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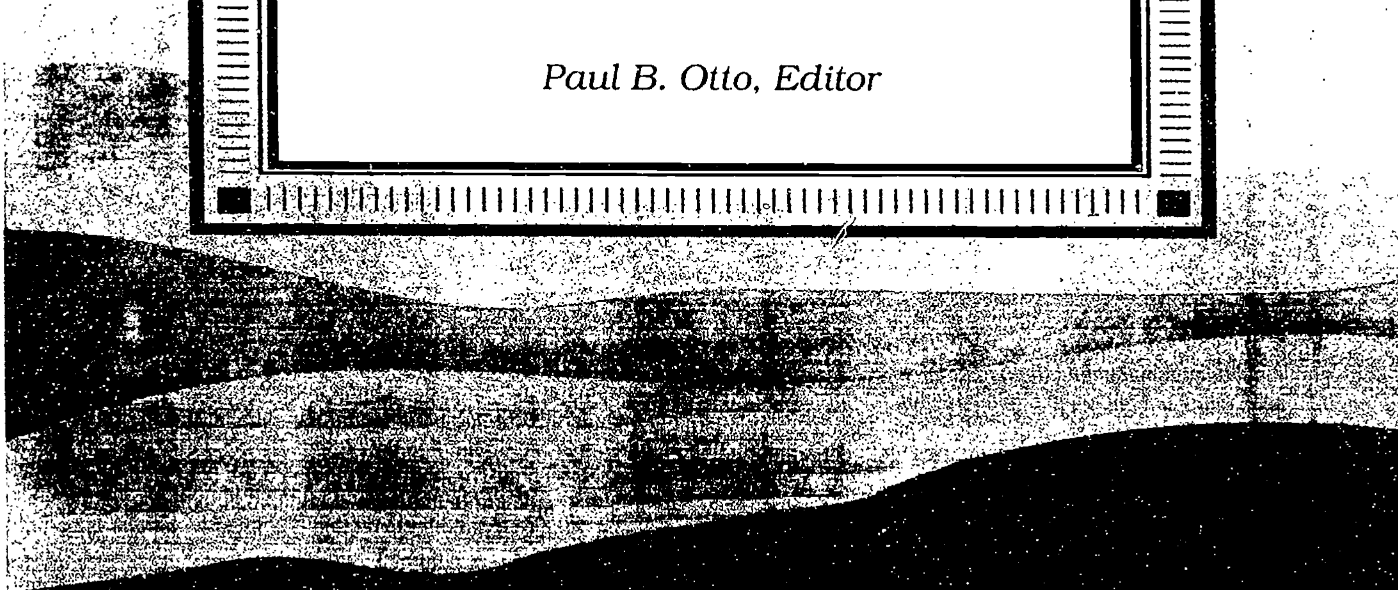
ABSTRACT

This yearbook of the Association for the Education of Teachers in Science (AETS) is designed to give a perspective on rural science education. It is presented in a sequence which leads from the definition and philosophy of rural science education, to the status of rural science education, research implications, the integration of science within the science disciplines, integration with mathematics and technology, Science-Technology-Society (STS), distance learning, political implications, Native Americans, and other cultures in rural science education. Chapters include: (1) "What is Rural Education?" (Horn, Jerry); (2) "Status of Science Education in Rural Schools" (Baird, Bill); (3) "Teaching and Learning Science in the Rural Setting" (Matthew, Kathleen); (4) "Rationale for an Integrated Approach to Teaching Science in the Rural School" (Prather, J. Preston); (5) "Blending Science, Mathematics, and Technology in the Rural Classroom" (Ostler, Elliot; and Grandgenett, Neal); (6) "STS in Rural Education" (Wright, Emmett); (7) "Rural Science Education: Water and Waste Issues" (Blunck, Susan; Crandall, Bill; Dunkel, Janet; Jeffryes, Curt; Varrella, Gary; and Yager, Robert); (8) "Distance Learning for Rural Schools: Distance Learning Defined" (Finson, Kevin; and Dickson, Michael); (9) "Political Ramifications for Rural Science Education in the Twenty-first Century" (Nachtigal, Paul); (10) "Science Education for Rural Native Americans" (Otto, Paul; Evans, Wayne; and Champagne, Liana); and (11) "Serving the Needs of Minority Students in Rural Settings" (Wilson, H. C.; and James, Robert). (JRH)

Science Education in the Rural United States

Implications for the Twenty-First Century

Paul B. Otto, Editor



ERIC Clearinghouse for Science, Mathematics, and Environmental Education

Science Education in the Rural United States

Implications for the Twenty-first Century

edited by

Paul B. Otto

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Association for the Education of Teachers in Science

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To my loved ones:
My wife: Kathy
My daughters:
Stephanie
Michaelle

In memory of my brother Stan
who passed away unexpectedly
at age 51
April 5, 1995

Preface

The United States of America sprang from rural roots. A land had been discovered by people, basically European, who were enamored by the rich resources and fertility of the land. Here was opportunity for the individual to be the owner of private land and to live a life of freedom, unconstrained for the most part, from the dictums of a central authority. It mattered little that people were already living here. Although respect for ownership may have, at first been followed, in principle, the indigenous groups were forced from the land onto reservations which festered unique rural problems still existent today.

After the first Atlantic Coastal settlements, people spread to "settle" and "conquer" the land. Contrary to the European style, the farmers built their homes on their land, rather than commuting from villages to till the soil. The land, in essence, became their home. Villages soon sprang up, with their economies intimately entwined and dependent upon the local agricultural enterprise. Here then was the grand experiment. Access to inexpensive land was readily available for even the most financially deprived. One could be the lord and master of his/her own land to develop as seen fit. The United States was inextricably attached, at least philosophically, to the land and its "ruralness."

As the country became more industrialized, large population centers became common. Masses of people migrated to the urban areas. Large centralized factories were established and efficiency became the credo. The assembly line worker, responsible for only a small portion of the product, replaced the master craftsperson. Bigger, less personal, seemed better and more efficient than the smaller, more personal.

The educational system of the large population centers soon followed suit. Large school plants accommodated multiple classes for large groups of children. If the assembly line model worked for business and industry, it likewise should be the correct model for education.

Although considerable success was attributed to the large, factory style educational institutions, problems soon became evident. Attempts at solutions to educational problems became focused on the large urban and suburban educational center. The problems of rural education seemed to take a back seat.

Throughout the evolution of the United States society, the rural schools continued and still remain today. Rural schools are typically not looked upon as being on the cutting edge of education. Rather, they tend to be visualized as poverty-ridden and backward, with few resources for a viable education for the present era. Overlooked is the fact that many of the so-called innovations advocated in educational circles appear suspiciously similar to age-old practices used in rural schools. Students with the highest standardized test scores come from states which are predominantly rural.

A clear definition of present-day rural is difficult because of the diversity among rural schools. Rural communities are often equated with remoteness and smallness. Rural schools typically are small and are located in remote areas. However, some very rural schools can be found relatively close to our largest urban areas and serve large numbers of students.

Jerry Horn, in Chapter 1, provides insight into what constitutes rural science education as well as an exploration of the philosophy of rural science education. Rural schools can be defined on the basis of population, economics of the supporting communities, geographic location, and philosophic underpinnings. Jerry used case studies of three fictitious schools to paint a panorama of rural communities with diverse economic bases and geographic locations.

In Chapter 2, Bill Baird discusses the status of rural science education. He begins with an overview of the relative size of rural education, ethnography, and the preparation and the typical work load of rural science teachers. Special rural science education problems, activities for science instruction, and teacher inservice activities are discussed. Of special interest is the section on the successes in rural school science education.

Kathy Matthew focuses specifically on teaching and learning science in a rural setting in Chapter 3. She launches from the platform of general aims and goals of science education as set forth in the national standards and benchmarks, to draw parallels for rural science education. An examination is made of effective practices from the research literature to extrapolate inferences for rural science education in the future.

An historical foundation for an integrated approach is broached by J. Preston Prather in Chapter 4. He builds the case for integrating science disciplines in rural science teaching based on the constructivist model. Integrated models from the research literature are described. Prather then explores strategies for integration, an overview of curricular organizations, and concludes with a discussion of the efficacy of using the integrated approach to teaching science in the rural school.

Elliott Ostler and Neal Grandgenett, in Chapter 5, build on the groundwork on integration laid out in Chapter 4 to give specific relevance to the integration of science, mathematics, and technology in rural science teaching. The responsibilities of rural schools in general, their isolation and the problem of economic decline are all looked at from the perspective of the national standards for mathematics and science. Integration is viewed from the position of lowering the burden on rural schools in meeting the mathematics, science, and technology needs of their students into the twenty-first century.

Emmett Wright opens Chapter 6 with the statement "The most prominent ideas being purported for rural schools of the future have embedded in them many of the prominent concepts and principles that have been associated with the relationship between science-technology-society (STS) education programs." After a consideration of the definition of STS and a literature overview supporting STS as a viable science instructional strategy, he gives a personal overview of STS teaching in a rural setting. As a professor in a prairie environment, Emmett gives some very insightful clues as to the utilization of local human, economic, and physical resources which are naturals as the basis for STS science teaching in a rural setting.

Blunck, Crandall, Dunkel, Jeffryes, Varrella, and Yager, in Chapter 7, broach the utilization of social issues, local events, and problem situations in local communities to engage students' minds in the things that characterize the science curriculum. An exploration of how students learn leads to the revelation that they "construct their own meaning from their own explanations of things they see, do, or ponder on." An integrated model with a rural focus evolves based on the concept of building on the students' inherent knowledge base. Working examples are described based on the Iowa Scope, Sequence, and Coordination Project.

A discussion of distance learning in rural science education by Kevin Finson and Michael Dickson is presented in Chapter 8. An historical background serves as the basis for a discussion of the technologies espoused for distance learning. The needs of rural schools for distance learning are explored along with suggestions for the utilization of distance learning as well as teaching strategies unique to distance learning. Finson and Dickson cover the spectrum of adjustment of the rural school structure, program needs, equipment components, and overviews and descriptions of various distance learning technology systems.

Paul Nachtigal, in Chapter 9, gives a unique perspective in the area of political ramifications for rural science education in the ensuing century. He contrasts four myths prevalent in science education with the reality of the real word. Science education is viewed as apolitical, but it is in fact, quite political. Nachtigal appears to endorse the David Orr position of replacing our industrial, competitive society with one grounded in, and in harmony with, our environment. He advocates the conduct of public affairs in "bioregions," at the ecosystem level with the collaboration of rural and nonrural citizens residing in surrounding rural areas acting in concert for the common good.

Because the mind set of rural in the United States typically is a farm or ranch scene with a windmill, a one-room country school rusting obsolescent farm machinery, and inhabited by caucasians, it is easy to overlook rural cultural diversi ;. An important segment of rural education is the indigenous populations. In Chapter 10, Otto, Evans, and Champagne present background in the history of educating Native Americans, which has been a litany of attempts at molding them into the ways of the predominant culture. Examples are given of projects predicated on the concept of utilizing the traditional culture in the teaching of science. Such an approach may be more influential than attempting to exploit unique Native American learning styles. Little evidence can be found in the literature to support a unique Native American learning style.

H. C. Wilson and Robert James present another perspective of minorities in rural science education and in Chapter 11 broach the fallacy of the "one best model" for science education They discuss the validation and inclusion of minority cultures in the teaching of science to make it culturally relevant. The problem of limited

English proficiency (LEP) is addressed with suggested solutions. Two projects in Texas were discussed, involving black and Hispanic populations. One of the projects was especially intriguing in collaborating with the US Department of Agriculture's Agricultural Research Service.

Rural science education appears to be a part of the United States' educational mindset. It has always been understood to be prevalent, but rarely given priority. The present yearbook is designed to give a perspective on rural science education. The authors presented the story in a sequence which led from the definition and philosophy of rural science education, to the status of rural science education, research implications, the integration of science within the science disciplines, integration with mathematics and technology, STS, distance learning, political implications, Native Americans, and other cultures in rural science education. The work in this yearbook can serve as the focus for further interest and research in respect to rural science education.

PBO

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Chapter 1
What is Rural Education?

Jerry G. Horn

Rural America is a place, a segment of our population, a time in history, a concept and maybe even an imaginary mosaic of all that many want and others want to forget. Just as there are many definitions of rural America, a common definition of rural education is equally elusive. We often select symbols or logos for rural education with outlines of the stereotype one-room school with a steeple and large bell. Certainly, as one drives across the country, it is not difficult to identify structures that were once rural schools serving a geographically defined population of farm families. Today, some of these buildings serve as community centers, antique stores, barns, storage buildings and homes, while other have long since been removed from the land or destroyed. Stories abound of children walking or riding horses from the surrounding farms to attend a school that often did not extend beyond the eighth grade, and the teachers were sometimes only a few years older than some of the students. In some townships or counties, a one- or two-room school might have served an area no larger than eight to ten square miles; and in the western ranch lands, one might have been the school for only the children of the workers of a single employer.

History and folklore tell us that the school was one of the first two or three permanent buildings constructed in the new towns that sprang up with the western migration in America. Rural education in the earliest days of this country probably consisted of little more than the basics of reading, writing and the particular interests of the teachers who had little or no preparation for teaching. In the eastern parts of the country, rural schools provided the earliest form of education for families of farmers, miners, fishermen, craftsmen, merchants and others who lived in villages and settlements largely defined by the availability of roads and other forms of transportation.

Clearly, there were some common characteristics of these rural schools, but the diversity then was as evident as it is today. In the book, *In Search of a Better Way*, Paul Nachtigal(1982) provided an overview of "Education in Rural America"(pp. 3-13). As he describes several communities, one notes his continuing themes associated with geographic isolation, small student population, transformation of economic base, and school consolidation. In some cases, one cannot help but detect what must be despair and loss of hope among some of the poorest people in the country with few if any skills for employment.

Remnants of rural communities of the past can be found today, but the diversity of what some would call rural today is just as great. To illustrate this, three communities which have been given fictitious names will be described.

Stewart is a town with a population of 623 in the Midwest. It was named for the railroad foreman who supervised the crew that laid the first railroad across this area, and a state highway connects it to the county seat, some 15 miles away. In the mid-fifties, it was a bustling farming community of more than 2,000 with a small hospital, two doctors, two or more grocery, department, hardware, and variety stores, automobile dealerships, restaurants, beauty and barber shops, service stations and grain elevators. Today, it has none of these except one grain elevator, grocery store, and restaurant. New businesses include a "Pick and Pac" store where one can choose from a limited grocery stock and can buy gasoline, coffee, pre-packaged sandwiches and pastries, and a few items endemic to the needs of the area, i.e., work gloves, ropes and halters, and off-the-shelf cattle medications. Most of the family farms of 160 acres that once produced a variety of crops, i.e., wheat, cotton and sorghum, and maintained a small herd of cattle on the nontillable acres have become a part of much larger agricultural operations that grow nothing but wheat. Absentee land owners are more the rule than the exception. This transition of farming had been slowly occurring as original owners retired, but the economic disaster of the 1980s among many farmers greatly accelerated forced sales of land and foreclosures. A review of the job opportunities in the weekly newspaper will at best include one or two hourly jobs for temporary farm or domestic work.

The Stewart Independent Public School is now a part of Western Hills Community Schools. In the town of Stewart, there is an elementary school, and the junior high and senior high school students board a bus and are transported to a new secondary (7-12) school located equidistance from the three towns that consolidated their school districts in 1990. Due to declining enrollments in the three school districts, an expanded set of curriculum requirements that were established by the state department of education, a state school funding formula that penalized high per pupil cost districts, and buildings in need of substantial remodeling and maintenance, the decision was made to accept a consolidation incentive grant from the state. Over a period of a very difficult 18 months, the three communities made the decision to maintain an elementary school in each town, as long as the average daily attendance did not drop below ten students for three consecutive years in more than two of the seven grade levels (K-6), and to consolidate all secondary students in a new facility. This new building was constructed in open farm country, and virtually all students must ride a bus from an elementary school or provide their own transportation. Most of the teachers are of families within the county, and spouses are employed either as teachers within the district or work at jobs in the county seat, which is a town of about 10,000 residents located just off an interstate highway.

The school has expanded its curriculum to include foreign language, computer science, chemistry and physics. The vocational subjects have been de-emphasized, and all of them will eventually be dropped, but students may take them through arrangement with an area vocational school. Competitive athletic contests among the three now consolidated school districts had always generated large crowds and an intense rivalry. The newly formed secondary school has been placed in a different interscholastic league, and there is noticeably less interest on the part of community members to drive to these contests or to even attend those scheduled at the new school. The once popular school reunions have all but died, but there are attempts being made to create a combined alumni association of the three schools.

Discussions with school officials reveal a perception of guarded optimism about the future of the new school arrangement, but there is general agreement that the students have more subjects from which they can choose. However, there is substantial concern about the disconnection that seems to be occurring between the community and the school. Almost all students leave the area upon graduation, and while some may return after college or other initial career choices, there are few occupational opportunities within Stewart and the other two towns of a similar size that make up the new school district.

Lakeville is a small town in the northeastern part of the United States. Within the city limits, there are 1,421 year-round residents with another 2,100 living in platted, small subdivisions scattered throughout the school district. During an average week in the summer, there are an additional 500 or more persons who vacation in cottages and seasonal homes scattered around the natural lake on which Lakeville is built. For the most part, the summer vacationers are generally well-to-do professional or managerial families who have permanent homes and work in a major city some 2 1/2 hours away. For all practical considerations by the school, the area has a population of 3,500, and it is becoming "younger" and more highly educated through the migration of generally younger, professional families into the platted subdivisions. Most of this group work in two small cities within 30-45 minutes of Lakeville. While their children attend the Lakeville schools, the families have little in common with most of the long-term residents of Lakeville. Two distinct social circles are emerging, one around the traditional center points of rural communities, church and school, and the other around those with interests in the arts and country club events.

The Lakeville schools consist of a single campus, with an elementary school (K-4), a middle school (5-8), and a high school (9-12). The elementary school is at full capacity, and some classes meet in mobile classrooms. The middle school was built in 1985 as a unique facility that will accommodate various sized teaching space, and it has specialized science, art and music areas. The "Learning Center" includes an array of library and media-based materials for teacher and student use. The middle school principal came to the district with the opening of the building, and she has implemented a number of innovative programs in cooperation with a regional university and the intermediate educational service center. The high school offers a traditional subject-based curriculum, and the teaching staff consists of long-term employees of the district. Most of them taught in the old 7-12 combined junior-senior high school building that was remodeled in the early 1980s and is now used as the high school building.

Lakeville is surrounded by productive farms where corn, soybeans, vegetables and grapes are grown and marketed within the area or in the nearby small cities. The community was established in the mid-1800s, and while there are some minorities, it can best be described as a white community of northern European descent. However, some of the newer residents in the subdivisions are African American and Asian American. Family values are treasured as is a strong work ethic and a high regard for a basic education. The newer residents, those generally living in the platted subdivisions outside town, have moved there from large cities or suburban areas where schools were much larger and an extensive curriculum was offered. A number of meetings have been initiated by "concerned parents" who are asking for more advanced courses in science, math and foreign languages and more specialized offerings in the arts and humanities. Computer education, two years of a foreign language, modern dance and advanced placement courses are high on their list of demands. The school board has responded to these concerns by creating two new positions, a technology coordinator and curriculum director, and a pledge to review the entire curriculum over the next year.

The tax base for this school district is largely from local property taxes, which are now approaching the maximum allowable limit. Many of the "in town" residents are on fixed incomes, and the farmers struggle to have income that meets the escalating expenses for machinery, fertilizer, and chemicals used as herbicides and insecticides. A few small business service providers are springing up, but most show little hope of opportunities for new jobs for local residents. A major retail business, similar to a WalMart, has been built at the edge of town, and local businesses are beginning to feel the loss of sales to this corporate run enterprise.

The future of Lakeville in terms of population growth is bright, and the growth is coming in the form of upper middle class families with an average of 2.3 school age children per household. Additional subdivisions are on the drawing boards of two major builders from one of the nearby small cities. It is anticipated that streets and utilities will be in place within three to four months, and the first show homes will be available for an aggressive marketing campaign within six months. There are rumors that a new fast food business will be built near the high school, and a new motor hotel will be built on the main access road to the town lake.

The third community that is illustrative of rural America is one located in an area where coal was once mined by two large companies. The town is known as Pinewood, and it has a population of about 1,067 residents. Most live in single story homes that were built before 1950, and most are in need of considerable repair and maintenance. Reportedly due to high labor costs, low prices for coal, and a depleted source, one of the mining companies shut down operations ten years ago. The other company struggled to maintain its operation at a level of 50% or less of capacity for another five years, but for the last five years there has not been any mining in the area, and unemployment is nearly 60% and increasing among adults. Most of the residents have lived nowhere other than Pinewood, and they do not have any employable skills beyond coal mining. Government subsistence and pensions are the major sources of income. Illiteracy among adults over 50 years of age is about 60%, and even among those of high school age, illiteracy is far above the state average. While the reported crime rate is not nearly what one would find in an inner city area, domestic violence is clearly on the upswing, and several cases of child abuse have been reported. Single parents, as caregivers for children, are becoming more the norm than the exception. The school has established parenting classes, special programs for pregnant students, and an extensive counseling program that focuses on sexually transmitted disease control.

The schools for Pinewood include an elementary school on the edge of town and a combined junior-senior high school near the center of town. The elementary school was built in the 1950s with substantial support and on property donated by one of the coal mining companies, and the junior-senior high was constructed in the 1930s as a government WPA project. It has undergone a number of "remodeling" efforts, which have created a maze of hallways and rooms. It is evident that the instructional materials are very limited, and the science laboratory is all but uninhabitable. Extensive damage from water, chemicals and general misuse is found everywhere in this teaching space. Chemicals are found in unlabeled and corroded containers in a closet off the main laboratory, and dirty and broken glassware is everywhere. Terrariums and aquariums have been neglected for a very long period of time, and the textbooks are old and out of date.

The general atmosphere in the school is gloomy and uninviting. Teachers are very casual in their approach to their responsibilities, and they see little hope or reason for many of the students to even attend school. One is heard to say, "Why waste my time and the state's money on those students who are not able to pass even the simplest of remedial classes?" Lack of a caring interest on the part of teachers is a reason often cited by students who choose to drop out of school. Athletic teams exist, but student participation and attendance at games are very low. Open house at school may bring 50 parents to the schools which their sons or daughters attend. Notes to parents about lack of effort or poor school work do not generate a response from parents. It is becoming more and more difficult to find persons to run for positions on the school board; and, even among the current members, sporadic attendance at meetings to discuss continuing issues within the district is a problem.

The major businesses in town provide the basic necessities, and food stamps are the primary medium of exchange at the grocery store. The local beer tavern has a waiting line upon its opening at 11 a.m., and it is heavily patronized until closing at 2 a.m. From a graduating class of about twelve students per year, maybe one or two will attend college and another two or three will enroll in a vocational school. The other graduates remain in Pinewood and follow an all too familiar pattern of unemployment and welfare.

