaching process. Instead, he observed 55 minutes of learning as students worked intently in groups on the project we had discussed at the beginning of the period. Cooperative learning had put the focus on student participation, and I was not the center." But cooperative learning, McWhorter says, is much more than sticking kids in groups and telling them to solve problems. "After reading about the great benefits of cooperative learning, I promptly prepared a lesson, put the students in groups, and let them go. Disaster! About all that happened was that the students had a good rap session and made noise."

McWhorter followed the advice of leaders in cooperative learning to introduce one new structure per month. "By the end of the year," he says, "I had learned nine new formats. More importantly, the students had learned them as well and were able to use them easily."

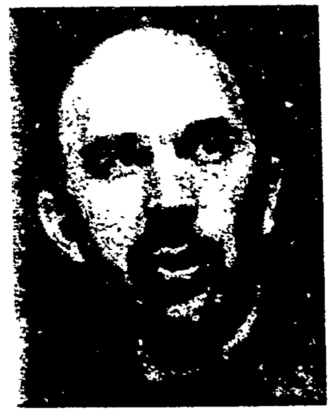
"The skills required for these structures should be taught," he adds. "Students cannot be expected to perform under completely new parameters without guidance. Again, it is best not to go too fast. I started with group projects that did not require social skills and progressed to more complicated projects as skills were learned."

The positive consequences of McWhorter's efforts came not only from cooperative learning, but also from the careful process he followed to implement it. "In the short time I have used cooperative learning, I have seen an improved attitude in both the students and myself. My students are more actively involved because my lessons have much more variety and organization. I am much more comfortable with the approach I am trying to incorporate into the classroom. By easing into it one step at a time, I have maintained a positive attitude and enjoyed the journey."

Cooperative Learning in Chemistry Labs. Larry Brown teaches math and physical science at Cusick High School, located along the Pend Oreille River about 50 miles north of Spokane, Washington. Brown's SMART project gave his chemistry students opportunities to express ideas and get feedback from their peers that would be, as suggested in the report from Project 2061, "analytical, suggestive, and come when students were interested."

In Brown's chemistry laboratories, however, conflicts between lab manual directions for exercises and the requirements of cooperative structures spurred further innovation. During early trials of the cooperative structures, Brown observed that students tended to do the entire exercise rather than specialize on the assigned tasks and cooperate to enhance their learning.

"This led rapidly to a ho-hum attitude



"In the short time I have used cooperative learning, I have seen an improved attitude in both the students and myself."

Mel McWhorter, Washington

"Some students don't take to heart suggestions from a teacher. How much better if they come up with their own strategy."

Diana Prichard, Oregon

of going through the motions." Brown notes. "I overcame this situation by giving each student a similar lab from a different author, then having each student present what he or she learned about safety, background, procedures, and outcomes."

The students, he reports, quickly became critical readers of the manuals and had different lab experiences to impart to one another.

Portfolios in Math and Science

All SMART teachers attended a session on portfolio assessment at the first SMART academy. Three of them went on to create projects that would introduce the use of portfolios as a classroom assessment method to improve evaluation and promote instructional innovation. Each project emphasized elements in a definition of portfolios used at the academy: *A portfolio is a student's self-selected, self-reflective documentation of growth in understanding and skill over the period of one school year.*

The broad goals behind the portfolio project of Diana Prichard, eighth-grade math and language arts teacher in Sisters, Oregon, were similar to those in all three portfolio projects. She aimed to:

- Structure students' active participation in their own learning
- Encourage communication among students, teachers, and parents about what students have learned
- Provide additional assessment tools to reveal student progress and needs
- Establish a permanent record of student activities and abilities

Portfolios in Education Project (PEP). Prichard was ready to expand her prior success with portfolios in language arts to her mathematics classes in Sisters, where students were attending after being bused to a larger school 20 miles away for 25 years. It seemed an appropriate time to initiate a new assessment innovation along with a new school.

Prichard and a fellow math teacher worked together to initiate the portfolios project. Students selected works from four categories: journal entries, tests and writings about thought processes applied in them, problems-of-the-week and methods for solving them, and products of a variety of other math activities. Students and teachers held regularly scheduled conferences to discuss the contents of their portfolios and the learning represented by each student-selected piece. By the end of the year students were leading their own parent conferences and presenting their portfolios.

Whether reflective writing in journal entries or written explanations about missed problems on a test, Prichard and her students have new avenues for communication and understanding of what learning has or has not occurred. On one occasion, two students who missed the same problem wrote descriptions of the thinking processes they used to solve it, Prichard recalls. "By reading their explanations, I gained important information for re-teaching. One wrote, 'I didn't know what *prime factorization* meant.' The other wrote, 'I didn't know what *express* meant.' " The two students missed the same problem for very different reasons, notes Prichard. "One did not understand the mathematical concept of factorization, the second had a general vocabulary problem."

She points out another benefit of writing about missed problems on a returned test: "It can help a student decide for himself what method to use for improving his performance. Some students don't take to heart suggestions from a teacher. How much better if they come up with their own strategy. One student who did so put it this way: 'I missed points because I made dumb errors. I dropped a sign. I need to pay closer attention and check my work.' "

Prichard also found that portfolios broadened her own instructional repertoire. She relies less on the algebra text and more on a variety of enrichment materials and open-ended assignments. Since these assignments often require written responses, students also benefit from the integration of writing into the math curriculum. And as students and teacher communicate about math concepts, their shared and expanding knowledge—rather than grades—becomes the natural agenda for student/teacher conferences.

Introducing Portfolios in the Science Classroom. For Mel McWhorter, SMART represented an opportunity to adapt portfolio practices to his earth science classes. The hallmark of McWhorter's approach to portfolio implementation was the care he devoted to the change process itself. McWhorter's efforts with portfolios followed on the heels of his earlier SMART project with cooperative learning strategies. His success in developing these group work strategies in his classes had taught him that gradual steps, carefully charted, are the effective way to change.

"I didn't even have a very good feeling for what a portfolio is, let alone the full value of it," McWhorter says of his earliest efforts. McWhorter reviewed research on portfolio use in education, which allowed him to give much better direction to the students. Throughout the year, he continued to inform his practice with models and other ideas from his research. He also planned his own evaluation of the project as well as evaluations by the school principal and English teachers. This created a project component that would tell him whether his project was effective and why (or why not).

McWhorter also allowed his students to become familiar with portfolios gradually. Throughout the 1992-93 school year, he gave them the time necessary to assimilate the concepts and get used to the practices associated with portfolios. Early in the year he began assigning activities which the students would find valuable when it came time to learn about selection and evaluation of pieces as records of their development. These activities included writing (e.g., journals, essays, and critical responses) and other means of displaying information (e.g., graphs). Next, McWhorter taught ways to form criteria for evaluating work and selecting pieces for portfolios. At the end of the year, students compiled final portfolios that expressed their understanding of their own learning.

Portfolios to Promote Student-Led Inquiry. Portfolios in Larry Brown's classroom are, among other things, a medium for scientific investigation through writing. His students respond to his adaptation of portfolio practices by taking off in new directions as they explore science and math. Their starting point is the use of portfolios to collect information and write comments from their readings.

"The most interesting comments are from their outside readings," Brown says. "Students include definitions of new words and phrases they run across. Then they go on to record their questions and forge ahead in some strange areas—quantum physics, light, astronomy, high energy reactions, traffic flow, and how baseballs curve. As a result of these digressions, collected in their portfolios, students are directing their course of study to a significant degree."

Portfolios, Brown found, led to changes in his instruction. "The inclusion of students' reflections in their portfolios has forced me to change both my day-to-day presentations and my tests," he says. "Backing away from over-explanation, I now allow the students room to make mistakes from which they can learn. Recently, I evaluated answers to an essay question in physics, then returned the answers to the students with suggestions for improvements. The students re-submitted their revised answers. Prior to this, I would have taken the first response as the measure of student learning."

LESSONS FROM THE LAND

I am convinced that students should learn about and be aware of the environment they live in. It touches and affects their daily lives constantly. As teachers, we tend to get so wrapped up in teaching topics in accordance with curriculum guides that we tend to ignore the very being of our students, their backgrounds, and their livelihoods. If our students were to learn about their own area, they would come to understand how special it is.

—Anna Angaiak, Alaska—

Rural teachers choose and remain in small schools because they are nourished and inspired by their surroundings. They are drawn to the wide open spaces, the grand vistas, and the stunning beauty of the rural landscape. It is not surprising, then, that seven of the SMART teachers focused on projects that developed lessons from the land. Lessons to insure that the land is loved and its beauty protected; lessons to show that the methods of science and mathematics can preserve and repair, not destroy.

There are attractive features common to lessons involving the local environment. In rural schools, the laboratory is readily available and accessible. A study of the local stream or wildlife population may be just a short walk from the classroom door. Environmental studies are also interdisciplinary, linking the science disciplines and mathematics in natural ways. They are relevant and meaningful, offering students responsible and purposeful roles as data gatherers, recorders, and interpreters. Classrooms often work collaboratively with natural resource agencies, providing them with useful information while benefiting from the expertise and resources of the agency.