The superintendent of schools has been in this position for 24 years, and he expects to remain in Pinewood until retirement in the next two or three years. Most of the teachers were trained at a regional college, now a university, and they live in the next largest town of 6,500, which is 23 miles away by way of a two-lane road.

In this state, funding for schools is a 50-50 split between the state and local property taxes with little attention given to the school district's ability to raise tax revenues at the local level. As a result, Pinewood Schools are poorly funded now; and the very base upon which one-half of their funds are generated, property and mineral resources, is deteriorating in value each year.

Communities like Stewart, Lakeville, and Pinewood are found throughout the United States with only a few differences. On the one hand, one finds desperate efforts to survive and to maintain at least one school in their town. The mere fact of having a school is very important. In other areas, interest in education is very low; and the future is so dismal that having to go to school or to support the school in any way is a burden. In Lakeville and the hundreds of communities like this across the country, a real transition is occurring. The time honored ways of the past and the expectations of schools are rapidly being put to test. Young parents are asking the schools to respond; and if they don't, the communities are easy targets for charter schools, home schooling and other forms of alternatives to the public school.

Rural communities are diverse, and many are undergoing significant changes. The schools that serve the communities are groping to respond in ways that are politically correct, educationally sound, and fiscally responsible. However, in many cases these three principles cannot be honored without a substantial influx of resources and a commitment to change and improvement.

Definitions of Rural

There are a number of definitions of rural, and attempts to arrive at a commonly accepted operational definition have consumed considerable amounts of time and been the source of much frustration and confusion. As described in *The Condition of Education in Rural Schools* (Stern, 1994), the U. S. Census Bureau defines "rural" as "a residual category of places outside urbanized areas in open country, or in communities with less than 2,500 inhabitants, or where the population density is less than 1,000 inhabitants per square mile" (p. 4). While this definition is useful, the Census Bureau also categorizes data as "metropolitan" or "non-metropolitan," and these two categories are inclusive of all areas. Some consider "non-metropolitan" as equivalent to rural, and by definition New Jersey does not have a non-metropolitan county; therefore, it would not have a rural place (Stern, 1994). Those who are familiar with the practical perception of rural would quickly indicate that there are rural areas in New Jersey and every other state.

Within the broad category of rural, Nachtigal (1982) recognized considerable diversity when considering values, socioeconomic factors, political structure/locus of control and priorities for schools. From his work (p. 274), the following categories of rural communities are shown:

Categories of Rural Communities

		Values	Socioeconomic Factors	Political Structure Locus of Control	Priorities for Schools
I	Rural Poor	Traditional/ Commonly Held	Fairly Homogeneous/ Low Income	Closed, Concentrated, Often Lie Outside Local Community	Mixed and Low
II	Traditional Middle America	Traditional/ Commonly Held	Fairly Homogeneous/ Middle Income	More Open/Widely	High
III	Communities in Transition	Wide Range Represented	Wide Range/ Low to High	Shifting from "Old Timers" to "Newcomers"	Wide Range, Resulting in School Being Battleground

Sher (1977), a well known scholar on rural education and his innovative work on establishing school-based businesses, may have best summarized the complexity of trying to define rural:

The simple fact is that rural people, rural communities, and rural conditions are so diverse that one can find evidence to support nearly any characterization. Someone wishing to describe rural America as a collection of Lilliputs or as bastions of racism, cultural and economic stagnation, reactionary politics, and stifling social environment will not have a difficult time finding rural communities that substantiate this negative analysis. However, another person desirous of portraying rural America as a network of stable, efficient, thriving communities, or as the nation's best example of social egalitarianism, economic independence, cultural continuity, participatory democracy, and institutional accountability will have equal ease in justifying this favorable characterization. (p. 1)

However, Stern (1994) has identified two common elements of rural; sparse populations and distance from urban centers. Although these are not specifically defined, this is a useful way to look at rural, particularly as one considers the provision of education opportunities for children, youth and adults in these communities. Depending on one's definition, it has been said that one-third of the elementary and secondary students in the United States attend rural schools and two-thirds of all schools are rural. Using the categories of locales of the U. S. Department of Education, National Center for Education Statistics (city, urban fringe, town, and rural) (Stern, 1994), "about 6.9 million students attend some 22,400 rural schools, accounting for 16.7 percent of regular public school students and 28 percent of regular public schools" (p. 14). By whatever definition, suffice it to say that a sizable number of students live and attend schools in rural America.

Role of the School in the Rural Community

The school, the church and the community were almost inseparable in the earliest development of this country. Social events centered around the functions of the churches and schools; but as communities grew and became more diverse in their religious affiliations, the schools became more the institution around which the community circulated. Attendance at athletic and other school events became common and expected, whether or not one had children in school. News, rumors, stories, and happenings were points of discussion among those in attendance. Often adults became acquainted with each other through activities associated with their children, and school personnel were well known and most often lived within the community. The school was the largest single financial investment of the community and the source of the greatest pride. Friday nights, the traditional night for athletic events between schools, found virtually everyone in the community at a football or basketball game cheering their team on; and "away" games left the town almost empty as residents followed the team wherever they might be playing.

In an examination of the local newspaper, front page news often cited accomplishments of students and the events of the school for the week or month. The month of May brought graduation, and the newspaper carried the pictures and the accomplishments and plans of the graduating seniors. Celebrations in the communities always included school groups, whether it was national holidays or local events. Because many rural communities were agriculturally based, local and county fairs were important events. The judging of animals and other products shown by students, as well as adults, was well attended; and the results were listed in the newspaper. Future Farmers of America (FFA), Future Homemakers of America (FHA) and 4-H clubs were directly involved with the schools and were an integral part of the educational process. Other school activities, such as the band, choral groups, and drama/school plays, provided much of the cultural aspect of the community.

While the community supported the school, the community responded in kind beyond the traditional taxing mechanisms for school costs. Bake sales, car washes, sales of advertising, clean-ups, special dinners, and other student fund-raising events often occurred and were well supported. Monies from these activities helped the schools and organizations within the schools make special purchases related to curricular and extra-curricular activities. Among these uses were uniforms, student travel to events, costumes for plays, and even equipment for vocational and academic programs.

Today, as has been true over the years, schools often have the largest payroll and purchase the largest amount of goods and services of any single entity in rural communities. Other businesses depend upon the expenditures within the community, such as the local automotive garage and the wholesale gasoline dealer. More recent involvement of schools in the commerce of the community is related to school-based businesses. While there are several versions of this concept, one of the better known movements of this nature operates under the auspices of REAL Enterprises (Rural Education through Active Learning). Jonathan Sher of North Carolina and Paul DeLargy of Georgia have been instrumental in the development of REAL and a number of student run/owned school-based businesses, such as a day care center, a restaurant, graphic arts service, and a miniature golf business. These involve educational components in regularly scheduled classes in schools and practical work with the business. Organizers have been careful to ensure that the newly developed business would not compete directly with an established business in the community. In addition to learning how to develop and operate a business, student-owners provide a needed service for the community with hopes that it will be sustained and even provide future employment. In other words, it teaches students how to create as well as assume employment in an operating business.

Similar school-related businesses have been developed in South Dakota, Kansas and Texas; but the vocational departments of many schools have initiated student projects for which a salable product is expected. For example, carpentry classes have built homes, garages, storage buildings, and outdoor furniture and resold them to the public. FFA chapters have fabricated and sold feed and watering troughs, farmed school-owned land, and salvaged farm products from leftover harvests of vegetables, cotton, and other materials that would not otherwise be used by the private land owner. In effect, schools and students in these schools have a number of ties as consumers and as a part of the businesses in their communities.

While many of the roles of schools in rural communities are very positive and are the source of much pride and an indication of the loyalty of the citizens, students do not generally remain in their rural communities after graduating from high school. In fact, those who do leave the community and obtain additional post-secondary education are least likely to return, because employment in many fields is not available in rural communities. In effect, rural America is providing a considerable amount of the resources for other elements of society in the form of their young people and the financial investment being made in their education. This presents a considerable drain on the resources of marginally economically viable communities; but maybe even more importantly, it robs them of the future contributions of their own. This writer remembers inquiring of the future plans of a senior class of about 25 in a small town in Kansas in the mid-1980s, and not one student indicated his/her intention of remaining in the area. Reasonably, those with the highest aspirations for professional and technical occupations would be the ones most likely to pursue their careers in urban and suburban areas; and thus rural areas would not benefit from their knowledge, community leadership, investments in real estate and consumption of goods and services.

Facilities of the school are used for a variety of functions, both school related and those of general interest to the community. Frequently, the only large meeting place is the school auditorium, and the school cafeteria/lunchroom is the facility used for political, social, and other large functions where a meal is served.

One must conclude that the role of the school in the rural community is great and is very important. This involvement is of mutual benefit, and it serves as a way in which there is a continual tie between the school and members of the community, although more than 75% of them do not have a child currently enrolled in the school. This fact alone is of concern to many school administrators and school boards across the country. How do you keep an aging, graying population interested and involved in the schools? One innovative school superintendent in Kansas managed to get a branch post office put in the high school, and the Michigan Partnership for New Education (MPNE) has a Local Area Partnership (LAP) as an element of that state's movement to create Professional Development Schools with both public and private foundational support. While these efforts are commendable, they are isolated events. As discussed elsewhere, rural America extends to every corner of this country; and, to date, rural America and the importance of rural communities and schools have not received as much attention as the problems more evident in urban America. Rural communities have a rugged independence that is a strength as well as maybe their own worst enemy. However, in many areas there is a repopulation of the rural countryside, and with the availability of rapid communications through a variety of electronic means, many jobs and careers can be pursued almost anywhere. The real choice is where one wants to live and not where one wants to work.

Learning and Teaching in Rural Education

There is a long-held belief that small schools cannot provide students with the breadth and depth of courses that will enable them to pursue their desired aspirations. Also, it is often said that teachers in small schools are less well prepared than their larger school counterparts and thus are less likely to be as effective. This section attempts to describe a variety of situations that will give the reader an understanding of the diversity that does exist.

At the elementary level, the curriculum is less dependent on the school's ability to offer specialized courses, and there are few demands to provide options beyond those required to meet the needs of special children. Special needs are generally provided through educational service centers, intermediate service agencies, cooperatives, itinerant teachers, or other arrangements. On occasion, multigrade classes are created to address the problem of low enrollment. Depending on the pattern of consolidation over the years, elementary schools tend to serve a smaller geographic area and have a smaller number of students. This is reflected in the broader distribution of elementary schools across a rural school district. On the other hand, middle schools have been created to meet the demands of adolescents, as well as to provide a new approach to teaching. Whereas the junior high schools of the past focused on specific areas, i.e., math, general science, English, etc., and in essence were miniature high schools, there is a distinct middle school concept that extends across all subject areas. In some middle schools serving a rural area, this is practiced in schools/buildings that were designed and planned to meet the needs of newly formed school boundaries. As in the elementary school, there is a lesser demand for specialized course work, but the advent of study in music, art, and other subjects begins to surface.

In those communities in transition from an intact rural base to one of new subdivisions with families oriented to suburban life, schools are feeling the pressure of parental expectations that are new and different from the past. This requires additional expenditures and the acquisition of teaching expertise that may or may not be available in some areas. In some regions of the country, there is a surplus of teachers; and schools may be able to meet their needs. In other situations, there is a shortage of teachers, especially in those subject areas where demands are greatest; and some potential teachers are unwilling to accept positions in rural areas or at locations of some distance from their families/homes.

The high school level has been the focal point of the most criticism or concern with the curriculum in rural education. There is a general belief that small schools, which are more prominent in rural areas, are less able to offer a broad-based curriculum and the depth that is demanded of schools for the future. Queries for more explanation of such a perception will inevitably produce references to the lack of advanced science and mathematics courses and foreign language offerings, and the unavailability of teachers with majors in the subjects in which they are assigned to teach. Yet, these small schools do meet the requirements of the state and provide a program for students that will enable them to graduate and meet entrance requirements in most colleges and universities.

Schooling in Rural America

The rural community functioning as a tightly knit unit of common people with common interests is becoming less and less an accurate description, particularly as it relates to schools. After the first wave to close one-room schools and to form consolidated K-12 school districts, there were a few elementary schools whose students advanced to a combined 7-12 school. Students still knew each other, and parents of the community and the teachers could call most students by name. This provided a support base for students and a continuity in the fiber of the school as a community in and of itself. The curriculum in rural America had not wandered far from the mainstream of the basics. The reason for this was probably reflected in the values of rural communities as well as the ability of schools to offer only a basic curriculum. Resources and the scarcity of a sufficient number of students did not allow for an expanded or extended curriculum in most cases. High school students might have had an elective or two from which to choose beyond the required curriculum for meeting graduation requirements. In many schools this meant a choice between agriculture and shop for boys and home economics and business education (secretarial training) for girls. A typical four year high school curriculum would have included four years of English, two years of history and social studies, one year of mathematics, and one year of science. Other required courses might have included a course in civics or government, a state history course, physical education and an art or music course. Credit was often given for participating in band, chorus, speech, athletics or other activity type courses. The debate in school board meetings sometimes centered on whether the school should be ensuring that each graduate was able to effectively enter the work force with employable skills or be accepted into public colleges of the area. This generated much debate and dialogue but little change in the curriculum.

The sciences in small schools serving rural communities generally include only whatever is required by the state. This frequently means a biological science course and one in the physical or earth sciences. Small schools find it difficult to offer chemistry and physics on a regular or annual basis. Part of the problem is related to the number of students who would be interested and to the difficulty in finding qualified teachers in these areas. It is not at all uncommon for small schools of today to be without any science teacher at the high school level who is fully qualified to teach all of the sciences. In too many cases, persons assigned to teach the sciences are minimally qualified or even teaching on a temporary license or deficiency plan for which they may teach for a designated period of time while completing additional course work.

However, to portray all science teachers in rural schools as unqualified and ineffective would be a great injustice. Some of the most creative approaches to teaching science can be found in the classrooms of dedicated professionals of small schools. This writer is aware of an individual who is a licensed veterinarian, but who wanted to teach science in a rural community. His classroom is exciting and vibrant, and he reflects the interest that he hopes his students will obtain. Science to these students is every day of the year, as the instructor has them working on projects in and out of school and during the summers as well.

Unfortunately, examples of teachers who are able to maintain this level of enthusiasm over many years and against tremendous demands on their time are all too rare. In a small school, a teacher may teach five or more separate daily courses with separate preparations each day. Teachers also coach, drive school buses, sponsor clubs and organizations and serve on a variety of school committees. The responsibilities for small schools are basically the same as those for large schools, and there are fewer teachers and other support/supervisory personnel to revise curriculum, plan for site-based management, prepare accreditation reports, order supplies and materials, etc. When you are one of the two science teachers in the school and there is not a science supervisor for the district, you have a tremendous responsibility and must make major commitments of time and energy.

Over the years, science teaching in this country has changed, but there remains an overriding feeling that the best science is "hands on" science. In rural America, the opportunities to be a model for this concept are present. Small class sizes, less bureaucracy, and greater opportunities for using the out-of-doors are elements that should be supportive of this notion. For a student who grew up on a farm, the practical aspects of plant growth, animal reproduction, the effects of climatic conditions, seasons of the year, predator and prey relationships, and ecology are not new topics. To combine education with everyday living is a powerful learning opportunity, and rural education has made use of that to some degree. However, the changing face of rural communities presents a profile in which fewer and fewer rural students actually live on a farm or have anything to do with this enterprise. On the other hand, one now finds FFA clubs with a substantially larger number of girls involved in feeding and showing animals at county fairs and livestock shows.

Rural education of today is an ever-changing landscape, and some of the more recent innovations of expanding the curriculum, accessing master teachers, and working with students through distance education will be discussed later. However, it might be best to summarize some of the more visible strengths and weaknesses of rural education. In a publication of the Mid-continent Regional Educational Laboratory (McREL, undated), *Redesigning Rural Education-Ideas for Action*, the following lists were presented:

Rural education has many strengths:

- There is broad consensus in rural areas that education is important.
- Students are educated in small groups, opportunities exist for cross-age tutoring and team learning.
- Student/teacher ratios are low and students receive individualized attention.
- Teachers know students well. Discipline and vandalism, often signs of alienation, are not problems. Communication is personal, direct and rapid.
- The entire organization operates on a human scale. Community members agree on goals. They are proud of the school and the success of its students.

Rural education also has weaknesses:

- Small schools can only offer a limited range of traditional courses.
- Teachers are often the only subject expert in the school. They often have five or more preparations for different courses each day. There is little free time for planning or collegial exchange.
- Teacher training is geared to a mass market dominated by suburban and urban schools, so teachers in rural schools must often learn on-the-job.
- Opportunities for advanced training, research and professional exchange are limited by budgets and distances.
- Many rural areas are suffering economic decline and shrinking tax revenues. (p.1)

On a bookmark distributed by Schools for Quality Education, the small schools organization in Kansas and the state affiliate of the National Rural Education Association, rural is described in terms of "Rural is More" and "Rural is Less."

Rural is More

- Personal relationships.
- Opportunity for individual student recognition.
- Leadership and responsibility of students.
- Participation of parents.
- Community support.
- Traditional values.
- Students attend college.
- Positive self images.
- Student respect for school.
- Student respect for teachers.

Rural is Less

- Dropout.
- Vandalism.
- Crime rate.
- Discipline problems.
- Drug use.
- Overcrowded classrooms.
- Negativism.
- Erosion of parental authority.

Consistent with some of the earlier characterizations of rural communities, they are proud of their schools and they perceive them as doing a good job. In a study of small schools in Kansas, Horn (1987) found that students, teachers, administrators, board of education members and community adults rated the following variables as "usually" or "definitely" present or true in their school.

a. Students take two or more years of science and mathematics.
b. Teachers have good attendance.
c. School maintains safe environment.
d. A low crime rate exists.
e. Teachers are well prepared.

In a follow-up study of graduates of small schools across a seven-state area, Horn, Anshutz, Davis and Parmley (1986) found a negative correlation between school size (enrollment) and the percentage of graduates who take courses in physics/chemistry and trigonometry/calculus. In that same study, it was found that career guidance/counseling is provided in an informal but effective manner. Also, students seemed satisfied with both the content and the manner in which they were informed of career opportunities and the academic requirements for entering the fields.

The continuing concern about the lack of breadth in curriculum offerings may have been partially put to rest from the results of a study by Monk and Haller (1986) in New York:

> This lack of uniformity-no district was consistently good or poor in its offerings-suggests that the quality of a school's programs may be less related to its size than to idiosyncratic factors such as the presence of a particularly effective and committed teacher or administrator. (p. 30)

The involvement of students in activities of the school deserves special consideration. Small schools have attempted to emulate their larger counterparts in the maintenance of an extensive array of extracurricular activities. Not only is the opportunity available for students to participate in a wide variety of such activities, it is almost necessary. In the case of football, they need almost all students who are physically able to participate; and even with this, many rural schools have had to resort to participation in six- and eight-man (person) teams. The availability of athletic teams for boys and girls in small schools permits many students who would not be able to compete in a larger and more selective environment to be a part of the centerpiece of many rural communities. The same generality applies to musical groups, such as band and chorus, speech teams, casts for plays, and other formally organized and school-sponsored programs. At the same time, leadership positions in student councils, as class and club officers, and as school representatives to special events are potentially more available to students in small, rural schools. It is not uncommon for a student to participate on competitive athletic teams throughout the year, be a member of the band, sing in the chorus, have a part in the class play, and serve as a officer for their class and one or more other organizations.

While this is usually considered as a positive aspect of being a student in a rural school, it does place heavy demands on the time and energies of some students. Those who are successful in these endeavors are usually well organized, highly motivated and strongly supported by family members. Support from families comes in many ways, including encouraging participation, attending events, assisting students with home responsibilities, providing the necessary financial resources, etc.

In essence, it is possible for students in small schools serving a rural area to "be someone" and to be recognized within the school and the community. Students and their achievements are a source of pride for the communities, which is easily observable from a review of the local newspaper. News about student accomplishments is published on a regular basis, and 10 or 25 year reflection sections of newspapers will often contain mention of students in those earlier times.

The demands on students for the time to participate in so many activities are great, but there is also the possibility of pressure from a number of sources for participation. For example, the gifted athlete or even earlier maturing high school students may be pressured to participate in activities, even though there may not be a personal interest. However, the benefits and advantages of participating in extracurricular activities of the school are probably substantially greater than the disadvantages. Students in college leadership positions have often gained experience in high school, and certainly the FFA has provided the prerequisite training and opportunity for high school students (male and female) to pursue careers in politics and other professions requiring skills learned in this program.

Innovations and Successes

Rural communities have traditionally been characterized by a "can do" attitude. The challenges in rural education are often associated with one or more common factors: scarcity of resources, geographic isolation and small numbers of students. Responses to these challenges have been creative and seemingly made use of exhaustive attempts to preserve the presence of a school in rural communities, the identity of towns/villages and a feeling of independence and accomplishment.

With the advent of federal and state laws and regulations to mandate serving the needs of special students, cooperative arrangements among a number of school districts created a new entity in the structure of K-12 education. Simply, these organizations are often referred to as "cooperatives," and they provide special education teachers and other services for the students of membership schools. Many cooperatives have expanded services to include joint purchasing programs, inservice/staff development programming, administration of grants, and other programs that have emerged in response to common needs. In some states, mandated or voluntary "intermediate service centers/agencies" have been developed. Generally, these intermediate units have an array of services that is broader than those provided by cooperatives and serve a larger number of school districts. In some states, such as Texas, there is a growing closer relationship of intermediate service centers and the state department of education.

Intermediate service agencies and cooperative special education units have served rural schools well by providing needed/required services at an acceptable cost level, by preserving individual school district choice in selecting/using services, and by not threatening the individual identity of local schools.

Other cooperative arrangements have emerged to meet more generalized local needs. An example is a "computer assistance consortium" that began in the mid-1980s with four small/rural school districts and the Center for Rural Education and Small Schools at Kansas State University. The schools were in need of continuing advice on computer planning and purchases and individualized assistance for teacher usage on an immediate response basis. The Center had a history of working in a collaborative manner, and the match was made. During the first year, four schools and the Center employed one person to spend one day a week in each school in a service capacity; and the fifth day was used for researching/previewing new products and practices. This consortium has now grown to include twelve schools and employs three persons to work directly with schools. The project was initiated through the efforts of the Center Director, Jerry Horn, and Lew McGill, superintendent of Riley County Independent School District, with the encouragement and consultation of Paul Nachtigal of the Mid-continent Regional Educational Laboratory.

Other voluntary cooperative arrangements among rural schools have included shared teachers and administration; technical services; and multi-school athletic teams, musical groups, and other student organizations. Cooperative staff development programs, whether generated locally or based on sponsored arrangements with providers from the public and private sectors, are commonly used to reduce costs and to meet specialized needs.