In some cases, these lessons provide opportunities to objectively examine complex resource issues that are controversial and emotional. They become powerful exercises for problem solving and citizen development. Finally, because such lessons extend the classroom outdoors, they are fun and add variety to classroom routines.

Caribou Study

Michele Bifelt teaches science to grades 7-12 at Jimmy Huntington School in Huslia, Alaska, an isolated Athabascan village on the Koyukuk River, which flows into the Yukon just as the river turns south from its westward course across Alaska. Bifelt had two purposes in mind as she developed an integrated, thematic study of caribou. She sought to counteract the difficulty elementary teachers have in finding time to "fit science in" while pressed to teach the basics. "I proposed to integrate the science curriculum with basic studies in such a way that there would be no extra preparation time for the elementary teachers," she says.

Bifelt also wanted to provide a culturally significant science experience for students with strong cultural traditions. "By studying the spring caribou hunt, instead of a commercially prepared activity set," she says, "students would see that science is already an integral part of their lives, not something imposed by another culture."

Bifelt had 14 students from the combined fifth- and sixth-grade class set the direction for the caribou study. After an introduction to the project, students generated a list of questions they wanted to answer about caribou. "The list was a page long and covered almost everything I would have listed anyway," Bifelt says. Their questions fell into three areas:

1. Anatomy and physiology. Examples: What size are their hooves? Can caribou digest meat and milk?
2. Behavior. Examples: How does a herd choose a leader? What happens to a calf when the mother dies?
3. Interactions with humans. Examples: Do Eskimos use caribou differently than Indians? What are local legends about caribou?

Bifelt was similarly impressed with the students' thoroughness in brainstorming possible sources for answers to the questions. "Again, they were amazingly complete in covering most of the sources I had expected to consider," she says.

Students began their research with a week of letter-writing to outside sources, including the Fish and Wildlife Service, the University of Alaska, and the Cooperative Extension Service. While waiting for responses, they prepared interview questions for the local experts—the village elders and hunters. Elders told stories which were compared with legends from other Athabascan Indian tribes, as well as with Eskimo legends. Catherine Attla, a

Huslia elder, shared the following story with a couple of young interviewers:

"This year the caribou were close to town, the first time since 1970. Back then, the caribou were on the runway. Some young men chased them with snow-goes. The caribou have spirit. Chief Henry said you aren't supposed to tease the caribou. He said they won't come back for a long time. He didn't blame the boys, though. The elders should have taught them to respect the caribou."

Elders came to school as guest presenters during special cultural events. One afternoon a grandmother of two of the students showed the class how to scrape a caribou skin to make a mattress. "They experienced a tradition which the community wishes to preserve," says Bifelt. "They even used traditional bone tools made and donated to the class by one of the elders."

The highlight of the project was an overnight field trip to a cabin 45 miles away. "It was in early April when the herds begin their migration back to the coast," Bifelt says. "This is also the time of the spring hunt, an important event for people who depend on caribou and moose for food. A small caribou herd of about 70 animals was only two miles from the cabin. This was fortunate; we might have had to go as many as 10 miles to do any observations."

Bifelt had prepared the class for field work with practice observations and discussions of what to expect. The students observed the herd under pressure as two parents hunted, then "learned how to clean a caribou carcass, a survival skill for this subsistence culture," says Bifelt. They also examined the internal organs and the parasite pupae under the caribou's skin.

Back in the classroom, integrating other disciplines was easy. In addition to writing letters, the students wrote a research summary and a news story. They practiced map reading and made their own maps of the range of northern Alaska herds. They developed graphs comparing the sizes of different herds in Alaska and of the data they collected in interviews about the number of caribou taken in the village in two different years. Mathematics was also used to estimate the time it would take to get to the herd for the field trip.

"Counting all the hours that we put into this project, I doubt that we saved much preparation time," reflects Bifelt. "However, a major goal was accomplished: The students had more science instruction integrated into other disciplines. The beauty of this arrangement is the continuous flow from one study area to the next, with no interruption in the thought process."

Furthermore, the Caribou Project has evolved to new levels of participation and commitment, with plans for ongoing projects using a different organism from the local environment. Fish that are year-round inhabitants of the Koyukuk River and surrounding lakes were the focus of the second year and involved the entire school and continued community support.

Forest Ecology

While participating in SMART, Norman Palmer moved to a new school, Union High School, located in the Grande Ronde River Valley between Oregon's Blue and Wallowa mountains. Palmer got involved in the development of a new forest ecology curriculum for fourth- to sixth-graders. The Blue Mountains Learning Center (BMLC), one of five in the Pacific Northwest devoted to public education in resource management, was initiating the program and seeking participating teachers. Palmer joined a steering committee of teachers and BMLC staff to review, design activities, and implement the *Whole Ecosystems in Balance* (WEB) curriculum. Their plans included two weeks of daily classroom activities led by high school students, followed by a one-day field experience along a creek in the Blue Mountains.