More recently, a number of distance education projects have emerged in rural education. Often with the cooperation and assistance of small locally owned telephone companies, two-way interactive distance education projects now provide relatively small groups of schools (4-10) with advanced mathematics, specialized sciences, foreign languages, and advanced placement courses, among a number of other curriculum broadening offerings. While several arrangements can be found, the general pattern includes originating a program from one school where a teacher is available, with the other schools paying a subscription fee or contributing a course with their teacher in another curriculum area. In most cases, the local telephone company was approached by a group of school officials with an interest and need to expand and enrich the course offerings for their students. A good documentation of some of these efforts has been developed as a video by the Southwest Educational Development Laboratory (1994). The video is entitled "Local Heroes," which gives an indication of the demands and type of leadership required for small schools to develop and implement such innovations.

Other electronic delivery systems of instruction include interactive computer systems, but one of the most widely known and best supported projects is distance education via satellite. This medium of delivery was greatly enhanced by the STAR Schools Demonstration Project, authorized by the Education for Economic Security Act in 1988. This program focused on designing telecommunications systems and delivering educational programs in math, science and foreign languages to rural communities and underserved metropolitan areas with scarce resources. In its first year, four projects were funded; and three used satellite delivery systems. An example of one that specifically focused on rural populations was the Midlands Star Schools Consortium that primarily operated in the states of Kansas, Missouri, Oklahoma, Alabama and Mississippi. While this group developed and delivered a number of educational programs, foreign languages, mathematics, and science enrichment programs were highlights of the first year. Now, without federal support, foreign languages, German and Spanish, are the hallmarks of this group. One of the members has emerged as an effective marketing/brokering agent for educational programming. In addition, hundreds of satellite dishes (antennae) were placed across this five-state area, which allowed these schools to access much more programming from the public sector or on a subscription basis from other vendors.

A unique four-day school experiment was initiated and tested in Colorado. This project demonstrated that notable cost savings in many areas and dedicated time for staff development and extra-curricular activities could be achieved through a four-day school week. A description and evaluation of this project is reported by Richburg and Edelen (1981).

An impressive number of innovative programs developed/implemented in rural education are described in *Educational Programs That Work in Rural Settings* (Rural Education Association and National Diffusion Network, 1987). A more recent source (Stern, 1994) provides additional examples of other innovative programs with particular attention to those that have been government sponsored.

Certainly, the issue or the threat of consolidation has been central to a number of efforts to improve the efficiency and effectiveness of rural education. Nachtigal (1980) traces three rather distinct themes of rural education reform from a historical perspective. The first theme, "the rural school is the problem," was evident in the late 1890s and early 1900s. The "necessarily existent small school" theme emerged in the 1950s, and in the 1960s, with the advent of massive federal intervention, the theme that "the problems of education are generic" became evident. Within the concept of each of these themes, numerous attempts to reform schools occurred, often surfacing in conjunction with the issue of consolidation. Many of these innovations proved to be successful, and they have been maintained in rural areas and expanded to suburban and urban settings. Other programs proved to be unsuccessful in this context, particularly when there was an unfamiliarity or the absence of a long term working relationship between the change agents and the rural communities. Oftentimes there were serious underestimations of the significance of independence and community pride that shaped the dynamics of innovation and change.

Re-discovering Rural Education

Over the past 15-20 years, rural education and those individuals who have toiled in this arena have enjoyed a new and more positive recognition. Stories abound that literally no one in the federal government would claim responsibility for rural education. The first evidence of recognition by the federal government occurred with the U. S. Department of Education Act of 1979 in which ED was directed "to establish a new organizational commitment to the nation's schools and placed responsibility for carrying this out in the Office of Vocational and Adult Education" (Stern, 1994, p. 27). The location of this placement of responsibility is interesting in and of itself. Why would it not be in the Department of Elementary and Secondary Education? In 1983, the first policy on rural education was announced by Secretary Bell in the form of the "Rural Education and Rural Family Education Policy for the 1980's." Basically, this policy focused on assuring an equitable share for rural schools of funds and services provided through the U. S. Department of Education. Of course, the problem with this concept is that the allocations are often made on the basis of headcount, and the funds that eventually get to a local school may be of such a small amount that any reasonable programmatic response is impossible.

The 1983 rural education policy was publicly announced at the annual meeting of the National Rural Education Association (NREA). This event triggered attention and greater respect for the NREA, which had re-organized itself after many years as an affiliate of the National Education Association. Tracing its origins back to 1907, the NREA is today an organization of more than 1,000 members, including school administrators, teachers, school board members, higher education faculty and administrators, and state department of education personnel, among other interested groups. The stated goal of NREA is "to further the improvement of educational opportunities for all children in rural areas with additional attention to those for whom opportunities have been severely limited in the past." In its membership brochure, the NREA claims to be "THE national voice for rural education."

The 1983 annual meeting of the NREA was hosted by the Center for Rural Education and Small Schools at Kansas State University, in conjunction with this center's own annual conference that began in the last 1970s. In addition to this being the event for the public announcement of the rural education policy, the focus and format of the NREA conference took a distinct turn. Previously, it had been an annual event of showcasing programs and schools of the area in which the conference was held. The conference has changed to include invited papers, research reports, debates of significant issues and representation from a much broader audience, geographically and professionally. More recently, the NREA has added a research forum and a rural education congress component. All of these changes heightened interest and increased the impact of the organization on practice and policy formation.

During the late 1970s and 1980s, a number of centers for rural education were established. Notably, most of these have been in conjunction with a college or university. Examples of these may be found in Montana, Colorado, New Mexico, Nebraska, Kansas, Oklahoma, Texas, Missouri, New York and Tennessee. Service, research, and development are common to most of the centers, but some have chosen particular areas of emphasis. Rural education units or programs have also been established within a number of professional organizations, including the National School Boards Association (NSBA) and the American Association for School Administrators (AASA). The ERIC Clearinghouse on Rural Education and Small Schools (ERIC/CRESS), now associated with the Appalachia Educational Laboratory in West Virginia after a number of years at New Mexico State University, provides a reservoir for an increasing number of publications on rural education. Journals now exist as an outlet for research and reports of practice in rural education. Notably among these are *The Rural Educator* and *Research in Rural Education*. Numerous newsletters focusing solely on rural education or including special dedicated segments on rural education are disseminated across the country by centers, offices, and organizations with a newfound interest or affiliation with rural interests. Each of the ten OERI/U. S. Department of Education funded regional education laboratories has rural education components; and, in fact, a defined portion of their funds and effort must be directed to the needs of rural/small schools.

All of this attention on rural education over the past 15 years is interesting in that there have not been critical events or crises, increases in funding, or national studies that have resulted in major political debates about the woes of schooling in rural America. The general dissatisfaction with education and the negative reports related to schools in urban, poverty-laden settings may certainly have encouraged seeking alternative schools in le threatening environments. However, the perseverance and dedication of individuals in many settings and the role played by grassroots organizations, like the People United for Rural Education (PURE) in Iowa and the Schools for Quality Education (SQE) in Kansas, should be given considerable credit for the "rediscovery" of rural education. Other states have developed rural education associations and formed official affiliation with the NREA.

The Future and Concluding Comments

The concept of the one-room school, impoverished and barely meeting any reasonable standards of quality for the education of children and youth, will be long remembered but difficult to find in the future. Many of the practices associated with small schools serving rural communities will become mainstream practices in more populous communities and schools. Opportunities for a broader type of employment will greatly influence the composition of what we now know as rural America. Technology will link schools and citizens to an almost unimaginable configuration of information, data bases and resources. Schools, as collecting places for students to study and socialize, may be greatly diminished in the future. Schooling may be reconceptualized to occur at many locations and by quite different means. However, the social needs of students and adults will have significant impact on the future of schools and communities, as will the capacity of the country to support any public enterprise that is viewed as excessively costly or unable to demonstrate its ability to produce. Rural education faces a number of challenges in this regard. Clearly, there are problems and weaknesses in rural education, but there are identifiable successes. Stern (1994) has summarized the condition of education by this statement.

> With an improved research capacity to better target rural needs, and with the lead of model rural schools that are successfully serving their students, strategies can be designed to extend education opportunities to students everywhere (p. 72).

This section of the yearbook has been written to provide a relatively brief examination of rural education and small schools serving rural communities has been rendered. As with any analysis, this is incomplete, but the information provided can provide assistance to those with little experience in rural education. Those with considerable knowledge and experience should recognize this as a fair representation of a truly interesting and potentially rich environment for developing and demonstrating the best of practice and research to improve education for all America.

References

Horn, J. G. (1987). *A study of the perceived effectiveness of Kansas small schools* (Technical Report). Manhattan, KS: Kansas State University, Center for Rural Education and Small Schools.

Horn, J. G., Anschutz, J., Davis, P. & Parmley, F. (1986). *A study of rural/small schools and their graduates in a seven state area* (Technical Report). Manhattan, KS: Kansas State University, Center for Rural Education and Small Schools.

Mid-continent Regional Educational Laboratory. (No date). *Redesigning rural education: ideas for action*. Aurora, CO: Mid-continent Regional Educational Laboratory.

Monk, D. H. & Haller, E. J. (1986). *Organizational alternatives for small rural schools*. Ithaca, NY: Cornell University, Department of Education.

Nachtigal, P. M. (1980). *Improving rural schools*. Washington, DC: U. S. Department of Education

Nachtigal, P. M. (1982). *Rural education: In search of a better way*. Boulder, CO: Westview Press, Inc.

National Rural Education Association. (1984). *Your invitation to membership* [Brochure]. Ft. Collins, CO: J. Newlin.

Richburg, R. W. & Edelen, R. W. (1981). *An evaluation of the four-day school week in Colorado* (Technical Report). Ft. Collins, CO: Colorado State University, Department of Education.

Rural Education Association and National Diffusion Network. (1987). *Educational programs that work in rural settings*. Longmont, CO: Sopris West, Inc.

Sher, J. P. (Ed.). (1977). *Education in rural america: A reassessment of conventional wisdom*. Boulder, CO: Westview Press.

Sher, J. P. (1988). *Class dismissed: Examining Nebraska's rural education debate*. Chapel Hill, NC: Rural Education and Development, Inc.

Southwest Educational Development Laboratory. (1994). *Local heroes: Bringing telecommunications to rural, small schools* [video]. (Available from SEDL, 211 East 7th Street, Austin, TX 78701).

Stern, J. D. (1994). *The condition of education in rural schools*. Washington, DC: U. S. Department of Education, Office of Educational Research and Improvement.

Chapter 2
Status of Science Education in Rural Schools

Bill Baird

As noted in the previous chapter the economic, as well as geographic settings of schools and communities labeled as "rural" are varied indeed. Rural schools range from the very small to those that are large, by even suburban standards. Those schools which meet the criteria for being "rural" account for a substantial portion of the school population in the United States.

Joyce Stern cites recent data from the Schools and Staffing Survey conducted by the National Center for Educational Statistics on the size of rural education in America (Stern, 1994). According to the NCES there were 79,876 regular public schools that enrolled more than 41 million students during the 1991-92 school year in the 50 states and District of Columbia. About 22,400 of these schools meet their definition of rural. These schools and their teachers educate about 6.9 million of our nation's young people. Rural education thus accounts for about 28% of all public school buildings and 16.7% of all public school students. "Some 560,000 elementary and secondary teachers, or about 24 percent of America's more than two million public school teachers, were employed in rural school settings in the school year 1987-88" (p. 33).

Despite the fact that one out of four teachers works in rural environments, most preservice curricula neglect to prepare teachers for unique rural conditions. Rural school systems fail to recruit and retain good teachers for their classrooms (Horn, 1985). Rural schools pay teachers $4,800 less in base salary and $1,600 less in BS starting salary than their nonrural peers. Only 6 percent of rural teachers are members of minority groups, compared with 12 percent in nonrural schools. Rural teachers tend to be younger and have less teaching experience than nonrural teachers. Teachers in rural classrooms are often assigned to teach subjects for which they are not academically prepared or certified. In rural science classrooms, 24 percent of teachers lack academic majors or certification in the subject they teach (Stern, 1994). Carlsen and Monk(1992) found that science teachers in rural middle and secondary schools averaged 3.1 years less experience, reported taking fewer science courses and science methods courses, and had fewer advanced degrees than their counterparts in nonrural schools.

If rural schools offer less money for their teachers and assign them outside their area of preparation, then shouldn't we expect test results to reflect less learning among rural students? If younger, less prepared teachers are managing rural classrooms, where poverty is more widespread than in urban and suburban schools, then how can we explain the high level of satisfaction among parents, and student achievement equal to that of nonrural learners? Why is it that job satisfaction levels among rural teachers are no lower than those of other teachers (both are about 30 percent)? Why are attrition rates about the same in both groups (9 percent per year in 1986-88)?

Questions About Rural Schools and Science Teaching

Answers to the following questions will be examined in this chapter:

1. In what ways are rural schools similar to nonrural schools? How are they different?
2. Are laboratories and supply rooms in science departments well equipped and frequently used?
3. Are rural schools and class sizes larger or smaller than nonrural schools and classes?
4. What are some descriptive characteristics of rural science teachers?

5. How many different subjects do rural teachers prepare for each day?
6. What are the perceived needs of rural teachers, and how do these compare with needs felt by other teachers?
7. What are the most common instructional strategies among rural science teachers?
8. What are some common problems among rural science teachers?
9. What resources are available to assist those who work with rural schools?

Sources

Two resource books were helpful. They are *The Condition of Education in Rural Schools*, published in June 1994 by the U.S. Department of Education, Office of Educational Research and Improvement, and *Riding the Wind: Rural Leadership in Science and Mathematics Education* from the Northwest Regional Educational Laboratory. Both of these books, as well as rural education directory of organizations and resources, are described in the resource list at the end of this chapter.

Selected tables and figures are used, with permission, from an article that appeared in the November 1994 issue of *Science Education*, published by John Wiley & Sons, Inc. That article—*Comparison of perceptions among rural versus nonrural secondary science teachers: A multistate survey*—was co-authored by myself, Preston Prather, Kevin Finson, and Steve Oliver. The author is indebted to many colleagues like these who helped assemble data from eight states on the status of rural science education as part of a project of the National Committee for the Study of Options for Rural Science Education (Prather & Oliver, 1991).

Data from the Council of Chief State School Officers (1990) casts light on rural issues which summarizes data on mathematics and science education from each of the states. Additional reports are available on science teaching conditions in states considered to be rural (Enochs, Oliver, & Wright, 1987; Baird & Rowsey, 1989). Shroyer and Enochs (1987) have provided additional guidelines for researchers wishing to explore rural science education. Those who would examine conditions in rural American schools are first confronted with what might be called the dilemma of definition.

Rural schools

Rural schools are characterized by being smaller, being more central to local community life, having more students eligible for free lunch programs, and being surrounded by sparse populations. While there are not many one-room schools left, school size is definitely smaller in rural areas. Table 1 is taken from data we collected on 1254 secondary science teachers. Of the 573 who classified themselves as "rural", 82.4 percent taught in schools with enrollment of less than 600 students. Only 35.1 percent of nonrural teachers taught in schools of this size (Baird, et al., 1994).

Table 1
School Enrollment by Type of School

Enrollment	Percent of rural teachers (N=573)	Percent of non-rural teachers (N=681)	Percent of Total teachers (N=1,254)
Less than 300	46.2	7.6	25.2
301-600	36.2	27.5	31.5
601-1,000	11.3	29.2	21.1
1001-1,500	5.2	25.0	16.0
More than 1,500	0.9	10.7	6.2

In my parent's rural communities the family, the church, and the school served as centers of community life. Even today, the school often serves as a polling place: banquet site; after-hours community center; adult education center: and the stage for drama performances, band concerts and community picnics. In small communities the school is often one of the largest employers, and represents the largest single expenditure of local property taxes. As national and international economic conditions have changed, rural circumstances have seen increased poverty, joblessness, and economic stress. Several reform efforts in the second half of this century have tried to address rural school problems. One of these is school consolidation.

McIntire and Marion (1989) question the merits of school consolidation. While economic benefits (bigger is better) prompted this reform effort, the quality of education in larger, consolidated schools is open to question. They argue that the impact of socioeconomic status (SES) on educational outcomes is profound and widely documented (Alspaugh, 1992). Since rural communities tend to have higher concentrations of youth living in poverty, simply busing them to a larger school building does not necessarily improve their learning. In McIntire and Marion's study, SES was held constant while school size was the independent variable. They found that student science scores were higher when students attended smaller (less than 300) schools than when they attended moderately sized schools (400-700 students) or large schools (900-1200 students). McIntire and Marion argue for the benefits of small schools in rural settings. Besides the documented science learning outcomes they note the "family-like environment" and "source of community pride and identity" typical of rural education (p. 6).

Alspaugh (1992) confirms these findings and adds other advantages of rural education in his study of 106 rural elementary schools in Missouri. Using scores on the Missouri Mastery Achievement Test to measure skills attainment in science and other subjects, he concluded that there are very few differences in average achievement levels for rural vs. urban schools. He proposes that students in urban schools segregate themselves by SES much more that those in rural schools. This may lead to achievement gains among students from low SES families and reduce the negative effect of SES on learning outcomes. He also notes the benefits of having more two-parent families in rural communities, along with less mobility. The presence of fewer minority students in rural schools may act to elevate achievement test scores.

The issue of minority populations in rural schools is interesting. Overall, 87 percent of rural K-12 students are White, while about 6 percent of their teachers are members of minority groups - compared with 12 percent in nonrural schools (Stern, 1994). In a national sample of science classrooms, Weiss (1987) found only 5 percent of teachers in grades 10-12 were Black. Atwater (1993) has pointed out the importance of multicultural awareness in science classrooms. Yet the largest differences in perceived needs of rural vs. nonrural secondary science teachers involved multicultural issues, with rural teachers feeling less need for help in this area (Baird, et al., 1994). This could be a result of rural schools having fewer minority students and fewer minority teachers, thus reducing multicultural concerns.

Rural science teachers

In a study of 456 middle and secondary science teachers drawn from a national probability sample stratified by region and community type, Carlsen and Monk (1992) compared rural teachers with their nonrural colleagues. Rural teachers were found to have about three years less teaching experience than nonrural teachers. Rural teachers reported completing 3.5 fewer undergraduate science courses and 0.7 fewer science methods courses than their nonrural peers. Rural teachers were more likely to teach non-science courses. They were less likely (48% vs. 65%) than nonrural teachers to have a graduate degree. Rural teachers were less likely to have majored in science. These differences could not be explained by differing state licensure requirements.

Stern (1994) reported that rural teachers are younger and more likely to have fewer than 10 years of teaching experience than those in urban and suburban schools. No gender differences between rural and nonrural teachers were found. Baird et al. (1994) found that 69 percent of rural secondary science teachers were between the ages of 31 and 50, and more rural teachers (36.0% vs. 30.0%) had fewer than 10 years of teaching experience.

Carlsen and Monk (1992) wonder if the type of teacher in rural science classrooms reflects what the district can afford. In bidding for quality teachers, are rural districts losing to urban and suburban systems? They conclude that, "... ruralness is negatively related to some key measures of schooling quality" (p. 10), and suggest that "the educational preparation of science teachers in rural schools is more limited than that of teachers working in urban and suburban schools (p. 13). If teachers in rural science classrooms have weak backgrounds in science, then how well will they implement a conceptual change model, or plan and manage classroom conversations, or question their students' understanding of science?

Perceptions of local needs and resources

Baird, Prather, Finson, & Oliver (1994) used results from distribution of 100-item teacher needs survey (Zurub & Rubba, 1983) to determine the perceived needs of secondary science teachers in eight states. Of the 1258 teachers who indicated a teaching assignment in grades 7-12, a total of 574 reported that they taught in a "rural" school. Teachers responded to 52 items identifying needs that might be considered as falling on a 5-point scale, where 1 = "not familiar", 2 = "no need", 3 = "little need", 4 = "moderate need", and 5 = "great need." Response options 4 and 5 were collapsed and responses of rural teachers were compared with nonrural teachers.

Table 2 displays these needs in rank order based on responses from all secondary teachers. This table also contrasts rural vs. nonrural teachers' needs. The bar chart indicates differences between rural and nonrural teachers' perceptions of need. Where the bar extends to the right, the need was felt more strongly by rural teachers than nonrural teachers. Bars to the left indicate that urban and suburban teachers perceived the need as greater than their rural counterparts. The most noticeable feature of this table is the similarity in perception of need by the two groups of teachers. The ranking of needs is quite similar independent of teaching environment. Both groups feel that their greatest needs (of those listed in the survey instrument) involve motivating students to learn science; finding materials at low cost; learning to use computers for instruction; applying hands-on-science teaching methods; and updating knowledge in science-technology-society, science career options for students, and software selection.

Activities for science instruction

In her 1987 survey, Weiss found that lecture remains the dominant mode of instruction among science teachers in grades 10-12, consuming 43 percent of mean instructional time compared with 21 percent for hands-on and laboratory activities and 11 percent for daily routines. On their survey instrument, Baird, Prather, Finson, & Oliver (1994) asked teachers to indicate the frequency with which they used nine selected instructional strategies. Table 3 lists the nine activities, ordered by decreasing frequency of use by teachers. The choice options were (1) "never," (2) "less than monthly," (3) "monthly," (4) "every two weeks," and (5) "weekly." To simplify comparison, choices #4 and #5 were collapsed into a single category of frequent use. Thus, the table shows what percent of teachers reported using the activity at least every two weeks.

As in Table 2, the final column presents a bar chart of the differences between rural and nonrural teachers' use of these teaching strategies. Where the bar extends to the left, rural secondary science teachers reported using the activity less than their nonrural peers. Rural teachers exceeded nonrural teachers in use of lecture, but were less likely to make frequent use of cooperative learning groups, hands-on laboratory activities, inquiry teaching, and individualized teaching strategies. Neither category of teacher makes frequent use of field trips, microcomputers, or peer teaching.

Are microcomputers and other technology available to rural teachers and students? Are they regularly used? Both the Weiss study (1987) and that by Baird, et al. (1994) found that over 98 percent of science teachers indicated that computers were available in their schools. Only 20 percent of teachers in the Weiss study felt that computers were readily available for science instruction. Over one-third of teachers in the Baird, et al. survey (37% rural; 38% nonrural) reported having no computers available for their own teaching. About three-fourths (74.8%) of rural students used computers less than once a month, compared with 77.3 percent of nonrural students. About one-third of teachers in both groups reported using computers once a week or more - mostly for word processing and record keeping. Regular use of computers for science instruction was equally rare in both rural and nonrural classrooms. This may result from lack of preparation for computer use among science teachers and perceived lack of ready access.