Palmer's responsibility was to coordinate the selection and training of high

Forty-six percent of the nation's school districts serve exclusively rural places.

school students. They presented 10 lessons in the elementary classrooms. For example, "Beauty and the Beast" provided students an opportunity to explore how animals are portrayed in unrealistic ways. In "Tree Leaves," students played a relay game to learn different tree species. The high school students were "well prepared and interesting and the lessons were hands-on," notes Palmer. "The grade school students were attentive and would ask their teachers about when the high school students were coming back."

Palmer's approach was to be as organized as possible (calendars, notebooks, and equipment boxes for the high school students) and to communicate clearly and often (notes to students and lunchtime meetings with the grade school teachers). Palmer is satisfied with the pilot year of the program. "The goal of teaching grade school students about forest ecosystems using high school students has been met, and in most ways, exceeded my expectations," he says. "These kids know that a forest is more than just trees."

Water Quality

Five SMART teachers developed projects that involve students in water quality monitoring and enhancement. Science teacher Phillip Springer from north central Montana developed an interdisciplinary project on ground water protection for the school well. Jerry Hendrickson, who teaches in a school along Puget Sound in Washington, enhanced his seventh- and eighth-grade science curriculum with water quality monitoring and enhancement of nearby streams, wetlands, and beaches. Karin Bigler's students investigated a local contamination problem in their community located in the Willamette River valley of Oregon. Students in Colette Cozort's and Patrick White's classes in the panhandle of Idaho studied streams within a short distance from their school.

Wellhead Protection. Phillip Springer teaches all science for grades 7-12 in Augusta Public Schools, which serve 150 students in a community 100 miles south of Glacier National Park. He strives to show his students the science in everyday situations and values interdisciplinary curriculum. Springer followed his teaching philosophy in developing a ground water study that would lead to a protection plan for the well water of the school while integrating language arts, computer literacy, and vocational-agriculture.

After coordinating planning among the various departments, the science classes collected and tested water and soil samples locally and from a nearby farm to determine the effects of geology and surface practices on them. They also studied elimination procedures and tolerance levels for unwanted materials to help in developing a plan for clean-up and surface practice controls. In computer and language arts classes, students used the water and soil data to create spreadsheets and other documentation.

The school board approved a wellhead protection zone and a protection plan that was economically practical and aesthetically pleasing. A student's videotape of the activities in the science classroom became part of a multimedia presentation for the Montana Department of Health and Environmental Services.

Because the entire project was developed around a local problem, Springer was challenged to find resource materials. State agencies and geology books became his primary resources. He also developed a collection of articles for student research. Springer needed alternative grading procedures as well. "Since we spent a great deal of time (usually four to five hours a week) in the lab, regular homework scores and tests were missing. I developed a communication portfolio system for filing water and soil test results and data analysis. Students also had questions to report on."

Adopt-a-Stream and Wetlands and Beach. Jerry Hendrickson has spent 25 of his 31 years in science teaching at Griffin School at the southern end of Washington's Puget Sound. Hendrickson's SMART project adapted a water quality monitoring program for Griffin School. The project, he hopes, will raise student awareness of the local environment. "My students will become more aware of the fine ecological balance in the watershed and assume some responsibility for the healthy ecology of Eld Inlet where they reside," he says.

Hendrickson began by teaching stream monitoring procedures he learned in an Adopt-a-Stream workshop. Then his students began monitoring three local streams on a regular basis. measuring flow. volume. and observing stream organisms as indicators of stream health. The adopted streams helped them qualify for a grant from the state Department of Fisheries which would allow them to hatch salmon in the classroom and place them in selected streams.

"We received a 60-gallon aquarium, filters, and a refrigeration unit," Hendrickson says. "In October, when the setup was complete, I picked up 500 Coho salmon eggs from one of the nearby hatcheries. We kept track of the development of the fry until April when it was time to release them. We matched the temperature of the steam to the aquarium and were able to turn the fish loose in optimum conditions. We only lost approximately 20 salmon in the process."

Hendrickson has continued and expanded the project, which now involves 75 life science students who hatched and planted 600 Coho salmon, and 65 earth science students who grew, measured, and planted 3,000 clams and 2,500 oysters on a beach near Griffin School.

"In addition to the student involvement in the project, we actually enhanced the fish population in Puget Sound," Hendrickson notes. He is also pleased with the emphasis on real science processes. "This project gave the students a chance to keep accurate scientific records, to take samples of the water to check for dissolved oxygen, to maintain constant temperatures, and to note any changes in the eggs and visual cloudiness in the water," he says. "Their reports to the Department of Ecology reinforced accuracy and the importance of correct observations."

Issues in Community Water Quality. Karin Bigler moved to Milwaukee Junior High, located in a suburb of Portland, Oregon, shortly after joining the SMART project. Bigler, who has taught science in rural schools for 17 years. has a long history of using the local environment in science education. Bigler feels that students need to wrestle with the complexity of real world issues while they learn the processes of objective scientific study.

She had no trouble finding an issue to tackle at her new school: trichloroethylene, a solvent used in many local industries, had contaminated several wells in Milwaukee. The source for the contamination had not been found and the cost of water from alternative sources was currently being paid by the residents and businesses in the area.

Bigler drew from her large repertoire of water quality curriculum to prepare the students broadly for the local issue. "Before my students could understand the process by which an aquifer could become contaminated or depleted, they had to understand some of the physical properties of water," reports Bigler. "So a portion of the term was spent on experiments related to density, solubility, and evaporation."

Her students needed to understand the hydrologic cycle, and Bigler incorporated a weather unit. "We recorded weather data daily through the month of April. Once we had several fronts—both cold and warm—move through in a single class period." Students conducted an intensive study of two streams on the school grounds. Bigler always begins with careful observation. "Teaching them to see the familiar with new interest is good for both teachers and students," she says.

Students sketch a map incorporating their observations: type of vegetation in

"My students will become more aware of the fine ecological balance in the watershed and assume some responsibility for the healthy ecology of Eld Inlet where they reside."

Jerry Hendrickson, Washington

Only one in five rural schools in the United States is located in a community dependent on farming.

the stream and along its banks; general shape of the channel; how the current seems to move, where eddies exist; and presence or evidence of animals, such as tracks in mud.

After observations are complete, students measure velocity, determine the shape of the channel and its flow volume, and take a census of the organisms using the stream and its banks as a habitat. "Cleaning up contamination is as much a problem as identifying its source, so we also did a two-day lab trying a variety of clean-up methods, including filtration, absorption of contaminants on activated charcoal, and distillation," Bigler notes.

Students then moved to the social and economic issues surrounding water contamination, using a commercially prepared simulation of a contamination problem. Bigler often stages such role playing on environmental issues, writing up real issues and assigning students to research and represent various points of view. When students went to work on the Milwaukee Water Mystery, they used actual well-testing data to trace the shape of the contamination plume and to identify possible sources for the contamination.

Because the issue had considerable publicity and broad public agency involvement, students had extensive sources for their research. During a simulated hearing, students played the role of business owners who were possible contamination sources, local residents, the Environmental Protection Agency, health officials, local governments, and various state agencies. Bigler usually assigns student moderators so she can observe and clarify points in the discussion. Bigler says that students "gained a great deal of awareness of the consequences of decisions and of the fact that no decision can be simple, but must be a compromise which reflects a variety of interests."

Streamwalkers in the Idaho Panhandle. Two Idaho teachers, Colette Cozort of Kendrick and Patrick White of Clark Fork, participated in Streamwalk II, a stream-monitoring workshop that adapted EPA's Streamwalk program for classrooms.

White, a mathematics teacher, teamed up with the biology teacher and offered a course called math/science ecology.

Idaho is developing a statewide performance assessment with performance tasks that are highly interdisciplinary. Because of this direction, White is motivated to explore the integration of mathematics and science while maintaining the rigor of each discipline. "A typical week included two days devoted to water sampling and analysis, two days of mathematical-related analysis, and one day of report writing," White says.

The class took place in three classrooms: at four nearby streams, and in biology, chemistry, and computer labs. Students collected data on three characteristics of each stream: habitat, water chemistry, and presence of organisms (biomonitoring). The habitat data included width and depth, velocity, and distance between riffles and runs. Water chemistry determined 10 different qualities, such as pH, dissolved oxygen, and phosphate level. Biomonitoring determined the presence of pollution-tolerant and pollution-intolerant species from tallies of organisms present.

"Ongoing analysis of the data provided students with a real world application of mathematics seldom found in the classroom," notes White. Students derived a final numerical value for each characteristic of a particular stream. "In order to obtain a single value for each of the 10 parameters of habitat assessment, many mathematical calculations were required, including cross-sectional area, volume of flow, percent of bottom substrate cover by type, percent of canopy cover, and riffle-to-run ratio," White notes. The water chemistry data required comparing their results to graphs of standard distribution for expected values of each chemical property.

The results of biomonitoring for each stream were compared by calculating an index of similarity from ratios of the species represented. When they were ready

to develop the final report for the Department of Environmental Quality, students used numerous statistical concepts to compare each stream to a reference stream.