TABLE 2
Ranked Needs of Teachers

Perceived need	Combined percent: moderate + great need - All Secondary	Combined percent: moderate + great need - Rural Secondary	Combined percent: moderate + great need - Non-Rural Secondary	Difference: Rural Minus Non-rural collapsed need
Motivate students to want to learn science	79.1	79.3	78.9	0.4
Identify sources of free & inexpensive materials	76.1	76.8	75.7	1.1
Use computers to deliver science instruction	75.2	77.6	73.3	4.3
Use hands-on science teaching methods	69.7	70.3	69.3	1.0
Update knowledge of uses of science/technology	68.7	69.0	68.4	0.6
Learn more about science careers for students	68.6	69.5	67.7	1.8
Select and order science software for computers	67.8	68.3	67.6	0.7
Update knowledge/skills in environmental science	66.9	70.1	64.0	6.1
Learn more about science related societal issues	65.4	66.2	64.8	1.4
Use a computer to help manage instruction	64.9	65.9	64.0	1.9
Use an inquiry science teaching strategy	64.7	68.2	61.8	6.4
Update knowledge/skills in chemistry	64.3	68.1	61.0	7.1
Update knowledge/skills in physics/phys. science	64.0	68.3	60.3	8.0
Evaluate own effectiveness as a science teacher	63.9	64.6	63.3	1.3
Construct science laboratory equipment	61.1	64.4	58.3	6.1
Select supportive materials for science instruction	59.7	62.1	57.7	4.4
Develop skills to diagnose/correct misconceptions	59.1	56.5	61.4	-4.9
Use test data to diagnose learning difficulties	58.8	60.2	57.7	2.5
Employ peer tutoring in science teaching	58.0	58.7	57.4	1.3
Set up a lab supply order with storage & retrieval	57.7	59.5	56.3	3.2
Employ individualized instructional strategies	57.5	59.1	56.0	3.1
Prepare teacher-made instructional materials	56.8	57.9	56.0	1.9
Maintain science laboratory equipment	55.8	56.8	54.9	1.9
Update knowledge/skills in earth science/geology	55.0	58.7	51.9	6.8
Direct a field trip to help students learn science	54.6	52.3	56.5	-4.2
Design measurement items to assess objectives	53.7	52.9	54.0	-1.1
Organize a science laboratory room	52.8	54.6	51.3	3.3
Conduct a science laboratory session	52.3	52.3	52.2	0.1
Learn more about multicultural science education	52.3	46.1	57.4	-11.3
Update knowledge/skills in biology/life science	52.3	54.8	50.2	4.6
Construct & use test item data bank	52.2	54.0	50.7	3.3
Update knowledge of the history of science	52.1	53.0	51.2	1.8
Use audio-visual equipment to improve instruction	50.8	54.2	48.0	6.2
Maintain live organisms for science instruction	50.1	52.3	48.4	3.9

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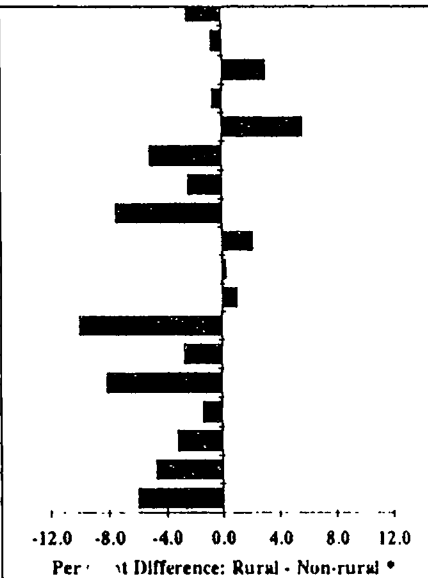
TABLE 2
Ranked Needs of Teachers

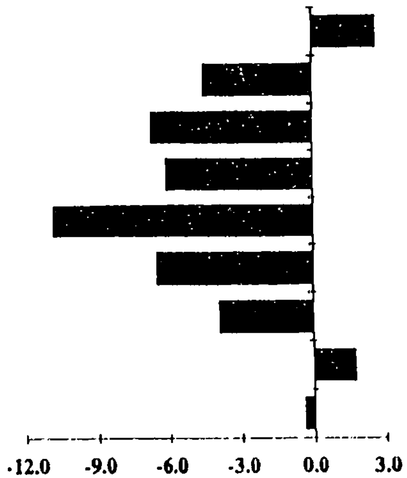
Demonstrate a science manipulative skill	49.2	47.9	50.4	-2.5
Provide for students' safety in science laboratory	49.1	48.8	49.6	-0.8
Learn more about cognitive development	49.1	50.8	47.7	3.1
Demonstrate a science process skill	48.9	48.6	49.3	-0.7
Select and order science laboratory equipment	48.6	51.8	46.1	5.7
Write objectives for skills needed by students	48.0	45.3	50.4	-5.1
Demonstrate a science concept	47.8	46.6	49.0	-2.4
Write objectives for attitudes needed by students	47.4	43.0	50.5	-7.5
Manage a science instructional budget	44.5	45.6	43.4	2.2
Select commercial science instructional materials	43.7	43.8	43.5	0.3
Work toward graduate degree in science education	43.5	44.2	43.1	1.1
Maintain student discipline	43.0	37.7	47.7	-10.0
Write lesson plans that integrate other subjects	40.2	38.8	41.5	-2.7
Write objectives appropriate for multicultural styles	39.1	34.7	42.8	-8.1
Write objectives for science knowledge of students	38.8	37.8	39.2	-1.4
Use student assessment data to determine grades	38.1	36.3	39.5	-3.2
Develop instructional unit plan for science	35.3	32.6	37.3	-4.7
Write lesson plans using history of science	33.2	30.0	36.0	-6.0



* Negative values (to the left) indicate that rural teachers felt less of the indicated need than non-rural teachers. Positive values (to the right) show a greater perceived need among rural teachers than among non-rural teachers. The relative difference for each item is indicated by the length of the bar.

TABLE 3
Frequency of Use of Selected Activities for Science Instruction

Frequency of activity for science instruction	Combined percent: every 2 weeks + weekly - Rural Secondary	Combined percent: every 2 weeks + weekly - Non-rural Secondary	Difference: Rural Minus Non-rural frequency of use
Teacher lecture in science class	96.1	93.4	2.7
Teacher demonstrations in science class or lab	66.3	70.8	-4.5
Laboratory activities where students handle objects	62.1	68.8	-6.7
Inquiry teaching strategies for science teaching	56.1	62.2	-6.1
Cooperative learning with task-oriented teams	36.5	47.3	-10.8
Individualized teaching strategies for science	33.8	40.3	-6.5
Peer teaching in which students help teach science	11.0	14.9	-3.9
Microcomputer activities in science class or lab	7.7	5.9	1.8
Field trips to off-campus sites for science reasons	0.5	0.9	-0.4



Per Cent Difference: Rural - Non-rural *

* Negative values (to the left) imply that rural teachers use the indicated activity <u>less frequently</u> than non-rural teachers. Positive values (to the right) show a <u>more frequent</u> use among rural teachers than among non-rural teachers. The relative per cent difference for each item is indicated by the length of the bar.

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One reason that rural teachers may use more traditional modes of instruction arises from the number of different subject preparations they must make every day. It is not uncommon in very small schools for a single teacher to be the entire science department. Baird et al. (1994) asked secondary teachers how many daily preparations each was required to make. The data are displayed in *Table 4*. Choice options were "one", "two", "three", "four", or "more than four." What is most notable about this table is the inverse relationship that results when rural teachers' preparations are compared with those of nonrural teachers. Over four times more rural teachers than nonrural teachers have four or more preparations per day, while one-third as many rural teachers have a single subject preparation. Clearly, rural science teachers must develop creative time management strategies to cope with frequent daily changes in subject matter.

Table 4
Number of Daily Preparations by Type of School

Number of daily Preparations	Percent of rural teachers (N=574)	Percent of non-rural teachers (N=683)	Percent of Total teachers (N=1,257)
One	8.2	25.7	17.7
Two	18.1	41.9	31.1
Three	27.7	21.9	24.6
Four	23.0	5.4	13.4
More than four	22.8	5.1	13.2

Problems in rural science education

Secondary science teachers were asked to indicate which of a selected list of local problems was "frequently a problem" or "a serious problem" (Baird et al., 1994). *Figure 1* shows that both rural and nonrural teachers ranked the problems in approximately the same order. Both groups felt that poor student problem solving skills, insufficient funds for equipment and supplies, inadequate laboratory facilities, and poor student reading ability were much more serious than out-of-date materials, poor teacher preparation, or number of textbooks. However, rural teachers rated the lack of career role models in the community as being more than twice as serious a problem as their nonrural peers. In contrast, the problems of large class size and lack of student interest in science were much more frequent among nonrural science teachers. This is consistent with findings that class size is smaller in small schools, and smallest in rural secondary schools (Stern, 1994).

The problem of resource availability and condition confronts rural science teachers more often than teachers in urban and suburban settings. This results from the combination of declining enrollment in many rural schools, combined with a severe downturn in the economy of agricultural communities. Where property and corporate taxes are high, school expenditures allow for the purchase of better equipment and supplies for academic use. In many rural areas today, school boards are facing disastrous collapse of their funding base. From 1979 to 1986 poverty increased twice as fast in rural areas as in urban areas among young adults and children. In 1986 one of every four children in rural America was living in poverty (O'Hare, 1988). This

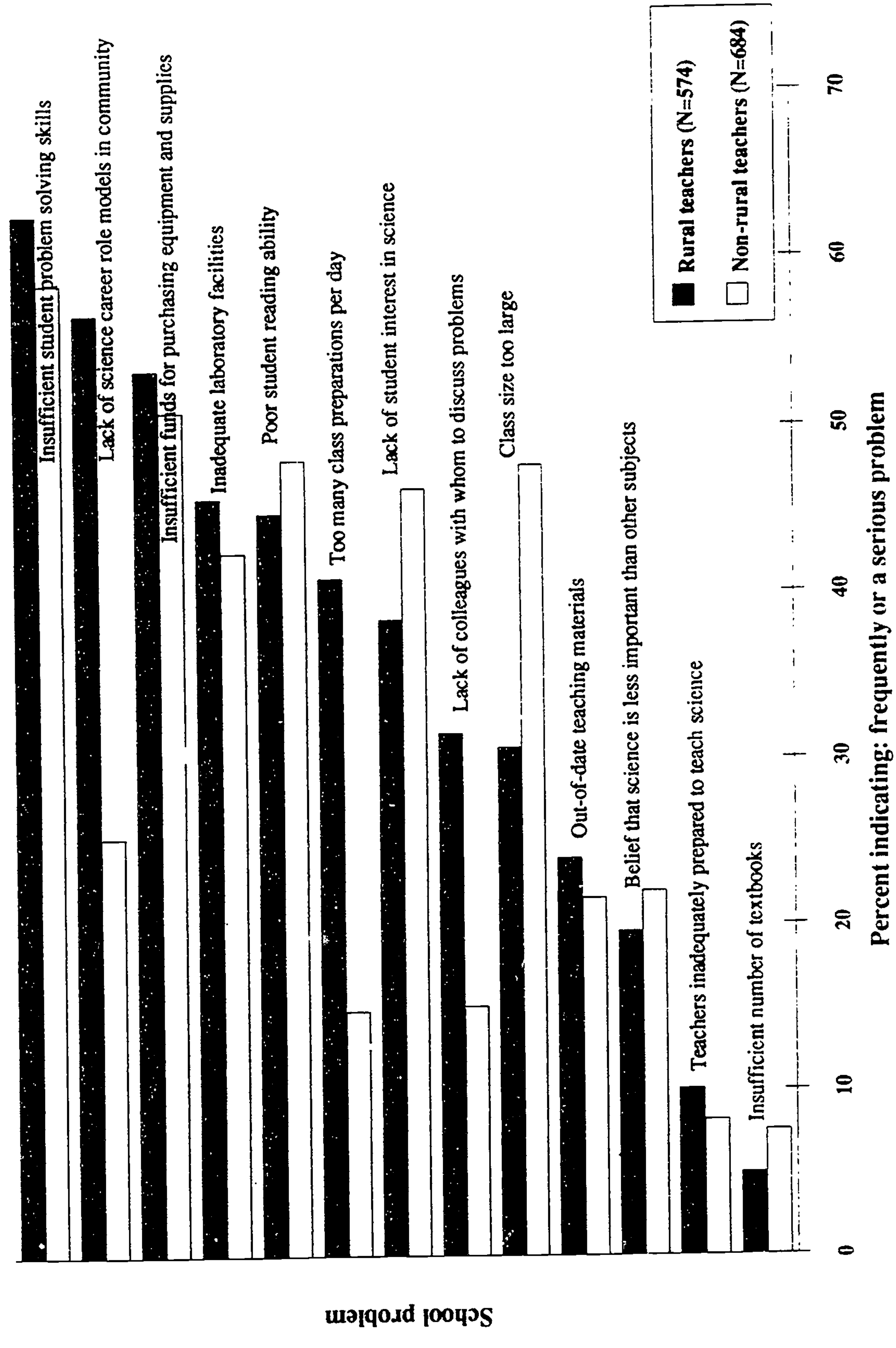

Figure 1. Perception of school problems among rural vs. non-rural secondary science teachers

problem has not been fully addressed by federal (Bass, G. & Berman, P., 1981) or state (Forbes, 1985) funding and programs.

The biggest financial pinch in rural schools derives from per-unit costs of educating a child. The cost per hour to operate a bus in urban areas is the same as in rural areas. But when rural buses are running four times as far, they require more fuel and must be replaced more often. The cost of a triple-beam balance is the same in both rural and urban classrooms. Yet having 100 students taking chemistry in an urban school leads to easier justification for balances than having 20 chemistry students in a rural school, especially when money is scarce. Choosing between balances and buses is a daily problem for rural school administrators.

Secondary science teachers (Baird et el., 1994) were asked about the condition of in-school resources for teaching science. More rural teachers than nonrural teachers (47% vs. 37%) considered these resources to be either "very inadequate" or "poor." Over half of both groups of science teachers (50.2% nonrural; 53.2% rural) felt that equipment and supplies for science laboratories were either "missing" or "barely adequate." Despite their belief that resources are below desirable standards, both groups report frequent use of science teaching laboratories.

Besides the condition of their laboratories, rural science teachers must deal with the problem of isolation. The relation between rural schools and isolation is not a simple one. For example, Stern (1994) notes that:

> In the spacious Mountain states where there are fewer than three students per square mile and less than one school per hundred square miles, only about 16 percent of the students attend rural schools. This compares to over 20 percent of students enrolled in rural schools among the South Atlantic states where there are more than 24 students per square mile and nearly four schools per hundred square miles. (p. 16). Yet in states like Alaska and Texas the connection between rural schools and isolation is more direct. Texas has the largest number of rural students (443,000) attending the largest number of rural schools (1,376). (pp. 15-16)

Isolation brings problems to rural science teachers. The scarcity of other science teachers in the same building and lack of access to nearby colleagues create a sense of loneliness that impacts morale among some rural teachers (Davis, 1987). While urban and suburban teachers can draw strength and ideas from attending frequent inservice workshops and professional conferences, rural teachers are more likely to find that isolation and lack of support for continuing education create a climate of living at the far reaches of science education.

Continuing and inservice education of rural teachers

The most common way to reach out and influence the practice of certified teachers is through regular inservice and continuing education. While some teachers attend graduate classes and some participate in professional conferences and institutes, almost all are expected by their school systems to take part in regular inservice workshops. While there is little comprehensive data on the extent of teachers' participation in inservice programming, there are some answers to questions of what prevents teachers from greater involvement in continuing education. Teachers in the Baird, et al. study were asked to indicate barriers to greater inservice participation by selecting one of five response options. Table 5 compares the responses from rural secondary science teachers with nonrural teachers. More rural teachers (63.1% vs. 49.3%) felt that lack of information or inconvenient location were major factors in their decisions regarding inservice opportunities.

Successes in rural science education

How successful are rural schools in teaching science? Comprehensive national data collected by the National Assessment of Educational Progress (NAEP) has provided evidence of learning outcomes since 1969. Rural students fell below the national means for science in the 1970 and 1973 assessments. But since 1977 rural students in all three age groups—9, 13, and 17 year olds—scored at the mean proficiency level in science (Welch and Wagner, 1989). These scores reflect improvement in basic skills, but U.S. students from all settings still do poorly on measures of higher order thinking skills. NAEP scores for students in what were classified as "extremely rural" schools fall below those students from "advantaged urban" schools and above the scores of "disadvantaged urban" students.

Table 5
Major Barriers to Greater Inservice Participation by Type of School

Barrier listed on response sheet	% of rural teachers (N=574)	% of non-rural teachers (N=668)	% of total teachers (N=1,242)
Lack of information	13.4	8.4	10.7
Inconvenient time or location	49.0	41.2	44.8
Poor quality of programs offered	9.6	16.2	13.1
Programs fail to meet my needs	23.7	28.3	26.2
Lack of personal energy or motivation	2.6	5.7	4.3

There are documented advantages among smaller schools for affective outcomes such as greater participation in sports and extracurricular activities, greater personal satisfaction, greater sense of obligation, less loneliness, and less frequent use of drugs (Fowler, 1992). And the similar achievement test scores among rural and nonrural students indicates that students and teachers in small schools overcome disadvantages to learning. The negative influence of lower socioeconomic status on academic performance is apparently outweighed by other factors acting to promote learning in rural science classrooms. Welch and Wagner (1989) speculate that the supportive nature of small schools in rural communities outweighs the influence of less frequent science activities and fewer science courses taken by rural students. With greater curricular opportunities, rural student performance might improve still more. Instead of using a deficit model for rural education, we may learn much from the successes of rural teachers and students.

The Northwest Regional Educational Laboratory's book - *Riding the Wind: Rural Leadership and Mathematics Education* - describes successful outcomes and solutions to many of the problems found in rural communities in their five-state region. By providing early and frequent field experiences in rural settings for preservice teachers, they have established improved recruitment and retention rates in the northwest. Mentors, networks, seminars, and university support for rural concerns have produced an inspiring success story among the 44 science and mathematics teacher participants of their project. All of us can learn from their efforts about how to better listen to rural teachers and prepare new teachers for rural challenges (Batey, A. & Hart-Landsberg, S., 1993).

One way to improve our efforts in rural education is to become more aware of success stories like those described in *Riding the Wind.* While that book focuses on efforts to improve science education among Native Americans in Alaska and isolated logging communities in the northwest, there are other directories of rural associations and special interest groups that should be useful to an even wider range of policy makers and teacher educators. For example, the American Association of School Administrators has published *The Sourcebook: A Directory of resources for small and rural school districts* (Armstrong, 1983). A more recent publication is the joint effort of the ERIC Clearinghouse on Rural Education and Small Schools and the National Rural Education Association, titled the *Directory of Organizations and Programs in Rural Education* (1990). Finally, the Appalachia Educational Laboratory has published (1993) the *Rural Education Directory: Organizations and Resources.* It is described more fully in the resource list below. Each of these provides helpful contacts for the networking that is so essential for problem solving in rural education.

Summary

We need to do a better job of preparing science teachers for success in rural school environments. Muse (1977) describes ways that universities can design preservice programs that help teachers to understand the dynamics of rural classrooms. Others have pointed out ways that universities can do a better job in this critical area (Prather, 1990; Finson & Beaver, 1990; Finson, 1990; Carnegie Forum on Education and the Economy, 1986; Gardner & Edington, 1982; National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983). Until we can prepare teachers to take advantage of the special challenges and opportunities they will encounter in rural schools, new teachers will face the isolation, lack of adequate science equipment, multiple subject preparations, and economic poverty that drive some to abandon science teaching careers. Given earlier field experiences, methods courses that include strategies for rural classroom teaching, and networking with successful teachers in rural schools, we should expect more teachers to express the same satisfaction as those in Project SMART cited in their final workshop:

> 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.
>
> (Batey & Hart-Landsberg, 1993, p.3)

Resource List and Helpful Publications

Much of the information in this chapter was obtained through the Internet by using a "gopher server" at the U.S. Department of Education. The complete address for readers who are Internet users and wish to search on their own is:

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gopher *gopher.ed.gov*

6. Educational Research, Improvement and Statistics/
 5. Educational Resources Information Center (ERIC)/
  16. ERIC Clearinghouses/
   1. ERIC Clearinghouse on Rural Education and Small Schools/
    2. Full-text Publications/
     7. Rural and Small Schools Digests/

The information above (especially menu choice numbers shown at the left on each line) is subject to change as the gopher at the U.S. Department of Education is modified. It is accurate as of March 29, 1995. Additional information on rural education may be available from the same source by the time this yearbook appears in print. Interested readers should explore this resource for updates. I was able to locate the three publications described below in less than an hour and order them the same day. The Internet offers an exciting new world for research!

Riding the Wind

Riding the Wind: Rural Leadership in Science and Mathematics Education is a 61-page report that describes a project of the Northwest Regional Educational Laboratory (NWREL) and the efforts of 44 rural science and mathematics teachers who began working together in 1990 to provide leadership in very small, rural settings. The report is organized around a series of lessons learned by the teachers and their teacher education counterparts from participating universities: (1) the challenges and rewards of teaching in a very small, rural school; (2) the need for strengthening ties between rural schools and teacher education institutions; (3) the value of teacher, community, and student mentorships; (4) country-style curriculum reform; (5) expanding instructional strategies; (6) using the community as the classroom; and (7) sustaining leadership roles in rural places.

Riding the Wind is available from NWREL at a cost of $11.95. Information about the Rural Education Program can be obtained by writing: Steve Nelson, REP Director, Northwest Regional Educational Laboratory, 101 S. W. Main, Suite 500, Portland, Oregon 97204. Office: (503) 275-9547, Facsimile: (503) 275-9489, Internet: nelsons@nwrel.org.

In the five states of the NWREL - Alaska, Montana, Oregon, Idaho, and Washington - two-thirds (64%) of the school districts are rural (serving unincorporated areas and towns of less than 2,500) and three-fourths of them are small (enrolling less than 2,500 students). The Rural Education Program is concerned with issues of educational quality, equity and access among small, rural schools and communities. It is organized and staffed to provide research data, information and technical assistance to help educators make more informed choices about small, rural communities, schools and classrooms. The Science and Mathematics Academies for Rural Teachers (SMART) project coordinated universities and rural schools for three years through a grant from the Dwight D. Eisenhower National Mathematics and Science Education Program. The goals were to (1) recognize and reward excellent teachers, (2) promote better preservice teacher experiences in rural settings, and (3) improve the recruitment and induction of novice teachers in rural schools through mentoring with master teachers.

The Condition of Education in Rural Schools

In June 1994 the U.S. Department of Education, Office of Educational Research and Improvement published a 140-page document titled *The Condition of Education in Rural Schools*. This excellent report provides data on a wide variety of issues that should interest policy makers, researchers, and educational leaders in rural settings. The report offers current aggregate data on rural educational variables including (1) economy and population, (2) location and characteristics of school districts, (3) school-community connections, (4) policies and programs, (5) teachers and principals, (6) effects of reform efforts, (7) finance policies and practices, (8) assessment of student performance, (9) education and work experiences of youth, and (10) future projections. The appendix contains 20 figures and 67 tables displaying such information as rural NAEP assessment outcomes, teacher demographics, course offerings, postsecondary plans of students, and per-pupil expenditures.