White's students have demonstrated an important characteristic of a performance task—their efforts and results are authentic. The task duplicated the challenges and expectations facing adults and professionals hired to monitor water quality. "The students have taken an active role in determining local water quality with the additional significance of publishing the results of their research and sharing it with the state environmental agencies," reports White. "It is our hope to continue this class for many years, comparing yearly reports and determining long-term changes in the quality of local waters."

A Community of Streamwalkers. Cozort was inspired to involve community groups as well as her students in Streamwalk. "We are an agricultural community dependent on a healthy stream system," she says. "Yet, as we've learned from others' experience, soil and chemical runoff and livestock populations can negatively affect our water quality."

She hoped a communitywide project would show her secondary science students that "learning is a lifelong process and that community collaboration is satisfying, productive, and may solve local problems."

Cozort's approach included training students and parent volunteers in the monitoring procedures to assess the physical, chemical, and biological components of the Potlatch and Little Bear streams. Her students taught the procedures to other interested secondary students, and made several visits to the grade school located downstream in the community of Juliaetta, where they taught the monitoring procedures to sixth-graders.

Cozort made arrangements for interested landowners along the streams to team up with students for future monitoring. "Students have already learned that there are significant differences in the status of various 100-meter stretches of stream from three miles east of Kendrick to points below Juliaetta (seven miles total)," reports Cozort. "Three chemistry students chose science projects to extend streamwalk study to creek sections near their homes. We now have data from above and below bulldozed areas, feed lots, and tributary entries."

Students then prepared reports, maps, and charts to formally present their findings to the senior citizens group and the community development committee. "They were excited about making presentations to community groups, and I believe that we impressed the adults we spoke to," notes Cozort.

Cozort is optimistic about the future and thankful to have the trial period over. "I expect next year to be more structured," she says. "Having the baseline data and learning process down, more energy can be given over to thoughtful observation and creativity. I look forward to a new year of knowing how to plan, what to do, and seeking improved strategies and involvement."

SPARKS AND EMBERS

Successes and failures occur for all of us. Yet the most satisfying experiences come from the continued effort to change and improve.

—Dick Shellborn, Alaska—

In the Northwest, there is less than one school for every 200 square miles.

My project has led me to a better understanding of the importance ownership has on learning. Students will be successful if they are allowed to choose, develop, sequence, and apply their own meanings to science concepts.
—Jim Warren, Idaho

Rural education is a rough journey, yet a promising one for teachers who know how to ride its winds. SMART teachers provided leadership in their states and throughout the region with their innovative classroom practices, community involvement, and professional outreach. They integrated science and math with other fields of knowledge and, in the process, promoted understanding of the natural environment that plays such a prominent role in the lives of rural people. They linked their own efforts to national curriculum reform, and they collaborated with other professionals to strengthen math and science education in their communities. Their leadership has provided the spark and ignited bright ideas for others to build upon. Their legacy is also one of glowing embers that, when fanned by others, will continue to improve math and science education for children in rural areas throughout the Pacific Northwest.

Sparks That Fly

SMART demanded a lot from rural teachers who are used to giving. SMART also forced many of its participants out of the classrooms, where they are most comfortable, and into the community, the school board meetings, the principal and superintendent's offices, other teachers' classrooms, and professional organizations. Such changes do not come easily. But embracing change that transforms learning into an active, engaging activity helped establish new leadership roles for many.

"Presentations, negotiations with administrators, the recognition of the responsibilities that accompany competency when you are leading reform initiatives in communities, these were new endeavors for many of our participants," says Nancy Murphy, a SMART teacher education coordinator now with Antioch University in Seattle (formerly of the University of Alaska). "Unexpectedly, they taught me many lessons about ways of supporting each other as they undertook risks. They were indeed a compassionate group. Some moved cautiously but steadily. Some forged ahead quickly. They all showed great respect for each others' styles and strengths."

SMART teachers impressed observers with their creativity, innovations, collaboration, and classroom practices. "The quality of ideas and creative approaches to teaching science and mathematics presented by SMART teachers equals that of any national science teachers' convention," says Donald Orlich of Washington State University. "When we visit the sites and observe the demands made on rural teachers, we must applaud their work."

SMART teachers journeyed into new arenas, took on new responsibilities, and created new projects. One consequence of SMART has been enhancement of self-worth, says William Hall of Montana State University. "These teachers have gained a tremendous amount of confidence and genuinely feel they can be of help to other teachers."

THE STATE-LEVEL ACADEMIES

During each of two school years following the regional academy in Corvallis, Oregon, state teams of SMART teachers and the higher education representative organized, sponsored, and presented an academy for rural science and mathematics teachers within their state. In most cases these academies were held in conjunction with existing conferences, typically a rural education conference.