The Condition of Education in Rural Schools is available from the U.S. Government Printing Office, Superintendent of Documents, Mail Stop, SSOP, Washington, DC 20402-9329 for $10.00 prepaid. Order stock number 065-000-00653-7. ISBN 0-16-045034-9

Rural Education Directory

The Appalachia Educational Laboratory Clearinghouse on Rural Education and Small Schools (P. O. Box 1348, Charleston, WV 25325-1348; phone 304-347-0465) has recently published a 57-page booklet titled "Rural Education Directory: Organizations and Resources" © 1993. This handy resource can be ordered for $12.00 prepaid as document number AL-594-OR from the above address. Section One contains an annotated listing of national organizations, networks, clearinghouses, centers and associations whose mission includes rural education, with addresses and phone numbers. Section Two lists all of the regional educational laboratories, with a description of their rural project activities and contact names. Section Three lists all contacts for the National Diffusion Network - a federally funded system that promotes successful educational programs, products and processes. Federal government agencies and resources that serve rural education, with descriptions of their missions are listed in Section Four. Section Five provides an alphabetical list of state education agencies and organizations with rural programs, along with a description of each program and contact information. State data centers that provide free information about small towns and rural areas for planning and research are listed in Section Six. Finally, Section Seven presents an annotated list of journals devoted to rural issues.

References

Rural Education Directory: Organizations and Resources. (1993). Charleston, WV: Appalachia Educational Laboratory, Clearinghouse on Rural Education and Small Schools.

Alspaugh, J. W. (1992). Socioeconomic measures and achievement: Urban vs. rural. *Rural Educator. 13*, (3), 2-7.

Armstrong, G. (1983). *The sourcebook: A directory of resources for small and rural school districts.* Arlington, VA: American Association of School Administrators.

Atwater, M. M. (1993). Multicultural science education: Assumptions and alternative views. *The Science Teacher, 60*, (3), 32-37.

Baird, W .E., Prather, J. P., Finson, K. D. & Oliver, J. S. (1994). Comparison of perceptions among rural versus nonrural secondary science teachers: A multistate survey. *Science Education, 78*, (6), 555-576.

Baird, W. E. & Rowsey, R. E. (1989). A survey of secondary science teachers' needs. *School Science and Mathematics, 89*, 272-284.

Bass, G. & Berman, P. (1981). Analysis of federal aid to rural schools. ERIC Document Reproduction Service, Ed 199 017.

Batey, A. & Hart-Landsberg, S. (1993). *Riding the Wind: Rural Leadership in Science and Mathematics Education.* Portland, OR: Northwest Regional Education Laboratory.

Carlsen, W. S. and Monk, D. H. (1992). Rural/Nonrural Differences among Secondary Science Teachers: Evidence from Longitudinal Study of American Youth. ERIC Document Reproduction Service, ED 350 133.

Carnegie Forum on Education and the Economy (1986). *A Nation Prepared: Teachers for the 21st Century. The Report of the Task Force on Teaching as a Profession.* Washington, DC: Carnegie Forum on Education and the Economy.

Council of Chief State School Officers. (1990). State indicators of science and mathematics education. Washington, DC: Council of Chief State School Officers, State Education Assessment Center.

Davis, J. (1987). Rurality and isolation in education. *The Rural Educator, 9* (1), 11-13.

Directory of Organizations and Programs in Rural Education. (1990). ERIC Clearinghouse on Rural Education and Small Schools and National Rural Education Associatio. Charleston, WV: Appalachia Educational Laboratory, Inc.

Enochs, L., Oliver, J. S., & Wright, E. (1987). *"Perceived needs and status of secondary science teachers in Kansas - 1987"* (Technical Report #1). Manhattan, KS: Center for Science Education, Kansas State University.

Finson, K. D. & Beaver, J. B. (1990). Rural science teachers preparation: A re-examination of an important component of the educational system. *Journal of Science Teacher Education, 1* (3), 46-48.

Finson, K. D. (1990). A survey of the status for NCATE/NSTA accreditation at small rural colleges. *Science Education*, 74, 609-624.

Forbes, R. H. (1985, August). State policy trends and impacts on rural school districts. Paper presented at the National Rural Education Forum, Kansas City, MO.

Folwer, W. J. (April, 1992). What do we know about school size? What should we know? Paper presented at the American Educational Research Association Conference, San Francisco, CA.

Gardner, C. & Edington, E. (1982). The preparation and certification of teachers for rural and small schools. Las Cruces, NM: ERIC Clearinghouse on Rural Education and Small Schools.

Hom, J. G. (1985, August). Recruitment and preparation of quality teachers for rural schools. Paper presented at the National Rural Education Forum, Kansas, City, MO.

Luloff, A. E. (1984). The cultural component of rurality. ERIC Document Reproduction Service, ED 248 0790.

McIntire, W. G. & Marion, S. F. (1989). Academic achievement in America's small schools: Data from high school and beyond. ERIC Document Reproduction Service, ED 315 250.

Muse, I. D. 1977). *Preservice programs for educational personnel going into rural schools.* Las Cruces, NM: New Mexico State University, ERIC Clearinghouse on Rural Education and Small Schools. ERIC Document Reproduction Service, ED 135 506.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983). *Educating Americans for the 21st Century*. Washington, DC: National Science Foundation.

O'Hare, W.P. (1988). The rise of poverty in rural America. Population Trends and Public Policy Report No. 15. Washington, DC: Population Reference Bureau, Inc.

Prather, J. P. & Oliver, J. S. (1991). Options for a rural science agenda. In J. P. Prather (ed.) *Effective interaction of science teachers, researchers, and teacher educators* (Monograph 1 of the SAETS Science Education Series). Charlottesville, VA: Association for the Education of Teachers in Science (AETS).

Prather, J. P. (1993). A model for inservice science teacher enhancement through collaboration of rural elementary schools and universities. Chapter in P. Rubba, L. Campbell, T. Dana, (Eds.), *Excellence in educating teachers of science : 1993 Yearbook of the Association for the Education of Teachers in Science*. Columbus, Ohio: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Shroyer, G. & Enochs, L. (1987). Strategies for assessing the unique strengths, needs, and visions of rural science teachers. *Research in Rural Education*, 4 (1), 39-43.

Stern, J. D. (1994). *The Condition of Education in Rural Schools*. Washington, DC: U.S. Department of Education, Office of Research and Improvement.

Weiss, I. (1987). Report of the 1985-86 National survey of science and mathematics education. Research Triangle Park, NC: Research Triangle Institute.

Welch, W. W. & Wagner, T. G. (1989). Science education in rural America. Elmhurst, IL: North Central Regional Educational Laboratory.

Zurub, A. R. & Rubba, P. A. (1983). Development and validation of an inventory to assess science teacher needs in developing countries. *Journal of Research in Science Teaching*, 20, 867-873.

Chapter 3
Teaching and Learning Science in the Rural Setting

Kathleen L. Matthew

So why do we have to learn science? What purpose does it have to students and society in general? In an informal poll conducted by the author, it was found that when elementary students were asked why they learn science in school, they did not make a connection between what they learn in the classroom and anything outside of the classroom. Effective science learning (Dreyfus, 1987) "depends on the ability of the student to recognize their (scientific principle) applicability, and to apply it correctly" (p. 23). Science instruction too often has (Jackson, 1983) "no relation to the concerns and interests of students" (p. 161). The student's focus is limited to the lesson of the day and not on the lesson's larger connection to life.

High school students also view science instruction as either a subject one has to take in order to graduate or a subject one takes because one possesses the cognitive ability to understand the subject of science. Students focus on the subject matter rather than science's real-life connections and applications. "The study of science as a way of knowing needs to be made explicit in the curriculum" (American Association for the Advancement of Science, 1993, p. 3). At all levels, teachers and a society dedicated to scientific literacy must clearly emphasize the role of science in students' lives. After science instruction, students' ability to understand and apply scientific principles to the world around them should be enhanced.

Aims/Goals of Science Education

Transferring scientific knowledge to every day occurrences is a goal of science education for all students. Bybee (1993) constructed the following list of aims and goals for science education:

1. fulfill basic human needs and facilitate personal development.
2. maintain and improve the physical and human environment.
3. conserve and efficiently use our natural resources.
4. develop greater community at the local, regional, national and global levels. (p. 44)

These four are interrelated and interdependent with concern for individual as well as societal needs in real-life situations.

Society expects that education will include the expectation that it will improve the quality of life and will be a vehicle of hope to give a competitive edge to young Americans in the free markets of today and tomorrow (Camp and Thompson, 1990). Science education is a key element in giving this competitive edge to rural youth. Increased emphasis on the use of science in everyday life will influence student learning as well as society's views toward scientific literacy (Rutherford et al., 1989).

Interest in improvement of science instruction is evident at the local, state, and national levels. At the national level, the National Commission on Excellence in Education (1983), the U.S. Senate Hearings on the Crisis in Math and Science (1990), the America 2000 (1991) goals for education, and Project 2061 (1993) all focused attention on the status of science education in the United States. All examined the need for effective science education. Moneys have been used to improve and study science instruction in the form of grants from the National Science Foundation (NSF) and the Eisenhower Foundation. Private industries such as McDonald's and Dupont have supplied teachers and schools with funding as well as instructional materials needed to enhance science education in the classroom.

One of the educational goals set forth in America 2000 (1991), to become first in the nation in science and math, was meant for all Americans, rural as well as urban. All Americans deserve a solid science education regardless of where they live. In a study of rural teachers of science, teachers stated that the purpose of science instruction was to give students a tool which will enable them to understand the world in order to act upon it and to prepare them for the future (Easton and King, 1991).

According to Nachtigal (1982), it is time to recognize and utilize the uniqueness of the rural setting. The characteristic strengths and weakness of rural influences should be taken into account when preparing rural science programs. The distinctive resources of the rural setting become an asset to curriculum planners when preparing relevant science instruction for rural students.

Status of Rural Science Education

There have been very few research studies conducted on the effect of rural vs. urban setting on student science achievement. Of the studies completed, there are conflicting reports. Sunal (1991) reported "mixed results in describing the conditions of rural science teaching and their effects on achievement" (p. 202). Camp and Thompson (1990) suggested that a developing body of research implies a positive correlation between a lack of available resources and poor student achievement. Rural schools often lack science resources which would characterize rural science education as being inferior to urban science education with generous resources.

DeYoung (1991) stated that "ruralness derives its definition from its isolation, both geographically and demographically, labor intensive income base, and pervasive poverty" (p. 274). This isolation helps to form a unified community belief for the school and its subsequent education of their children.

Although exceptions can be found, rural schools tend to be smaller than urban or suburban school. Evidence exist that when socio-economic class and IQ were not factors, the size of the school no longer had a detrimental effect on student achievement and, in fact, the small school setting may even enhance student achievement (Barr, 1959; Sher and Tomkins, 1977; and Bell and Sigsworth, 1987).

The 1990 Science Report Card (Jones, et al., 1992) described rural students' science proficiency as lower than the average advantaged urban student but higher than the average disadvantaged urban or other types of communities. This study agrees with Markovits (1984-85) contention that rural students seem to be "holding their own in science achievement" (p. 9).

These findings would appear to suggest that other factors besides school size have a greater affect on rural student science achievement. Rural school students are no longer seen as "the people left behind" as reported by Nachtigal (1982) but are viewed as unique in strengths, needs and vision (Schroyer and Enochs, 1987).

According to Nash (1980) and Anand (1988), most of what is taught in rural schools is irrelevant to the needs of people living in rural communities because most science curriculum has its origin in urban concerns and needs. Low achievement in science subjects in rural areas has been attributed to this lack of relevancy of the agenda to the needs of the students living in rural areas. In the 1990s, programs are being implemented in rural areas which address the unique needs of the rural communities.

The 1924 clash of values between science and traditional beliefs and sacred and secular values (Becker, 1950) still has science educators in rural communities skirting certain science content. Evolution, the body and sexuality, AIDS, drugs and other controversial content remains undiscussed and off limits for science educators in many rural communities. Because some rural students are not exposed to a complete science curriculum, achievement on standardized tests could suffer.

Project 2061: Science Education for All Americans (1994), outlines a national curriculum for all Americans. The outline is broad enough to allow rural teachers the freedom to explore areas relevant to their students and their unique situation (Rutherford et al., 1989).

Characteristics of the Rural Science Experience

To understand science education concerns in rural schools requires knowledge of the system under which it is taught. The profile of America is changing from one of urbanization to one of rural communities. As this change takes place, dissatisfaction has arisen about the educational system of the rural communities. Urban people view the rural school system as lacking innovation and inadequately supplied while local rural people view their schools as adequate and appropriate for local needs (Markovits, 1985).

The dissatisfaction with school systems has played out in federal and state courts in the form of lawsuits charging that urban and rural school systems are unequally and inequitably financed (Camp and Thompson, 1990s). This view and the subsequent lawsuits have had a positive impact on the availability of science materials, supplies, and instructional opportunities in rural schools.

The emphasis on strengthening the science curriculum in rural schools and expanding the technology available will enhance students' achievement. However, there must be a focus on the unique characteristics, needs, and strengths of the rural schools (Dacus and Hutto, 1989). "We can no longer attempt to make rural schools into urban schools" (Shroyer and Enochs, 1987, p. 39-43).

Federal moneys have been allocated for study and improvement of rural science education. Studies aimed at understanding and strengthening rural schools have explored and reproduced successful programs at the rural level. Nachtigal (1982) emphasized the need to tailor the programs to the specific needs and strengths of a rural community.

Shroyer and Enochs (1987) conducted a study to identify strengths of rural science education in order to build leadership and future vision for rural science education. Teachers identified rural school strengths as: a) more personal contact between teachers, administrators, students and community; b) a family atmosphere; c) school improvement is a function of an involved school community with shared responsibility for the results: and d) the rural setting is an "open book" with plants, rocks, animals, etc. at the fingertips of students and teachers.

There are a number of rural school science projects and programs utilizing the specific strengths of rural communities. Dacus and Hutto (1989) initiated a long-term natural history project in New Mexico providing information, workshops and support for rural teachers of science. As a result of this project, the participants are teaching science units they developed and are very enthusiastic about teaching and learning more science. Otto (1993) conducted a hands-on project with rural science teachers of Native Americans in South Dakota. The teacher participants utilized not only the rural setting to teach science, but also the Native American culture. Teacher participants reported teaching more science with higher student interest. Moore (1989) described a Governor's School Program for gifted students of science located in rural Virginia areas. Greater opportunities for the rural students to use scientific materials, to experiment with sophisticated technology and to achieve at higher levels were reported as a result of this project. Singh (1990s) presented a project to increase rural Alabama minority students' interest and performance in science and math. High expectations, minority modeling, and the use of hands-on activities resulted in higher enrollment of minorities in math and science courses.

A number of Kentucky initiatives dedicated to the improvement of science, mathematics and technology in rural areas are presently under way. Partnership for Reform Initiatives in Science and Mathematics (PRISM) is working on ways to help rural communities gain access to upto-date scientific and technological information. Mathews and Winkle (1982) reported that action is needed for computer equity programs to increase rural female representation and interest in technology. Barriers and patterns of avoidance now persist in rural female use of technology.

Tompkinsville, Kentucky has an Outdoor Learning Center for their rural students, complete with planting plots for individual classes and a pond to observe and analyze. The Center is easily accessible to students and teachers during the school day. The money for this project was donated, in part, by the residents of the town. These are just a few of the many projects tailored to the unique characteristics and strengths of rural areas.

The single most important factor in a good science education program is the teacher (Karplus and Thier, 1967; Sher, 1977; Mechling and Oliver, 1983). During a presentation at The Rural and Small Schools Conference held at Kansas State University, a list of teacher, student, administrator and the community characteristics associated with exemplary elementary rural science programs was presented. The characteristics included (Pembelton, et al., 1987):

Teachers:

- Want to teach science.
- Are dynamic and young at heart.
- Provide a stimulating environment.
- Promote inquiry.
- Are eager to learn with students.

Students:

- Are actively involved.
- Identify problems.
- Make decisions.
- Learn how to learn.

Administrators:

- Are supportive of science.
- Are involved with it.
- Provide resources for teaching it.
- Encourage comprehensive teacher in-service.

Community:

- Recognizes the importance of quality science.
- Supports school's science program. (p. 121)

Science Teaching Strategies Used in the Rural Setting

The methods used to teach science can determine whether a program is effective or simply "has the children marking time" (Mechling and Oliver, 1983, p 14). Saul and Jagusch (1991) contend that science can be taught in two different ways 1) as a subject to be taken on faith or 2) as a subject where doubt has merit and proof is essential. The difference in the two approaches depends on the teachers' understanding of science and their belief about how students learn science.

Currently, constructivism, creating meaning using one's prior knowledge and experiences, is a popular learning theory embraced by many teachers of science throughout the education community (Prather, 1993) and touted as a possible unifier of science education (Yeany, 1981). This student-centered theory has the potential for strengthening students' insight into how science impacts them.

Science learning experiences occur in many places besides the classroom. Churches, grocery stores, libraries, factories, and playgrounds are a few locations which have the capability of becoming rich fields for learning and applying science. Each of these places has its own unique form of science education, both formal and informal. Each place is significant for its potential to provide opportunities to learn and to apply science information (Cremin, 1977). Meaning can be constructed from students' prior knowledge of these familiar places.

In spite of the current knowledge of how students learn, the most commonly used method of teaching elementary science continues to be the textbook (Hofwolt, 1984; Mechling and Oliver, 1983). Markovits (1984-85) reports that most rural high schools use standard textbook programs also. Donald Wright found that 50 to 80 percent of all science classes use a single text or multiple texts as the basis for instruction (cited in Mechling and Oliver, 1983).

Teachers who use a textbook exclusively encourage a passive role for their students. They ask students to memorize to prove their knowledge of science content. These teachers then find that students are unable to transfer that information from one situation to another (Gagne, 1985).

Matthew (1995) conducted an urban/rural comparison study of methodologies used to teach science in elementary classrooms of South Dakota. The research findings concluded that 1) the textbook was more likely to be used by urban elementary teachers than extreme rural elementary teachers to teach science, 2) extreme rural elementary teachers of science were more likely to integrate science content into other subject areas (usually math) and discuss science content not based on a science textbook at a higher rate than urban teachers, and 3) hands-on science methods were more likely used by urban teachers while extreme rural teachers conducted more demonstration activities for their students.

Rural science teachers take more field trips utilizing observation and communication skills. They cannot afford extensive laboratory facilities (Markovits, 1984-85), but the lack of equipment forces teachers to think of innovative and creative methods and use materials at hand to teach science concepts in an interdisciplinary fashion (Schroyer and Enochs, 1987).

Conclusions

The rural educational setting has unique strengths that can produce outstanding opportunities for the rural teacher of science. Utilizing the materials, resources, and environment of rural areas affords promising possibilities, but creative and imaginative means must be exercised for successful science teaching use. Rural settings are very different and individual. Because of this individuality each setting must be examined by the rural teacher of science in order to utilize it to the teacher's and student's best advantage.

Methods to teach science and specific goals of science may be different for rural teachers and students because of their unique needs and strengths. Individual issues and values of each rural setting can best be investigated and addressed by the science teachers living in the rural areas. Guidance can be given in the form of grants, ideas, and support from outside sources, but ultimately it is the science teacher who will make the biggest difference in the quality and quantity of rural science education.

An in-depth study of rural science education needs to be conducted as many existing studies are contradictory and inconclusive. Research that identifies good science teaching and focuses on how effective teachers communicate with their students will provide information essential to improve rural science education. Science concepts and processes must be taught to students in rural areas in order to build a strong scientific foundation and to meet the national goal of being first in the world in science and math; first for rural as well as urban students.

References

Aldridge, B. (1990s). *Crisis in science and math education*. Senate Committee on Governmental Affairs United States Senate Hearing. 101st Cong., 1st session. Nov. 1989, pp. 73-95. 101 Congress (1st session). Washington, DC: GPO.

American Association for the Advancement of Science (AAAS) (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Anand, V. and others (1988). *Teaching of science and technology in rural areas*. National Council of Educational Research and Training: New Delhi. (ERIC Document Reproduction Services No. ED 300 201)

Barr, R. (1959). Urban and rural differences: Ability and attainment. *Educational Research, 1*(2), 49-60.

Becker, H. (1950). *Through values to social interpretation*. Darhan, NC: Duke University Press.

Bell, A. and Sigsworth, A. (1987). *The small rural primary school*. New York: The Falmer Press.

Bush, G. (1991). *America 2000: An education strategy sourcebook*. Washington, DC: U.S. Department of Education. Bybee, R. (1993). *Reforming science education*. New York: Teachers College Press.

Camp, W. and Thompson, D. (1990s). Financing rural schools in a complex and changing environment. *Journal of Rural and Small Schools* (1), 35-40.

Cremin, L. (1977). *Public education*. New York: Basic Books.

Dacus, J. and Hutto, N. (1989). Improving science education in rural elementary schools: A collaborative approach for centers of rural education and museums of natural history. *Journal of Rural and Small Schools 4*(1), 13-17.

DeYoung, A. (1991). *Rural education: issues and practice*. New York: Garland Publishing, Inc.

Dreyfus, A. (1987). The potential role of agriculture in science teaching. *Research in Rural Education, 4*(1), 23-27.

Easton, S. and King, R. (1991, Nov). *The status of science and social studies education in selected rural schools of Northeast Alabama and Northwest Georgia*. Paper presented at the Annual meeting of the Mid-South Educational Research Association. Jacksonville State University: Alabama. (ERIC Document Reproduction Services No. ED 350 127)

Gagne, E. (1985). *The cognitive psychology of school learning*. Boston: Little, Brown Company.

Jackson, P. (1983). The reform of science education: A cautionary tale. *Daedalus112*(2), 143-166.

Jones, L.; Mullis, I.; Raizen, S.; Weiss, I.; and Weston, E. (1992). *The 1990s science report card*. Washington, DC: Office of Educational Research and Improvement.

Hofwolt, C. (1984). What can teachers do to increase their effectiveness in the science classroom? Are there methods and instructional strategies that are more effective than what teachers currently use: In D. Holdzkom and P. Lutz (Eds), *Research within reach: Science education* (pp. 43-57). Washington DC: NSTA.

Karplus, R. and Thier, H. (1967). *A new look at elementary school science: Science curriculum instruction study*. Chicago: Rand McNally and Company.

Markovits, P. (1984-85, Winter). Science education in rural schools: In transition. *Rural Educator* 6(2), 9-11.

Mathews, W. and Winkler, L. (1982). computer equity for young women in rural schools. *Research in Rural Education* 1(1), 37-41.

Matthew, K. (1995) *Rural/urban education in South Dakota elementary schools: Is there a difference?* Unpublished Mechling, K. and Oliver, D. (1983). Activities, not textbooks: What research says about science programs. *Principal* 62(4), 41-43. Moore, N. (1989). Rural students/regional programs. *Roper Review XII* (2), 112-113.

Nachtigal, P. (1982). *Rural education: In search of a better way*. Boulder CO: Westview Press.

Nash, R. (1980). *Schooling in rural societies*. New York: Metheun.

National Commission of Excellence in Education. (1983). *A nation at risk*. Washington DC: GPO.

Otto, P. (1993). *Science for Native Americans: An elementary school teacher inservice project*. Curriculum and instruction Conference Proceedings. Vermillion, SD: University of South Dakota. (ERIC Document Reproduction Services No. ED 363 670)

Pembleton, -Sil, Ed.; and others (1987). *Science Education in Rural and Small Schools*. Proceedings from the Rural and Small schools Conferences, Science Education Sections: 1985-1987. Manhattan, KS: Kansas State University Center for Science Education. (ERIC Document Reproduction Services No. ED 340 568)

Prather, P.J. (1993). Reform revisited: The trend toward constructivist learning. *Journal of Elementary Science Education*, 5(2), 52-70.

Rutherford, R.; Ahlgren, A.; Warren, P.; Holmes, C.; and McCutcheon, G. (1989). *Project 2061: Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

Saul, W and Jaqusch, A. (1991). *Vital connections: Children, science, and books*. Washington DC: Children's Literature Center, Library of Congress.

Schroyer, G. and Enochs, L. (1987). Strategies for assessing the unique strengths, needs and visions of rural science teachers. *Research in Rural Education* 4(1), 39-43.

Sher, J. and Tomkins, R. (1977). Economy, efficiency and equality: The myths of rural school and district consolidation, in Sher, J. (Ed.) *Education in rural America: A reassessment of conventional wisdom*. New York: Westville Press.

Singh, J. (1990s). Improving math and science for minority students. *Gifted Child Today*, March/April, 6-7.

Sunal, D.W. (1991). Rural school science teaching: What affects achievement. *School Science and Mathematics* 91(5), 202-210.

Yeany, R. (1991, June). A unifying theme in science education? *NARST News* 33(2), 1-3.

Chapter 4
Rationale for an Integrated Approach to Teaching Science in the Rural School

J. Preston Prather

Necessity, according to the British dramatist George Farquher (1678-1707), is the mother of invention; and the legacy of rural and small schools[1] confirms that observation. "Many so-called 'innovations' being championed today were born of necessity long ago in the rural schoolhouse" (Stern, 1994, p. 1). These included "cooperative learning, multi-grade classrooms, intimate links between school and community, interdisciplinary studies, peer tutoring, block scheduling, the community as the focus of study, older students teaching younger ones, site-based management, and close relationships among teachers and students" (p. 1). Several of those practices, when unified through an integrated approach to constuctivist learning, constitute an effective basis for an integrated approach to teaching science in rural systems. The legacy will continue if the resultant integrated approach should, like the practices listed above, prove to be applicable to non-rural as well as rural education.

Promotion of an integrated approach to teaching has been traced back to the works of Herbert Spencer in the 1800s (Stack, 1961). Aikin (1941) reported on research supporting an interdisciplinary approach; and Vars (1991) observed that the progressive education movement of the early 20th century "included a strong emphasis on student-centered, integrative approaches to education, usually under the name of core curriculum" (p. 14). Since then, Vars (1991) noted, the effectiveness of curriculum integration has been examined in more than 80 studies:

> In nearly every instance, students in various types of integrative/interdisciplinary programs have performed as well or better on standardized achievement tests than students enrolled in the usual separate subjects....Despite solid research support, the popularity of core-type integrative programs waxes and wanes from year to year, as education shifts primary attention from student concerns to subject matter acquisition to social problems and back again. The continuing challenge is to design curriculums that simultaneously take into account solid subject matter, the needs of the learner, and society's problems. (p. 15)

Beane (1991) concurred that a balanced emphasis on students' needs, social issues, and content is needed; "yet the integrated, interdisciplinary curriculum is still rare" (p. 9). (Like Beane and Vars, many writers used the terms *interdisciplinary* and *integrated* in an essentially interchangeable manner with regard to curriculum). There has been much talk about the apparent academic and affective benefits of such an approach to teaching, but little has been done to put the principle into practice. Many rural schools are in a unique position to capitalize upon these benefits and assume a role of leadership in the reform of school science education.

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[1]Much diversity exists in the definition of "rural schools" employed by the various institutions, agencies, and groups interested in the improvement of rural education. In the absence of a clear and generally accepted distinction between the terms "rural school" and "small school," many writers use the terms more or less interchangeably (Prather & Oliver, 1991). This is the case in this chapter; and it is understood that most of the qualities, characteristics, and needs herein ascribed to rural schools may apply as well to any small and relatively remote school or school system.

The Call For Integrated Instruction

In science as in all subject areas, most reform efforts have focused on issues of teaching methods and the learning environment. Few initiatives have sought substantial change in the basic concepts of curriculum and instruction that undergird educational practice. Since the beginning of the history of education, for instance, a basic belief that *students learn because teachers teach* has been accepted almost without question. Also, the idea that a *curriculum should be formulated by a curriculum committee or state board of education or some other external or expert authority* has enjoyed almost axiomatic status in the governance of education. These ideas prevailed even into the "new curriculum" movement in science education (Prather, 1993b) that began in the late 1950s:

> Consequently, most of the new programs focused largely on subject-oriented and teacher-centered issues such as the need for better instructional materials, better content mastery, and better teaching skills and testing strategies. Similarly, most programs were conceived from the perspective of *what students should know* as determined by curriculum planners, school boards, or other authorities. One of the most important elements—*the self-perceived needs of the students*—was largely neglected. (p. 60)

Over the past decade or so, however, widespread interest in the concept of constructivist learning has mandated a reexamination of many traditional principles; and it has placed the learner clearly in the center of the planning loop for both curriculum and instruction. Current reforms call for a student-centered, activities-oriented outlook to curriculum and instruction rather than the teacher-centered, subject-oriented approach that is typical of most science teaching. This amounts to a revolutionary new direction for educational planning and development, and it will require radical curricular change. However, many powerful factors are involved, and substantive change may be very difficult to achieve (Beane, 1991):

> It seems that no matter how radical restructuring talk may otherwise be, it almost never touches on the curriculum itself....The fact is that the subject approach has been with us so long and is so deeply entrenched in our schooling schemes that it has virtually paralyzed our capacity to imagine something different. The network of educational elites—academic scholars, state departments of education, certification bureaus, and text and test publishers—forms an almost intransigent force that makes serious reform seem almost impossible. (pp. 12-13)

Hurd (1991) also stated that there has been extensive pressure for reform of the science curriculum over the past decades, but there has been little change. The so-called layer-cake curriculum, which was created by the National Education Association's Committee of Ten in 1893, is a classic example of the resistance to change that educational traditions may exhibit. The committee declared that high school science should be taught as discrete disciplines each year, beginning with physical science and followed by biology, physics, and chemistry. That pattern persists today, more than a century later, as the prevalent curricular pattern in secondary science.

Both *Project 2061*, promoted by the AAAS (American Association for the Advancement of Science, 1990) and the NSTA's (National Science Teachers Association, 1993) *Scope, Sequence, and Coordination* reflect a widespread concern that the traditional, subject-centered approach is inappropriate for school science teaching. Brunkhorst (1991) agreed that "the traditional science disciplines are no longer isolated from each other or from other intellectual fields" (p. 36); and she called for science instruction that is more relevant and sensitive to students' needs. It is especially important that rural educators identify and build upon community and other non-school influences that may affect students' interests and perceptions of the relevance of science (Carlson, 1992; Charron, 1991; Stern, 1994; Sunal, 1991).

Hurd (1991) observed that the integration of school subjects is clearly needed. He noted that "In this century, science and technology have merged to become an integrated system" (p. 33). Given this, Hurd contended, the traditional form of discipline-specific science instruction misrepresents the nature of science. If science teaching is to either reflect the nature of contemporary science or be relevant to students' interests and needs, this must be changed (Hurd, 1991).

The reform movement of the 1990s calls for an integration of school subjects: a conceptual convergence of the natural sciences, mathematics, and technology with the social and behavioral sciences and the humanities into a coherent whole. A unity of knowledge will make it possible for students to take learning from different fields of study and use it to view human problems in their fullness from several perspectives. (p. 35)

Hurd (1991) was clearly aware of the magnitude of the challenge for change presented by the concept of integrated science teaching. "Breaking out of the intellectual straightjacket and nostalgia that characterize traditional science courses will not be easy," he cautioned, "We must start from scratch" (p. 35). A team of teachers found this to be the case as they struggled to develop an integrated program (Drake, 1991):

> We spent long hours discussing hows and whys and what each of us could live with. The only thing that seemed clear was that what we once understood as curriculum design would not work for this project—we had to let go of the old models....If we had to characterize the curriculum process in one phrase, the best way to describe it would be "dissolving the boundaries." Each of us brought boundaries to this project; we saw in retrospect how artificial they were—they existed of the ways in which we each had been taught to view the world. When we began to trust our own experience... the boundaries dissolved in many different areas. (p. 20)

The need for integration has been long recognized and widely discussed (Henry, 1958; Neurath, Carnap, & Morris, 1955; Hurd, 1991), and several writers have reported successful efforts (Beane, 1991; Crane, 1991; Drake, 1991; Green, 1991; Romance and Vitale, 1992). Integrated science teaching is also promoted by many other advocates of reform. However, if it is to become common practice, the educational community must follow the example of Drake and her colleagues and let go of many old curricular and instructional models that impede its development. Alternative approaches to science teaching, including integration of content and instruction, are being developed in schools at several sites around the country through *Project 2061* (AAAS, 1990) and *SS&C* (NSTA, 1993). If these experiments produce significant evidence of improved student performance in science, and there are indications that they shall, there will be intensive and extensive public pressure to reform school science programs accordingly. This would make it easier for cautious curriculum planners and other school officials to find comfort in constructive change and break with long-established traditions. Until such evidence is available, however, most school officials may continue to adhere to traditional curricular and instructional practices; but many rural school systems may not have the option of indulging in a wait-and-see attitude. Many of them are faced with a necessity for change for a variety of reasons, including economic limitations and state and federal mandates.

Challenge And Opportunity For Rural Schools

Fletcher and Cole (1992) noted that "Isolation, the lack of concentrated numbers of students, and limited resources have historically plagued education in rural areas" (p. 31). Furthermore, rural school systems typically suffer from economic deprivation (Sher, 1988; Stern, 1994). Such limitations do not excuse schools from responsibility of compliance with educational mandates. Like their suburban and urban counterparts who may have much larger economic bases and instructional resources, rural and small school systems are expected to meet the demands of new laws and regulations. For example, as Fletcher and Cole noted, special education services must be provided for exceptional students in any school regardless of economic condition or size.

Some rural systems have opted for consolidation to cope with such problems, but many have developed other means of fulfilling their responsibilities. For instance, Fletcher and Cole described the development of rural collaboratives to pool resources for special education and other needs while retaining each system's autonomy and close relationship to the community it serves. Field (1988) reported that 25 rural elementary school teachers collectively researched and wrote a seven-volume science activities manual for grades K-6 to enable them to systematically implement hands-on-science teaching in their classrooms, thereby overcoming a problem of outdated and inadequate curricular materials. Through cooperation with a university, 27 rural school systems established a local team leadership development program to provide instruction on the use of those manuals for thousands of inservice elementary teachers (Prather, Hartshorn, and McCreight, 1988). That program evolved into a model for school/university collaboration for teacher enhancement (Prather, 1993a). Rhoton, Field, and Prather (1992) explained that local team leadership development may provide an effective alternative to employment of an elementary science specialist in rural and small school systems where such a position may not be economically feasible.

Those are only a few examples of recent programs that, to paraphrase Stern's (1994) very apt metaphor, were born of necessity in the rural school teaching arena. Clearly, innovation is not a threat to teachers in many rural and small school systems. Rather, it is a necessity and source of hope for teachers who must function under severely restricted conditions as they labor to produce a better product from already too-limited resources. Perhaps this explains why, as Stern observed, so many rural schools participate so boldly in initiatives for reform. All teachers want the best they can provide for their students, and the necessities of rural school teaching have made thoughtful and determined risk-takers of many teachers and school officials. The results are cause for optimism among rural schools, which have typically been declaimed for poor student performance compared to students in urban and suburban schools (Stern, 1994).

> In recent years, rural performance has risen on selected national assessments so it now approximates the national mean. Performance is below that of suburban students, but higher than that of urban students. (p. 3)

The results are also cause for enthusiasm among educators in general. As noted earlier, such practices as cooperative learning, older students teaching younger ones, peer education, and interdisciplinary studies were products of the pressures of the rural school teaching arena. Stern's comments about the contributions of rural education and the improving status of rural student performance suggested that rural schools represent a potent source for continuing educational innovation and improvement, and this appears to be the case. As the country moves into the Information Age, for example, many new initiatives will be required. Introduction of computers and the electronic information network into school classrooms is an expensive undertaking, and rural schools typically suffer from severe budget limitations; but some rural school systems have already taken steps to meet the challenge.

An eight-state survey by Baird, Prather, Finson, and Oliver (1994) revealed that, contrary to prevailing opinion, rural teachers have about equal access to computers in their classrooms; and they make approximately the same use of them as their nonrural counterparts. Although that study and an earlier survey by Weiss (1987) found that regular use of computers is very limited among both rural and nonrural teachers, it appears that rural schools are again exercising innovative initiative as they employ distance learning strategies to prepare teachers to incorporate new technology in their programs (Thurston, McGrath, & Stone, 1992) and school-home partnerships to promote computer literacy among 4-6 year-olds (Swick, 1992). In an effort to expand students' horizons far beyond their rural environs, such schools maintain the rural education tradition of doing their best with what they have. Educators would do well to watch rural schools for possible insights into cost-effective ways to incorporate computer technology into instruction.

Educators would also do well to study rural schools' efforts to meet the challenge of integrated instruction. The potential for progress in that arena is enhanced by two important factors. First of all, it is a matter of survival for many rural schools to find time and labor-efficient ways to provide quality education with sometimes severely limited instructional resources. Second, many rural secondary school teachers (like most elementary teachers) already teach several subjects and are accustomed to multiple preparations (Baird et al., 1994). Being more experienced in multi-disciplinary teaching and already accustomed to multiple preparations, those teachers should be able to make the transition to integrated instruction much more easily than teachers accustomed only to preparation for single-subject teaching.

The currently popular concept of constructivist learning, like the AAAS (1990) and NSTA (1993) reforms, lends credibility to a variety of non-traditional curricular and instructional practices that may be especially applicable to the problems of rural science teaching. These include closer teacher-student relationships; teacher and student involvement in curriculum design;

student-centered instruction with activities-oriented lessons; curriculum-life connections rather than textbook-driven curricula, emphasis on the relation of science to technology and society; and preparation of students for life-long science learning. That credibility, and the potential benefits of the above practices, should encourage even more innovative risk-taking among rural school officials as they seek reasonable options for improving science teaching.

Constructivism: An Inducement For Integrated Instruction

Constructivist learning, commonly called "constructivism," is one of the most prevalent topics of current discussion among teachers and researchers in both science and mathematics education (Matthews & Davson-Galle, 1992). However, as happened with the concept of scientific literacy and other intuitively appealing ideas, there was a very limited research basis for many claims of its educational efficacy. Consequently, Cobb (1994) expressed concern that "pedagogies derived from constructivist theory frequently involve a collection of questionable claims that sanctify the student at the expense of mathematical and scientific ways of knowing" (p. 4). Conversely, others have applauded its inherent sensitivity to student needs, interests, and personal learning styles. Although research is needed to validate many claims ascribed to constructivism, it is clearly student centered; and that is its major contribution to the current dialog on science education reform. Also, as discussed below, it is supportive of a balanced emphasis on content.

Constructivist learning may be defined in terms of the acquisition of two basic types of knowledge: knowledge that is constructed in the mind of the learner; and knowledge that is not constructed in the mind of the learner. As Chaillé and Britain (1991, pp. 6-8) noted in their work on applications of constructivism in early childhood science education, Piaget (1970) perceived knowledge in terms of the three divisions shown in italics in the following paragraph and in Table 1.

Knowledge constructed in the mind of the learner includes *physical knowledge*, which is based on both personal observation and experience, and *logico-mathematical knowledge*, which is based on personal comparisons or seriations of objects (Hands-on teaching methods and inquiry learning are accommodated by both categories.). Knowledge not constructed in the learner's mind was defined as *social arbitrary knowledge*, which involves acquisition of language arts to facilitate importation of already constructed bodies of knowledge or conventions (such as Newton's Laws) from authoritative, external sources. Social knowledge (Chaillé & Britain, 1991) "is knowledge that can only be transmitted socially, such as customs, particular names, and labels for things—anything that is clearly culturally determined and therefore arbitrary" (p. 7).

Social knowledge may be communicated through parental or teacher pronouncements, textbooks, audio-visuals, dramatizations, lectures, demonstrations, and a variety of other student-passive means. Consequently, it involves the transmission of pre-constructed knowledge (which may have been fabricated in the mind of a teacher, textbook writer, or other authority) from an external source to a learner. The nature of this transmission and how it happens are current topics of debate among learning psychologists throughout the world.

The tripartite explanation of constructivist learning outlined above refutes a common criticism of constructivism as being totally opposed to traditional teaching practices. Rather, it highlights constructivism as inclusive of both personally constructed learning and authoritative (social arbitrary) transmission of pre-constructed knowledge and illuminates its potential for improvement of science teaching through a *balanced* curricular emphasis on the learners' personal (hands-on, logico-mathematical) experiences and the socially determined content to be learned. In other words, both personal experiences and language are necessary for science learning (Holliday, Yore, & Alverman, 1994). Similarly, the instructional implications of constructivism highlight the critical role that teachers must play as partners with students in the learning process. Based on these observations, constructivism may be credited with three unique contributions to the current reform movement: 1) a requirement for an unprecedented flexibility of curriculum to accommodate an emphasis on the needs of learners as well as the content to be taught; 2) reinterpretation of the role of the teacher as facilitator of meaningful learning experiences; and 3) reinterpretation of the learner as an active participant in the learning arena rather than a passive recipient of knowledge transmitted by expert teachers.

Implications Of Constructivism

Constructivism is rooted in the cognitive learning theory of the biologist turned epistemologist, Jean Piaget (1970), and David Ausubel's (1968) theory of meaningful learning. Piaget concluded that individuals organize and structure their own knowledge through interaction with the environment, and what a learner does with new information from the environment is largely dependent upon the cognitive (mental) structures already present in the person's mind. From Piaget's and Ausubel's perspectives, science instruction would be more relevant and acceptable (would be more meaningful) to learners if approached from the standpoint of the students' prior experiences and learning needs rather than from a fixed curriculum.

Much of the current emphasis on constructivist learning grew out of a concern about the educational efficacy of the student-passive, fact-oriented (social arbitrary) instruction that has prevailed over the past several decades. Few would deny that acquisition of facts is essential if a learner is to have access to the complex and often abstract principles that undergird modern science. However, many, like Miller and Blaydes (1962), have decried its overemphasis: "That which is untenable . . . is the allowing of this objective to be the dominant, almost the sole objective" (p. 13).

Transmission of factual information has been the almost exclusive focus in most science classrooms, and memorization and recitation (in written essays, verbal reports, question-answer sessions, paper and pencil tests, and so forth) were typical. For several decades, the use of concrete manipulatives in science instruction has been widely promoted as a way to help alleviate the problem by increasing student involvement. This method, generally called *hands-on-science teaching*, has been appreciated by many teachers as an effective way to enhance learning (Shymansky, Kyle, & Alport, 1983; Roychoudhury, 1994). Research by Clement (1982), Driver (1983), McCloskey (1983), and others indicated that hands-on-science experiences may play a key role in students' understanding of complex scientific concepts. For this reason among others, hands-on teaching is generally considered an essential component of constructivism. Even though it is an essential component of learning, however, hands-on science teaching alone is not sufficient for science education.

Students may learn a lot of scientific facts (natural history) about the phenomena of nature through hands-on science activities in the classroom or in their encounters with natural phenomena in day-to-day living; but such experiences alone often lead to intuitive misconceptions. McCloskey (1983) discussed the common intuitive misconception of impetus theory, an outdated medieval concept employed by Leonardo da Vinci and other leading scientific thinkers of the 15th and 16th centuries to explain the perceived relation of force and motion. McCloskey and Clement cited evidence that the great majority of people, including many science majors (a majority in some studies), misperceive the relation of force and motion in the sense of impetus theory rather that the currently accepted Newtonian concepts of inertia, acceleration, and action-reaction. The misperceptions were prevalent even among students who had studied Newton's Laws in school or college science classes. DiSessa (1982) reported a similar tendency among both elementary students and undergraduate college students to interpret the motion of a kicked soccer ball in terms of an ancient (and now scientifically unacceptable) Aristotelian concept of motion.

Those and other studies presented convincing evidence to support hands-on teaching methods. However, the benefits may be assured only if the hands-on learning experiences are integrated with study of appropriate science content and thinking skills. Through hands-on experiences, for instance, a learner may intuitively conceive a relationship between the motion of a baseball and the force applied to it by a bat. Through logico-mathematical reflection, perhaps aided by additional hands-on investigations (experimentation), the learner may further conclude that there is a direct relationship between the amount of force applied and the resultant motion of the ball. However, there is little likelihood that many students will construct a conceptual scheme similar to Newton's Laws on the basis of those learning experiences. Students are far more likely, as Clement's and McCloskey's work suggested, to arrive at an intuitively-based conclusion such as Aristotle's idea that motion occurs only if a force is applied or the medieval notion that the distance an object travels after being struck is dependent upon the amount of force applied. Although those common-sense cognitive constructions may be quite logical and intelligently conceived (and were considered scientifically correct for centuries), they are incompatible with currently acceptable scientific explanations that would define the path of the baseball in terms of abstract concepts such as inertia, acceleration, friction, and gravity.

Personal knowledge constructed in the mind of a learner may provide adequate explanations for some natural phenomena but nature study and the study of science are not the same. Wolpert (1993) observed that "Science often explains the familiar in terms of the unfamiliar" (p. 3). Many concepts of modern science such as Newton's Laws are based on complex and highly abstract constructions that are, "with rare exceptions, counter-intuitive" (p. xi). Although it is conceivable that any student may eventually construct any science concept through repeated independent observations and reflections, few would have the time to accumulate the extensive experiences and skills of inquiry required for such a pursuit alone. If they did, there is no guarantee that they would arrive at the same concept that is currently accepted by the scientific community without access to the community's current theories and principles to help focus their inquiry.

Scientists function in an arena of social interaction as well as independent inquiry. "Learning science involves both personal and social processes," Driver, Asoko, Leach, Mortimer, and Scott (1994) observed; and the social process "involves being introduced to the concepts, symbols, and conventions of the scientific community" (p. 8). Driver, et al., (1994) felt

> It is important...to appreciate that scientific knowledge is both symbolic in nature and also socially negotiated. The objects of science are not the phenomena of nature but constructs that are advanced by the scientific community to interpret nature. (1994, p. 5)

Driver et al., (1994) explained, "Learning science in the classroom involves children entering a new community of discourse, a new culture, and the teacher is the often hard-pressed tour guide mediating between children's everyday world and the world of science" (p. 11). It is unrealistic to assume that students can consistently construct complex conventional scientific concepts on the basis of physical experience alone, or logico-mathematical reflection alone, or social knowledge alone. A *balance* is required for constructive learning, and this balance must be a primary focus in planning science instruction. However it is an undergirding principle of most current reform efforts that, even with the best curriculum, effective education is critically dependent upon *involved and interested learners.* The curriculum and instruction must be meaningful to the students. Brooks and Brooks (1993) declared, "However, relevance does not have to be pre-existing for the student....Relevance can emerge through teacher intervention" (p. 35).