In 1992 the Alaska SMART Academy was held as a poster session with displays and special times for project presentations at the four-day Rural Instructional Improvement Academy in Fairbanks. In spring of 1993, SMART participants pre-

sented a two-and-a-half-hour hands-on lab session at the Annual Technology in Education conference. The session, "SMART Choices for Science and Math: Technology for Rural Schools," combined information about individual SMART projects, data/results from Michele Bifelt's caribou study, and hands-on opportunity to experiment with using technology to support the kind of schoolwide caribou study that Bifelt led.

In 1992 Montana SMART teachers presented sessions designed for rural teachers at a series of math conferences held around the state. Thanks to SMART teachers, the 1993 Rural Education Conference in Dillon featured an afternoon session of hands-on science and mathematics activities set up in eight learning centers with take-home materials.

Among the centers was Kimberley Girard's room filled with math puzzle party activities, designed to involve the community in joint learning with kids. Phillip Springer shared science lab activities for middle grades, using inexpensive lab equipment. Susan Wallace had several hands-on bird study activities from her eagle watch project.

In 1992 and 1993, SMART Oregon teachers led a similar day-long strand of hands-on science and math activities for K-8 rural teachers at the annual Small Schools Summer Institute in Monmouth. In the 1993 SMART Academy, Leonard Pratt presented a discovery-based geometry lesson based on compass and straightedge constructions. Don Parker led a decisionmaking/problem-solving exercise from his integrated thematic unit on the history, science, and math of penicillin. And Diana Prichard and Karen Withrow led a design challenge based on the failure of the new roof at their school under a heavy load of snow.

In some instances, the state SMART team drew upon rural resourcefulness and developed alternative venues to reach their rural peers. For example, the 1992 Idaho SMART Academy was held in conjunction with a NASA-funded program and provided two days of professional development for rural math and science teachers in McCall.

The academy was well received and successful in a number of ways. It brought together two often-competing institutions in the state—Boise State University and the University of Idaho. Though inservice credit was granted through Boise State, the conference was promoted and sponsored by the University of Idaho through the NASA grant that the university received. This collaborative effort drew 50 rural K-12 teachers from across the state—even though the conference was on the statewide inservice day.

Teleconference in Idaho. In 1993, seven Idaho SMART teachers shared math and science improvement strategies in a 90-minute, call-in teleconference called "Rural Schools: Taking the Lead in Science and Mathematics Reform."

The teleconference featured three panels, including "District Coordination of Math and Science Reform," in which Colette Cozort, Angie Lakey-Campbell, and Karen Garrison addressed curriculum restructuring to align with national mathematics and science standards and looked at reform through technology revitalization.

In another panel, Kermit Tate, Jim Warren, and Pat White discussed integrated curriculum as a strategy for reform. The panelists also discussed the relationship between integrated curriculum

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"I am sure that two years ago I would not have considered doing consultant work. Now I know that I know good science and how to facilitate good hands-on learning."

Don Lewis, Idaho

and Idaho's move to performance-based education. In the final panel, Don Lewis teamed up with Cozort and White for a presentation on using the local environment as a resource and classroom.

The teleconference stretched SMART teachers in new directions and involved the type of risk-taking that they often encourage of their students. "Although I was scared and did not enjoy it at the time, the teleconference was one of the best professional development activities that I have ever participated in," says Garrison. "My superintendent was very impressed with the content and the quality of the teleconference. I feel that it is a medium that needs to be used more in the future."

In addition to spreading the word about innovative math and science teaching in rural schools, the state academies provided professional renewal for SMART and other teachers. Garrison found that the academies were both affirming and empowering and helped form relationships with other rural teachers. "I found there are many rural schools in the Northwest that are doing a respectable job in offering a good education to our students," she says. "By pooling the intellectual and other resources available to our rural schools, we can continue to improve the quality of instruction and experiences presented to our students. The rural schools need to capitalize on the excitement and enthusiasm of their staffs."

BUILDING SELF-CONFIDENCE

Presenting ideas and innovative projects to other science and math teachers also helped build self-confidence among SMART participants. "The state academy has allowed me to see myself as a teacher with valuable ideas and methods," says Pfeifle. "This has given me the willingness to try more new things."

Lakey-Campbell found that she could rely on and learn from teachers in far-off places. "Before attending the SMART academy, I would not have felt comfortable asking teachers I did not know for assistance," she says. "Through the academies, I have come to know teachers throughout Idaho as well as the Northwest region. I now have a file of names of people who I know are willing to help me. I will continue to expand this list."