Provision of a relevant and balanced learning environment that encourages high levels of student involvement is a key to constructivist teaching. Student involvement not only improves immediate retention, Semb and Ellis (1994) reported, but it also enhances long-term retention. Student interest and involvement, in turn, are critically dependent upon students' awareness of the relevance of the topic of study. In a study of classroom and community factors that influenced students' perceptions of science in a rural school system, Charron (1991) found that "when relationships between the lessons and students' lives were made plain, the pupils were more motivated and remembered the material better" (p. 681). Those issues, curricular relevance and student involvement and interest, are central to both *Project 2061* (AAAS, 1990) and *SS&C* (NSTA, 1993). They are also problems that may be alleviated, in greater or lesser part, by integrated curriculum and instruction.

Indications For Integrated Instruction

Within the constructivist scheme, teachers are challenged to assume a primary part in curriculum development and to (Brooks & Brooks), 1993 "adapt curriculum tasks to address students' suppositions" (p. 69). In earlier reform efforts over the past 50 years or so, most new curricular and instructional materials were developed largely by groups of scientists and psychologists with very little involvement of teachers (Butts, 1982). Consequently (Prather, 1993b) "it is likely that the new curriculum was perceived as just another top-down instructional directive imposed by content area experts with few if any qualifications for or insight into the school science teaching arena" (p. 59). The locus of reform was outside the school science teaching arena rather than among the teachers who were expected to implement the new materials, and this precluded a general sense of ownership and confidence in the reforms.

Table 1
Outline Of Knowledge Acquired Through Constructivist Learning.

Two basic types of knowledge are further distinguished by the three subdivisions indicated in italics. The italicized terms, which were described by Piaget (1970) are discussed in Chaillé and Britain (1991, pp. 6–8). A balance of the three types of knowledge is essential to effective learning in science.

Type 1: Knowledge constructed in the mind of the learner

Physical knowledge
- Empirical
- Concrete
- "Hands-on"

Logico-mathematical knowledge
- Non-empirical, not concrete
- Reflective comparisons or seriations
- "Minds-on"

Type 2: Knowledge not constructed in the mind of the learner

Social arbitrary knowledge
- Conventional
- Authoritative
- Transmitted
- "Didactic"

Constructivism empowers teachers to reverse that trend and assume their rightful role as the *primary architects of learning*, and this is as it should be. "No single factor bears as strongly on the quality of science education as the ability of those who teach" (Atkin, 1983, p. 167). However, teachers must not presume sole responsibility for curriculum and/or teaching. The students they would teach should also be involved, along with others essential to the educational enterprise including parents or other primary care-givers.

Rural school science teachers, already conditioned to the necessity for innovation and calculated risk taking, are in a favorable position to take advantage of the opportunities for non-traditional science teaching inherent in the concept of constructivist learning. These include redesigning the classroom for hands-on-science teaching methods, planning student-centered rather than subject-centered lessons, sequencing content across grade levels, breaking away from dependency on the textbook, developing alternative assessment methods, and other innovations that offer hope for improved student interest and performance. Sensitivity to community values is also essential to a meaningful curriculum, especially in rural schools where close school community ties are the norm.

Integration of the various science disciplines is a logical first step toward improvement of science education. As a result of the traditional approach to science teaching, Brunkhorst (1991) observed, most students receive only a fragmented exposure to science. "Obviously," she concluded, "connections among the sciences cannot be understood if all the sciences are not available to all students" (p. 36). Prather and Shrum (1984) described geology and earth/space science as ready vehicles for integrating the physical, life, and environmental sciences. However, the scope of integration advocated by Hurd (1991) and others extends beyond the sciences per se to include all academic subject areas.

Rural science teachers should not isolate themselves in the quest for reform. Rather, as Jackson (1983) recommended, they should seek interdisciplinary cooperation involving teachers in all subject areas:

> What is needed is a sense of partnership...uniting *everyone* who seeks to see our

schools become better than they are....One and all must realize that *good* science teachers have more in common with say, *good* English teachers, and vice versa, than either does with mediocre or poor teachers within their own specialties. (pp.161-162)

Inherent in Jackson's observation is a means to the relief of a major problem in rural education. Numerous studies revealed that a sense of professional isolation from others within their area of specialization is among the most prevalent concerns expressed by rural school teachers (Baird, et al., 1994; Carlson, 1992; Sunal, 1991). Integration of curriculum and instruction will engage teachers within a variety of different specializations in a common effort. As the natural connections among the various disciplines become evident, teachers prepared in different fields will find kinship in those disciplinary overlaps. Also, as they work together in the planning and implementation of an integrated curriculum, their increasing knowledge of other teachers' areas of specialization will open new avenues for professional dialogue on topics of common interest.

Curricular integration represents a giant step that, when combined with hands-on/minds-on-science teaching within a constructivist learning arena, calls for nothing less than an unprecedented and revolutionary restructure of the educational enterprise. Teachers who would usher in such an era must be prepared to teach in a manner unlike that in which they were taught and derive their instructional objectives from a curricular perspective very different from that which guided their own education.

A review of literature on curricular integration revealed widespread agreement that schools aspiring toward that goal must be willing to let go of many old models and practices that are no longer appropriate. Examples include the layer-cake approach to secondary science teaching (Brunkhorst, 1991), the idea that instruction should be grade-specific (Drake, 1991), the notion that there is a specific scientific method that students should learn (Hurd, 1991), and schedules that disrupt classes and shuffle students to another location every 50 minutes or so (Eisener, 1991). Kuhn (1970), whose pivotal work has redefined the scientific community's perception of the nature and history of science over the last 30 years, also advocated a greatly reduced dependency on textbooks in science teaching. The notion that lessons must adhere to a particular format or timetable, or attain a specific set of predetermined curriculum objectives, must also be displaced by more flexible student-oriented perceptions of curriculum and instruction.

These and other options for change are advocated by the NSTA, AAAS and other agencies; and all are conducive to integrated teaching. The concept of constructivism, in turn, is conducive to the curricular and instructional flexibility required for integrated teaching; and this flexibility is a key to the future for rural schools. Rural population growth has slowed over the past decade (Butler, 1991). Already, the typical rural secondary science teacher is faced with multiple preparations, with approximately 45% required to handle four or more preparations per day (Baird et al., 1994). Rural schools have lower student/teacher ratios, and many rural teachers have multi-grade classrooms (Sunal, 1991); and a significant portion of rural teachers teach out of their field (Stern, 1994). If the population trend culminates in reduced enrollment and further limitations on fiscal support for rural schools, teachers may find themselves faced with even broader instructional responsibilities. Integrated teaching offers a means of coping with these pressures.

Because of small size and other factors, many rural school systems may be unable to marshall the resources necessary to initiate the planning and development of integrated curriculum and instruction. Some systems have overcome this sort of limitation through formation of rural collaboratives (Fletcher & Cole, 1992) and cooperative programs with universities to develop the local leadership needed for change (Prather, 1993a; Rhoton et al., 1992). The local community is also an important resource that must not be overlooked in any school improvement (Charron, 1991; Goodlad, 1987). This is especially the case in rural areas, where a sense of personal identification with the schools is typical (Stern, 1994).

The first priority of all teachers in any educational undertaking must be the well-being of their students. As indicated earlier, those who would integrate science curriculum and instruction will be embarking on a risk-venture. However, the risk will be limited. As Vars (1991) noted, the effectiveness of integrative programs has been reviewed in "more than 80 normative or comparative studies" (p. 15). In nearly every case, he reported, students in integrated programs performed as well as or better on standardized tests than those taught in discipline-specific courses. Ideally, the natural connections between the related subject areas in an integrated program will result in more meaningful and efficient lesson preparation. Properly planned, such a program should offer more effective use of facilities, enhanced teaching efficiency, better teacher morale, and improved student performance. Given this and the rural heritage of interdisciplinary instruction cited by Stern (1994), rural schools may approach the task of curriculum integration with a high degree of confidence in the potential benefits.

Strategies For Program Integration

A review of literature on the topic of curricular integration over the past decade revealed a variety of strategies that spanned the gamut from subject-centered to learner-oriented models and from highly structured to relatively unstructured designs. Little was found in the literature on the topic of the integration of science teaching in rural and small schools specifically, but much useful information about options that rural educators may consider was found in discussions of the nature and applications of integrated curriculum design.

The current interest in curricular integration was precipitated by the failure of the discipline-specific science instruction that has prevailed in most schools, rural and non-rural alike, over the past century. Hurd (1991) echoed the concern of many educators when he described the typical science curriculum of today as inappropriate for students' needs and out-of-touch with the nature, history and social relevance of science. "As a result," he declared, "the subject matter of traditional science courses is functionally inert outside of class" (p. 33). Curriculum integration has received much attention as an alternative (Vars, 1991):

> Educators once more are seeking ways to help students make sense out of the multitude of life's experiences and the bits and pieces of knowledge being taught in the typical splintered, over-departmentalized school curriculum. To lessen some of the fragmentation, various types of integrative or holistic curriculums are being proposed, including the distinct form of "core curriculum," which focuses directly on the problems, issues, and concerns of students. (p. 14)

Characteristics of many basic curriculum strategies were described in articles by Fogarty (1991) and Vars (1991). Both articles are reviewed below to illuminate the scope of options. Some of the models they discussed would be suited to integration of teaching in schools with a traditional separation of subjects, for instance; and some would require various degrees of integration of the academic disciplines as well. Rural school teachers and administrators who are interested in integrated teaching should carefully review both articles.

An Evolving Core Curriculum Perspective

Vars described four designs for integrative curriculum: Correlation, fusion, core curriculum, and unstructured core. The first two categories are essentially content-centered, and the remaining two designs are more student-centered. The simplest of the four is the *correlation design*, Vars explained; and it enables teachers of different subjects to simultaneously deal with one aspect of a topic in their classes while retaining the traditional separate identity of their particular subjects and classrooms. This approach has been employed in some elementary schools, where it is typical for one teacher to teach all subjects, but it is applicable to any level of study. It is a convenient design for schools or school systems that must start from scratch, as Hurd (1991) suggested, to plan the transition from a totally departmentalized curriculum. As teachers become more comfortable with the idea of integrated teaching through this model, they may more readily elect to venture into other dimensions of curriculum integration.

The *correlation design* may be conveniently implemented through the use of curricular themes, Vars noted. Several major themes, such as early American civilizations and structure of the Earth, may be selected for the year by the school faculty. Key thematic topics, such as rocks and minerals in the case of the latter theme, may be chosen as the basis for instructional coordination; and each teacher identifies related topics in her/his specific subject area. For example, a class in history might focus on the effect of the discovery of gold on the settling of California or the exploitation of coal on the industrial development of the nation. To help students understand practical applications of mathematics, a math teacher may have students research and calculate the worth in today's dollars of the total amount of gold mined at Sutter's Mill and determine the percentage of that amount compared to all gold mined in the country. Students could study the locations and cultural ramifications of major coal deposits in a geography class, and then move to a literature class where they discuss a novel or short story based on a topic such as social problems in the American coal mining areas or African diamond fields.

More general themes such as the concept of change, or the idea of ecosystems, may generate similar opportunities for teachers to share a common thematic focus in their instruction and help students make meaningful connections between subject areas. In any case the themes may span several grades or the entire K-12 grade structure, with each teacher adapting the focus of the topic of the day (or days, or week, or semester) to the level of development of students and the context of the lesson. As students move through their studies, the curricular connections would help them to better appreciate the worth of each subject as a source of insight into issues they may face in their own lives.

Vars' (1991) second category, *fusion design*, "takes integration a step further by combining the content of two or more subjects into a new course with a new name, such as Common Learning or American Studies" (p. 14). A third category, *core curriculum design*, extends the concept to a more student-centered and interdisciplinary focus; but it is teacher-designed (Vars, 1991):

> In core, the curriculum design begins with the students and the society in which they live. Needs, problems, and concerns of a particular group of students are identified, and skills and subject matter from any pertinent subject are brought in to help students deal with these matters. Staff may identify a cluster of student concerns or needs that are typical of the age group and design units that promise to be relevant to students. (p. 14)

The *unstructured core design* is (Vars, 1991) "the ultimate in student-centered curriculum . . . in which teacher and students together develop units of study" (Vars, 1991, p. 14). Though not specifically indicated in some cases, this sort of direct involvement of students in the planning of curriculum and instruction is implicit in most major programs for science education reform. As noted earlier, this extent of reform will require a complete break with some long established traditions. For example, it challenges, or actually discounts, the notion that curriculum development should be done by external individuals or committees of experts that are qualified to prescribe what learners need and how teachers should respond to that need. Unstructured core curriculum programs are based on the premise that the learners and teachers themselves are the most qualified to speak to those issues and should be so empowered. From the unstructured core curriculum perspective, what goes on in the teaching arena is subject to another locus of control—*the professional competence of the teacher*. General curricular objectives should be determined by teachers, ideally in consultation with other school officials and appropriate community representatives including parents and students (Vars, 1991):

> The only restrictions are that the study must be worthwhile, doable, and appropriate for the students' level of maturity. . . . The teachers and students jointly decide on specific questions of study, how the unit will be carried out, and how student progress will be evaluated. (p. 14)

A Curriculum Connections Perspective

Fogarty (1991) cataloged and explicated ten models for curriculum that were described as parts of a continuum through which teachers may "explore the connections within and across disciplines and within and across learners" (p. 65). They also constitute a sort of roadmap for educators faced with the task of making the transition from a traditional or fragmented curriculum, which emphasizes each subject as a distinct discipline, to an interdisciplinary approach and finally to a learner-oriented approach. A trek through the ten models would also be helpful for persons wishing to clarify the distinction between teacher-centered and student-oriented curricular concepts.

Beginning with an exploration of models that integrate "within single disciplines" (the *fragmented, con-*

nected, and *nested* models), and continuing with models that integrate "across several disciplines" (the *sequenced, shared, webbed, threaded,* and *integrated* models), Fogarty's (1991, p. 62) scheme extended to two strategies that integrate "within and across learners" (the *immersed* and *networked* models). However, Fogarty made it quite clear that the ten models were not to be considered a complete list. Rather, "teachers should go out and invent their own designs" (p. 65).

The *fragmented model* views the curriculum in the traditional manner of completely independent academic disciplines. Fogarty (1991) stated "Each is seen as a pure entity in and of itself. Relationships between subject areas—physics and chemistry for example—are only implicitly indicated" (p. 61). Fogarty (1991) continued:

> In middle and secondary schools, the disciplines are taught by different teachers in different locations, with students moved from room to room. . . . leaving students with a fragmented view of the curriculum. A less severe model of fragmentation prevails in elementary classrooms, where the teacher says, "Now, put away your math books and take out your science packets. (1991, p. 61)

The *connected model* encourages teachers to go beyond the teaching of facts and deliberately relate interconnecting ideas within a discipline, Fogarty (1991) explained, "rather than assuming that students will automatically understand the connections" (p. 61). The *nested model* accommodates a more in-depth approach in which undergirding concepts are targeted that will help learners to understand the natural relationships of factual information. "An elementary lesson on the circulatory system could target the concept of systems," Fogarty (1991) elaborated, "as well as facts and understandings about the circulatory system" (p. 62).

The *sequenced* and *shared models* are simple examples of strategies that begin to involve integration of subject matter per se. In the sequenced design, topics from each discipline are still taught separately (Fogarty, 1991) but "rearranged and sequenced to provide a broad framework for related concepts" (p. 62). In the shared model, two disciplines are actually brought together on the basis of overlapping concepts; and teachers from the combined subjects cooperate to share planning and take advantage of opportunities for more efficient teaching of shared concepts. For example, a teacher in a self-contained elementary classroom "might plan a science unit (simple machines) and a social studies unit (the industrial revolution) around the concept of efficiency models" (p. 63).

Several features of the *webbed model* (which may have derived its name from a vague resemblance to the radial structure of a spider web) resemble those of the correlation design described by Vars. It employs themes to integrate subject areas across departmental lines and may be implemented in schools that retain a separation of subject areas. A theme such as Inventions may lead (Fogarty, 1991) "to the study of simple machines in science, to reading and writing about inventors in language arts, to designing and building models in industrial arts, to drawing and studying Rube Goldberg contraptions in math, and to making flowcharts in computer technology classes" (p. 63). Because it is compatible with a traditional separation of subject areas but also requires an integration of instruction around curricular themes, this model represents an optimum design for initial efforts toward development of an integrated curriculum.

Fogarty (1991) described the *threaded* model as a metacurricular approach that supersedes the subject matter content to involve students in problem-solving situations. The disciplinary distinctions may be retained, but systematic student involvement is obtained by threading "thinking skills, social skills, study skills, graphic organizers, technology, and a multiple intelligences approach to learning throughout all the disciplines" (pp. 63-64). Content priorities would remain the responsibility of the individual teacher, but all teachers in all subjects would cooperate in planning and teaching lessons that emphasize the development of specific social or thinking skills. "For example, 'prediction' is a skill used to estimate in mathematics, forecast in current events, anticipate in a novel, and hypothesize in the science lab" (p. 64). This emphasis on student involvement qualifies the threaded model as a transitional design that bridges the gap between the traditional subject-centered curriculum focus and the student-centered approach promoted by most current reform efforts.

The *integrated model* combines an interdisciplinary rearrangement of science, mathematics, social studies and language arts with the student involvement emphasis of the threaded model. True to its name, this strategy integrates the disciplines (Fogarty, 1991) "by finding the overlapping skills, concepts, and attitudes in all four" (p. 64). Like other curricular designs, it is equally applicable to any grade level if adapted as appropriate under the professional judgment of a teacher (Fogarty, 1991).

> At the middle or secondary school, an interdisciplinary team discovers they can apply the concept of argument and evidence in math, science, language arts, and social studies. In the elementary classroom, an integrated model that illustrates the critical elements of this approach is the whole language strategy in which reading, writing, listening, and speaking skills spring from a holistic, literature based program. (p. 64)

Romance and Vitale (1992) described an elementary curriculum strategy that reflects Fogarty's integrated model. The program, which emphasized hands-on science teaching methods and science process skills, replaced "a district-adopted basal reading program with science-content reading designed to facilitate applied comprehension skills" (p. 545). The innovation enabled teachers to combine the previously allotted time for reading and science into a daily block for in-depth teaching of science. A year long study of the effect of the strategy in three fourth-grade classes compared to control groups revealed significantly improved achievement measured on standardized tests, more positive attitudes toward both reading and science, and increased self-confidence. Kumar and Voldrich (1994) described applications of literature books, such as Laura Ingalls Wilder's *Little House* series, in second grade science classes to provide authentic contexts for the study of weather and related topics such as air, water, heat, and light.

The remaining two curriculum strategies described by Fogarty (1991), the *immersed* and *networked* models, completed the transition to a totally student-centered as well as interdisciplinary emphasis. Student interest and self-perceived needs are the directive forces in each design; and, like the other models, both are also grade-level independent. Teachers and others may share expertise or otherwise help to facilitate learning experiences in both cases, but students are largely self-directed learners with primary responsibility for content selection. The integration of content occurs within the learner, Fogarty explained, and the main difference is the manner in which learners involve themselves in the learning experience—as an individual or as a member of a network of learners with common interests.

As might be expected from its name, students involved in an *immersed model* become (Fogarty, 1991) "totally immersed in a field of study" (p. 64). Integration occurs within the minds of individual learners as they reach out and bring in knowledge from many sources, filter it on the basis of their interests and expertise, and immerse themselves in their own learning experiences. A learner selects learning experiences on the basis of interest and need, with little or no intervention of teachers in any capacity other than as instructors of courses the student may choose to take (Fogarty, 1991):

> For example, a doctoral candidate may be a specialist in the chemical bonding of substances. Even though her field is chemistry she devours the software programs in computer science classes so she can simulate lab experiments, saving days of tedious work. She learns patent law in order to protect the ideas for her company and to avoid liability cases.
>
> Likewise, a 6-year-old writes incessantly about butterflies, spiders, insects, and creepie-crawlies of all sorts. Her artwork is modeled on the symmetrical design of ladybugs, and the patterns of butterflies. She counts, mounts, and frames bugs; she even sings about them. . . . The books she chooses reflect her internal integration of information around her pet subject. (pp. 64-65)

The *networked model* is (Fogarty, 1991) "like a three- or four-way conference call [that] provides various avenues of exploration and explanation" (p. 65). Integration of knowledge occurs across learners as they reach out and establish networks with resources within and across areas of expertise according to their perceived needs or interests. This model, like the previous one, is appropriate for educational arenas populated by highly motivated, self-initiating learners. A post-doctoral researcher, for example, may search the literature in professional journals to identify researchers in several areas of specialization related to her/his area of interest. Once several people are identified in different disciplines, visits may be scheduled with selected researchers to share ideas and compare current work. As the networking continues, a LISTSERV could be established to enable the multidisciplinary group to communicate regularly by e-mail and work together to explore areas of common obsession. Fogarty noted (1991) that such networking may also occur even among very young learners:

> Imagine a 5th grader who has had a keen interest in native Americans since his toddler days of playing cowboys and Indians. His passion for Indian lore leads him into historical readings—both fictional and nonfictional. Aware of his interest, his family hears about an archaeological dig that recruits youngsters as part of a summer program. As a result of this summer "camp," this learner meets people in a number of fields: an anthropologist, a geologist, and an illustrator. Already this learner's networks are taking shape. (p. 65)

Again, it is clear that the implementation of fully intergrated science education will require a complete break with the traditional concept of a fixed discipline that is imposed upon all learners in all school situations. However, the direction of integrated curriculum and instruction is far from arbitrary. Instead, Beane (1991) declared, "integration implies wholeness and unity rather that separation and fragmentation" (p. 9). By comparison, he concluded, the typical static curriculum that prevails in most schools represents a fragmented and unconnected assemblage of facts and skills. By its nature, an integrated program may never be completed (Vars, 1991): "The continuing challenge is to design curriculums that simultaneously take into account solid subject matter, the needs of the learner, and society's problems" (p. 15).

Planning For Change

Rural school systems aspiring to develop an integrated teaching program will find almost as many options for planning and implementing change as they will find models for curriculum integration. Some systems may find within their staff a determined body of leadership capable of planning and implementing a systematic program of reform, and others may need to bring in experienced innovators to generate interest. Discussions with other school officials in the region may reveal opportunities for collaboration among systems with similar interests to enhance the resources for such a task. In either case, school officials would benefit from cooperation with researchers and science educators who have expertise in curriculum integration to identify and review research-based options for consideration. Whatever the course of action, however, the transition to integrated teaching represents a definite break with long established curricular tradition and instructional practice; and it will probably take much time and effort to accomplish.

Jacobs (1991), a curriculum planner, suggested that meaningful curriculum reform would take about three years of systematic research, planning and development. Based on her experience in working with hundreds of school systems across the country, she recommended a four-phase plan of action to coordinate the extensive field work, planning and implementation, and final refinement and adoption of a pilot for an integrated unit. The four phases include: 1) Conducting action research; 2) Developing a proposal; 3) Implementing and monitoring the pilot; and 4) Adopting the program.