Wallace says that the state academies broadened the reach of rural teachers and provided them with a classroom full of colleagues who could share ideas as well as learn new techniques. "In Montana, we have developed a circle of educators and friends," she says. "We feel comfortable working together, we know of our strengths and weaknesses, and we can design an effective presentation. SMART gave us the opportunity to do what we do best: teach others."

Lewis gained the skills and confidence to provide assistance to other teachers in rural Idaho. "I just spent two days as a paid consultant to a consortium of Idaho school districts to write a K-12 outcome-based, hands-on science curriculum," he says. "I am sure that two years ago I would not have considered doing consultant work. Now I *know* that I know good science and how to facilitate good hands-on learning."

Garrison notes that her self-confidence has been heightened through her SMART activities, the regional and state academies, and the contacts made with other rural teachers. "I have gained the confidence to become active as an affiliate board member in the Idaho Council of Teachers of Mathematics," she says. "I am also pursuing my master's degree in administration, and I feel confident that my rural background is an asset, not a liability."

That shift in thinking—from defender of to advocate for rural schools—has also been a part of the legacy of the SMART project. "As I take classes in my master's program," Garrison says, "instead of defending small, rural schools, I am now actively promoting the many benefits of them."

Embers that Glow

In the end, it's really all about children and learning. When teachers learn from each other, when they create vital links to their communities, when they bring fresh perspectives and innovative methods into their classrooms, they really are preparing their students to live and work with others, to care for themselves and give back to their community, and to value lifelong learning.

SMART teachers know this. They see it in the students who go on to advanced learning. They witness it in those who get fired up about new concepts, and they take pleasure in those who remain in and contribute to their rural communities.

Michele Bifelt says that students, their parents, and others in the community all provide intrinsic as well as tangible rewards. "I feel good when parents come into the science room and marvel at their children's work," she says. "I feel great when younger students tell me that they can't wait until they are in my classes. I appreciate the public thanks I get from graduates during the graduation ceremonies. Most of all, I am rewarded by the number of my students who have attempted the larger world, who have felt secure enough in their skills to go on to college or technical school."

Dick Shellhorn of Cordova, Alaska, agrees. "As a teacher," he says, "nothing is more rewarding than watching your students go on to future successes."

Success, though, comes in many shapes, sizes, and forms. Not all students are interested in a four-year college degree. Some go into the military. Others learn a trade. Some become full-time homemakers. And yet others lead lives of quiet productivity, giving back to the community some of what it has provided to them. "Whether I spark a scholar or encourage a kid without a prayer, I am happy to be a teacher," notes Colette Cozort.

Diana Prichard found that working with students who historically have been considered at risk, underachievers, or hangers-on can provide deep and lasting rewards. "Some of my most rewarding experiences have been with those students who, for a time, have been turned off to math," she says. "One year I was assigned a low-achieving group. The first thing they told me was, 'We're the dumb kids.'

"It was a challenge to change their opinions of themselves and of math. But they turned out to be the neatest group of kids I've ever worked with. After learning how to do fractions, one boy spontaneously shouted, 'Fractions are awesome!' Another highlight was the day one of these students beat the best of the 'regular' students in a math contest. Working with this class proved to me that all students can get excited about math if they know they are learning."

The benefits of teaching in a rural community accrue to the teachers, as well. "Rural teaching allows teachers to really spread their wings and soar," says Melvin Henning. "Rural schools allow teachers the opportunities to make a difference in the lives of some pretty neat people—those who make rural America their home."

"As a teacher, nothing is more rewarding than watching your students go on to future successes."

Dick Shellhorn, Alaska

APPENDIX

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The authors gratefully acknowledge the skill and effort of many people as well as support from the funders. We thank:

The Fund for the Improvement and Reform of Schools and Teaching of the U.S. Department of Education for providing a three-year grant for the SMART Project.

The Northwest Consortium for Mathematics and Science Teaching under a grant from the U.S. Department of Education for funding, publication, and dissemination.

The SMART teachers for their energy, commitment, and candid explanations from which we could tell their stories.

The SMART teacher education representatives for their insights, perspectives, and enthusiasm for a rural adventure.

Steven R. Nelson, director of the Rural Education Program at NWREL, and Rob Larson, director of the Science and Mathematics Education Program at NWREL, for their good ideas and the opportunity to write this book.

Teri Shetters and Marian Grebanier, secretaries for the Rural Education Program at NWREL, for their willing assistance and support throughout the SMART project.

Tony Kneidek, editor at NWREL, for the competence with which he waded through our words.

Dan Stephens of the Renaissance Group for graphic design that captured our vague wishes so nicely.

Mary Girouard, desktop publisher at NWREL, for her care and dedication to design.

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