Phase one, Jacobs (1991) explained, should engage teachers in both internal and external research as a basis for initial planning. Internal research, conducted by small groups of teachers recruited according to grade levels or departmental affiliation as appropriate, is needed to monitor the school system's current curriculum patterns and teaching practices and identify areas for improvement. External research is needed to increase their awareness of other practices and research throughout the educational community as a basis for selecting options they may wish to consider. "Regional service centers, state education departments, national education organizations, and universities are excellent sources for learning about desirable practices" (p. 27). Up to one year may be required for this phase.

Jacobs (1991) suggested that "Phase two, proposal development, usually takes from two to four months during the first year of planning, and "the proposal should specify evaluation procedures, budget, timelines, and teachers' responsibilities" (p. 27). After a potential curricular area for application of an integrated approach is identified, she added, most schools propose to modify an existing unit into a pilot program for trial. Once the pilot has been accepted by the teachers involved and reviewed at the appropriate administrative levels (Jacobs, 1991), "it's time to try the unit in the classroom" (p. 27.)

Phase three, implementing and monitoring the project, occurs in the second year. This provides the data needed for revisions to improve the effectiveness of the pilot, Jacobs noted, and frequently the collegial interaction of teachers in the project is a valued outcome. During phase four (the third year) the pilot phase is refined and adopted as a permanent curriculum component the following year. There is no time to change or add to the curriculum in a given school year, Jacobs (1991) pointed out; but "a pilot can easily dissipate unless it is elevated to program status" (p. 4). Therefore this final step, the actual adoption and implementation of the program, constitutes the real test of a schools' resolve for curricular change (Jacobs, 1991):

> In order to adopt the pilot, they must replace whatever was offered previously. For example, the high school course guide will now state that there is a 9th grade Humanities course rather than separate English, social studies, and arts courses. (p. 28)

Vars (1991, p. 14) discussed three possible approaches to planning curricular integration: the "total staff approach," wherein *all teachers* in a school or school system are involved in the planning and implementation; the "interdisciplinary team approach," wherein *a group of teachers* from different subjects is formed to integrate their teaching around selected themes or other connections; and "block-time and self-contained classes" (p. 14) wherein *one teacher* is responsible for interdisciplinary instruction over an extended period of time. A variety of curricular designs may be used with either staffing pattern, Vars noted, and themes or other factors may change from year to year as teachers search for an appropriate curriculum for each new group of students. Fogarty (1991) suggested that "each staff member or team might choose one model to work with each semester" (p. 65), and use the insights gained to invent a design or designs suited to their situation.

Although these suggestions for curricular planning were not specifically addressed to rural education, their flexibility renders them adaptable to any situation. Like the curriculum models discussed by Vars and Fogarty, the guidelines for planning are useful in so far as they may inspire the imagination and/or encourage the commitment of educators devoted to improvement of the teaching arena. The planning schemes and curriculum models alike are very general and intended only as broad guidelines for creative thought, and all are dependent upon the initiative and imagination of innovative teachers for realization. Also, as Fogarty noted, the process of curricular integration never ends. It is a teacher-dependent process as accessible to the most remote rural school as to non-rural schools. Given the creative innovations credited to rural schools by Stern (1994) and others, rural schools may find the process especially beneficial as they seek to provide quality science education under increasingly challenging conditions.

Examples Of Science-Based, Integrated Teaching

A review of literature revealed numerous examples of programs for integrated science teaching. Reforms promoted by the NSTA (1993) and AAAS (1990) were obvious in many reports, and most programs emphasized high levels of student participation and other learner-centered practices that are commonly associated with a constructivist learning environment. For example, Greene (1991) described a science-centered elementary program that used hands-on activities, cooperative learning, and a thematic approach to create an integrated learning environment in which "students often choose their own assignments and materials, allowing the teacher to accommodate a range of learning styles and abilities" (p. 43).

Crane (1991) described a two-year, integrated science course for high school students that precipitated a change from subject-centered to student-centered criteria for graduation. Beginning with the class of 1995, she reported, the school "will replace the current credit-hour based graduation requirements with 19 performance-based graduation requirements" (p. 40). Swick (1992) outlined a program for integrating mathematics and computer learning for early childhood students through teacher-parent partnerships. Romance and Vitale (1992) integrated elementary science and language arts. Beane (1991) suggested that "the whole language approach now emerging at the elementary level clearly holds promise for an integrative curriculum" (p. 13).

Two reports, which are discussed in more detail below, were indicative of the scope of opportunity available for initiation of integrated instruction in rural schools. Beck, Copa, and Pease (1991) described several interdisciplinary high school programs that were developed through an effort to integrate the twin curricular components (vocational and academic) that characterize most secondary schools. Ramsey and Kronholm (1991) described an elementary school program that evolved around a science-related social issue of interest to students in a rural community school in Wisconsin.

Academic-Vocational Curriculum Integration

Beck et al.. (1991) chose two high schools as proving grounds for a bold curriculum project. The schools, which were located in a large metropolitan area and a rural school district respectively, shared a common trait—a bipartite curriculum structure. As in many high schools across the country, each had both an academic curriculum and a vocational curriculum. The project was designed to promote the integration of the two curricula. Through summer training workshops, "academic and vocational teachers, administrators, and counselors got better acquainted as professionals and began to develop interdisciplinary curricular interventions for the fall term" (p. 29).

The work began with research to examine current curricular and instructional patterns and seek opportunities for change. Several options were identified as the faculty of each institution considered the strengths and needs of their school, and the responsibility for action at each site was determined (Beck, et al., 1991):

> The decision about which approach to take belonged solely to the teachers and administrators who carried out the work in their classes and schools. Their decisions were based on their perceptions of the high school's goals, the students' needs, and their experience with interdisciplinary teaching. (p. 29)

Interventions in the rural school included exchange of biology and agriculture classes to enable students and teachers to learn about what goes on across the divide that separates the vocational and academic programs. Whereas agriculture students had previously only heard about tissue culturing, Beck et al.. (1991) noted, they had a chance to gain experience in culturing carrot tissue and to discuss "the ethical issues and the economic considerations of biotechnology" (p. 30). Similarly, the biology students studied water quality with the agriculture teacher (Beck, et al., 1991).

> Using "hands-on, minds-on" learning methods more typical of the vocational classroom, biology students visited a watershed, hosted university groundwater experts, and discussed controversial local issues, such as which local companies were discharging dangerous wastes into their river. (p. 30)

One of the outcomes of that venture was (Beck, et al., 1991) "a new agriculture/science curriculum in a new greenhouse, and a K-12 environmental program" (p. 30). A second integrative activity at the rural school enabled students of applied mathematics and business management to conduct a joint feasibility study to determine if the community should build a Frisbee golf course to provide recreation for students. In this program, which is an example of the correlation curriculum design discussed by Vars (1991), the separate identities of the two subject areas were maintained; but the study soon led the students and their teachers across the disciplinary boundaries.

The Frisbee golf course study required that the students learn and use data collecting skills, conduct market research, and master the statistical concepts and analytical skills they needed to conduct a feasibility study and, as Beck, et al... (1991) explained, it placed them in the position of responsible decision making as "the final products were videotaped impact statements and a decision not to build a Frisbee golf course." At the end, one student commented, "I learned that a lot of planning goes into new businesses" (p. 30).

Through these innovations, the students were afforded a broadened spectrum of educational experiences. In the first case the biology students were accorded an opportunity to make meaningful connections regarding practical implications of their academic studies. Similarly, the vocational students gained insight into the applications of biology for agricultural applications. In the latter case, the math and business students were challenged to use several process skills, were involved in meaningful applications of math and statistics, and worked together to conduct an actual research project that had an impact on their community. Commenting on the outcomes of their program, the authors clearly indicated their perception of the locus of control for curriculum planning and listed several benefits of program integration (Beck, et al., 1991):

> Collaborative work between academic and vocational teachers does not mean they will turn their backs on or ignore skills specific to each area. Rather, teachers and students, by working together, can sort out what is important in the curriculum for the students' futures. In so doing, they will create richer learning processes, higher educational aims, and, ultimately, an uncommon education. (p. 31)

A Science-Related Social Issues Approach

A social issues approach to integrated teaching is especially appropriate for rural school programs because of its sensitivity to the community context and its potential for expanding the learners' horizons of interest and experience. The school-community connection plays an important part in any learning situation, and it may have a much greater impact on student achievement in rural schools (Charron, 1991; Sunal, 1991). Ramsey and Kronholm (1991) confirmed this in an integrated program of instruction that employed an extended case study approach (ECS) to investigate a science-related social issue, The Timber Wolf Recovery Plan. This unit, which reflected many features of the "webbed model" of curriculum integration described by Fogarty (1991) and the "correlation design" described by Vars (1991), was adapted from earlier efforts to integrate the study of science and other subjects around community issues such as municipal solid waste.

The Timber Wolf study engaged a fifth grade class in a rural school in an extensive research program that integrated a variety of process skills and other meaningful activities required to deal with a real-life social issue. The students were keenly interested in the Timber Wolf Recovery Plan because it involved fascinating wild animals that lived in their region and were accorded near-legendary status in local folklore.

The study was designed to engage the students in an examination of beliefs and values surrounding the issue and to involve them in planning and completing investigations, collecting and analyzing data, making decisions, and taking action based on their conclusions. In order to determine the students' knowledge of wolves and their ecological relationships, Ramsey and Kronholm explained, the teacher began the study by requiring them to write a wolf essay. The essays indicated that most students had a very limited knowledge of the natural history of wolves, and this enabled the teacher to plan subsequent activities that would enable them to construct more adequate concepts of the wolf and its place in nature.

A variety of reading materials were provided to enable the students to enhance their reservoir of knowledge, Ramsey and Kronholm (1991) reported; and lessons were presented on the topics of predator-prey relationships, population dynamics, and ecosystems. "Many students soon began to understand that most of their negative feelings...about wolves were based on misconceptions" (p. 5). Building on the students' realization of their own misconceptions, the teacher helped them learn how to identify beliefs and values that others held on the issue. Invited speakers and other sources of information enabled the learners to identify key issues such as the effect of wolves on the deer population, safety of humans on wilderness trails and other recreational facilities, and threats to livestock. The students were intrigued by the variety of different perspectives they encountered.

The class continued the analysis of the issue by constructing a concept map to summarize what they had learned. (They mounted a picture of a timber wolf in the center of the map to highlight the topic of the study.) Once the map was completed, the students were able to construct a comprehensive picture of the problem of timber wolf management, and the map became a tool for identifying and communicating additional questions (Ramsey & Kronholm, 1991):

> The students decided that the most important problem to be researched was the beliefs and attitudes of the majority of Northern Wiscon-

sin residents about the timber wolf recovery plan. After much discussion and planning, it was decided to answer this question using a questionnaire to collect data about people's beliefs. Students prepared items for a ten-question survey instrument. . . . In order to sample the Northern Wisconsin population, 350 local residents were selected randomly from telephone directories found in the local library. The counties targeted for the study were those that would be impacted the most by a wolf recovery plan. (pp. 6-7)

Hand-written cover letters were prepared by the students, and the surveys were mailed along with pictures of themselves. Perhaps because of this personal touch, Ramsey and Kronholm noted, the students received a 60% response to the survey. Many respondents included personal notes, newspaper articles, or other things they considered important. The student-community connection was carried even farther by some respondents who included a stamped, self-addressed envelope and requested a copy of the results of the survey. These and other connections instilled in the students an awareness of the worth of what they were learning in school and a sense of personal contribution to better understanding of a meaningful public issue. The motivational benefits of such an experience are obvious.

Having gathered the data they needed for this stage of problem-solving, the class employed its mathematical skills to process the information. The students found that the majority of the respondents supported the timber wolf recovery plan (Ramsey & Kronholm, 1991):

> It is difficult to describe how excited and interested the students became ... They invested a lot of thinking and effort, and they generated a lot of good publicity for elementary science education. Collecting data about an interesting animal, involvement in a real-life issue, communication with real people, and trying to answer an important question all contributed to developing a sense of ownership of the outcome of the issue on the part of the students. Equally important, the students were learning to use research methods for real-life problem solving. (p. 9)

"Once the students had analyzed and investigated the issue, it was time to decide what actions were appropriate" (Ramsey and Kronholm, 1991, p. 9). They had gained extensive scientific knowledge about wolves, and they had constructed a comprehensive overview of the social and ecological dimensions of the issue of timber wolf restoration. Would they simply move on to another topic in the curriculum, or would they put their new concept to work to help resolve the issue? Working in cooperative learning groups, the students used a decision-making process to identify possible actions and consider their consequences. Eventually, they elected to raise money to donate to a group supporting the Timber Wolf Recovery Plan. Building on their arts and crafts experiences and an understanding of economics, they prepared and sold plaster of Paris wolf footprints and other materials to raise money (Ramsey & Kronholm, 1991):

> The actions taken by the students were not superficial....They were applying their newly acquired scientific knowledge to a very relevant, real-life issue. For them, science education had become very meaningful as they used it to try to make the world better by helping to solve a problem on the basis of carefully researched and documented scientific information. (p. 12)

At a critical time in their education, when many students are beginning to lose interest in school studies as fragmented and meaningless pursuits, those fifth-graders embarked on an integrated learning experience that provided convincing evidence of the importance of the study of science and other subjects for responsible citizenship. They were enabled to master the natural history, apply the reasoning skills, and construct the scientific and ecological concepts they needed to deal with an important, real-life problem. They had either learned or strengthened a variety of process skills and higher-order thinking skills, done extensive library research, and employed arts and crafts, history and geography, reading and writing, mathematics, music, poetry, science and other studies to do meaningful research. Their studies had led them from the confines of the rural school community to the far ends of the region, and they had learned valuable communications skills.

This was a natural issue for an extended study, Ramsey and Kronholm (1991) explained; and "other communities and regions may have equally interesting but different issues" (p. 4). A review of local newspapers will confirm this presupposition for most rural communities, and science-based integrated teaching will help many students realize meaningful connections among all subject areas and develop an appreciation for the relation of science and technology to society.

Conclusions

Science-based integrated teaching offers many benefits for rural schools. It enables teachers with different disciplinary backgrounds to work together and lessen the feeling of professional isolation as they realize the natural connections of their areas of expertise. It is dependent upon a close teacher-student relationship, which is a hallmark of rural schools; and it enhances the imagination and creativity of teachers and learners alike as they discover new ideas and meanings that would often be obscured by a separate-subject approach to a topic of interest. It provides learners a more comprehensive perspective of life and learning, and it extends their vision far beyond their local environment. Equally important, it is conducive to collaborative efforts within and across school systems to enhance each collaborator's resources for accomplishing its educational mission. And most important of all, it is conducive to better teacher morale, improved student performance, and more positive attitudes toward learning in general and science education in particular. In addition, perhaps because of the increased student involvement integrated instruction generally involves, it may help to interest the "second tier" of students—those who for some reason or other do not choose to study science—that Tobias (1990) described. If so, it will help to involve a vast audience in education for scientific literacy.

Most models for curriculum integration are grade-level independent and may be applied throughout the K-12 spectrum, with teachers adapting the level of content emphasis and learning activities to the appropriate level for the students involved. This places teachers in a primary position of responsibility for curriculum and instruction, and it fully confirms their status as professionals in the field of education. However, integration of subject matter cannot be done by teachers for students; it is something that is done by the learners (Hopkins, 1937). A successful transition to integrated teaching must also centrally involve the students. The typical close relationship of teachers and students in rural schools is conducive to an ongoing process of interaction and planning of the nature required for purposeful integration of curriculum and instruction. Beane (1991) observed, "In all of this, however, the question in curriculum reform is whether educators are willing to make a leap of faith on behalf of the young people schools are intended to serve" (p. 13).

Rural educators should carefully examine the potential benefits of restructuring their school science curriculum along learner-centered, subject-integrated patterns. For some rural elementary teachers already accustomed to thematic integration of teaching activities in a manner similar to Var's correlation design or Fogarty's webbed model, the task may begin with working together to integrate the various disciplines along lines more compatible with their integrated teaching patterns. Many others, including most high school science teachers, may have little or no base for interdisciplinary program activity upon which to build; and they will have to start from scratch. However, the benefits of integrated teaching will be obvious once teachers become aware of the many curricular connections among the various disciplines, and this will entice some teachers to try an integrated approach. Word of anything that improves student learning travels fast; and once even a few teachers in a school system experience the benefits of integrated teaching, obstacles that rural schools must overcome for complete curriculum integration will seem much less intimidating.

For some schools, the transition may be easily attained; and for others more time and effort may be required. However, one writer implied, curricular and instructional integration should not be considered beyond the reach of any school or school system Fogarty (1991): A faculty can easily work with [any of the various integrative models] over time to develop an integrated curriculum throughout the school" (p. 65). But the goal should not be a replica of any existing model, Fogarty added. Rather, a unique program should be designed as necessary to meet the needs of the school and its students.

Those lacking the resources for planning and development of a major program of reform within their own school systems may overcome the limitations of size through collaborative programs (Fletcher & Cole, 1992; Prather, 1993a; Rhoton, et al., 1992). Cooperative action within systems or among neighboring school systems, including such innovations as faculty and/or materials sharing, may also help to overcome the need for specific expertise or equipment. Therefore, for many rural schools, the key to the future may be expressed in two phrases: *integrated teaching, and cooperative planning and program development*—provided they are begun today.

References

Aikin, W. (1941). *The story of the eight year study.* New York: Harper and Brothers.

American Association for the Advancement of Science. (1990). *Science for all Americans: Project 2061.* New York: Oxford University Press.

Atkin, M. (1983). The improvement of science teaching. *Daedalus, 112* (2), 167-188.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart, & Winston.

Baird, W. B., Prather, J. P., Finson, K. D., & Oliver, J. S. (1994). Comparisons of perceptions among rural versus nonrural secondary science teachers: A multistate survey. *Science Education, 78* (6), 555-576.

Beane, J. (1991). The middle school: The natural home of integrated curriculum. *Educational Leadership, 49* (2), 9-13.

Beck, R. H., Copa, G. H., & Pease, V. H. (1991). Vocational and academic teachers work together. *Educational Leadership, 49* (2), 29-31.

Brooks, J. G., & Brooks, M. G. (1993). The case for constructivist classrooms. Alexandria, VA: Association for Supervision and Curriculum Development.

Brunkhorst, B. (1991). Every science, every year. *Educational Leadership, 49* (2), 36-38.

Butler, M. (1991, Spring). Rural population slows during 1980-90. In Rural Conditions and Trends. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Butts, D. P. (1982). Science education. In H. E. Mitzel (Ed.), *Encyclopedia of Educational Research*, Vol. 4 (5th Edition). New York: The Free Press (MacMillan Publishing Co., Inc.), 1665-1675.

Carlson, R. V. (1992). What does it mean to work in a rural setting? A study of influences. *Journal of Rural and Small Schools, 5* (1), 41-47.

Chaillé, C., & Britain, L. (1991). *The young child as scientist: A constructivist approach to early childhood science education.* New York: Harper Collins Publishers.

Charron, E. (1991). Classroom and community influences on youths' perceptions of science in a rural county system. *Journal of Reasearch in Science Teaching, 28* (8), 671-687.

Clement, J. (1982). Students' preconceptions in introductory mechanics. *American Journal of Physics, 5* (1), 66-72.

Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher, 23* (7), 4.

Crane, S. (1991). Integrated science in a restructured high school. *Educational Leadership, 49* (2), 39-41.

DiSessa, A. A. (1982). Unlearning Aristotelian physics: A study of knowledge-based learning. *Cognitive Science, 6* (1), 37-75.

Drake, S. M. (1991). How our team dissolved the boundaries. *Educational Leadership, 49* (2), 20-22.

Driver, R. (1983). *The Pupil As Scientist?* Milton Keynes, England: The Open University Press.

Driver, R., Asoko, H., Leach, J., Mortimer, M., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23* (7), 5-12.

Eisener, E. W. (1991). Should America have a national curriculum? *Educational Leadership, 49* (2), 76-81.

Field, M. H. (1988). A chronicle of changes for elementary science in Tennessee. Education, 108(4), 419-426..

Fletcher, R., & Cole, J. T. (1992). Rural educational collaboratives: An economic and programmatic viewpoint. *Journal of Rural and Small Schools, 5* (1), 30-34.

Fogarty, R. (1991). Ten ways to integrate curriculum. *Educational Leadership, 49* (2), 61-65.

Goodlad, J. I. (1987). A comprehensive view of school improvement: Structure, process, and an agenda. In J. I. Goodlad (ed.), *The Ecology of School*

Renewal (pp. 1-19). Chicago: University of Chicago Press.

Greene, L. C. (1991). Science-centered curriculum in elementary school. *Educational Leadership, 49* (2), 42-46.

Henry, N. B. (Ed.). (1958). *The integration of educational experiences*. Chicago: University of Chicago Press.

Holliday, W. G., Yore, L. D., & Alvermann, D. E. (1994). The reading-science learning-writing connection: Breakthroughs, barriers, and promises. *Journal of Research in Science Teaching, 31* (9), 877-893.

Hopkins, L. T. (1937). *Integration: Its meaning and application*. New York: D. Appleton-Century.

Hurd, P. D. (1991). Why we must transform science education. *Educational Leadership, 49* (2), 33-35.

Jacobs, H. H. (1991). Planning for curriculum integration. *Educational Leadership, 49* (2), 27-28.

Jackson, P. (1983). The reform of science education: A cautionary tale. *Daedalus, 112* (2), 143-166.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press. (first edition published in 1962)

Kumar, D., & Voldrich, J. F. (1994). Situated cognition in second grade science: Literature books for authentic contexts. *Journal of Elementary Science Education, 6* (2), 1-10.

McCloskey, M. (1983). Intuitive physics, *Scientific American, 248*, 114-122.

Matthews, M. & Davson-Galle, P. (1992). Constructivi... and science education: Some cautions and comments. In S. Hills (Ed.), *The History and Philosophy of Science in Science Education*, Vol. II (pp. 135-144). Kingston, Ontario: Queen's University.

Miller, D. F., & Blaydes, G. W. (1962). *Methods and materials for teaching the biological sciences: A text and source for teachers in training and in service (Second edition)*. New York: McGraw-Hill Book Company, Inc.

National Science Teachers Association. (1993). *Scope, sequence, and coordination of secondary school science, Vol. 1: The content core, a guide for curriculum designers*. Washington, DC: National Science Teachers Association.

Neurath, O., Carnap, R., & Morris, C. (Eds.). (1955). *International encyclopedia of unified science. Vols. I and II*. Chicago: The University of Chicago Press.

Piaget, J. (1970). *Genetic Epistemology*. London: Columbia University Press.

Prather, J. P. (1993a). A model for inservice science teacher enhancement through collaboration of rural elementary schools and universities. In Rubba, P., Campbell, L., & Dana, T. (eds.), *Excellence in educating teachers of science (1993 AETS Yearbook)*. Columbus, Ohio: ERIC Clearinghouse, Ohio State University. pp. 131-149.

Prather, J. P. (1993b). Reform revisited: The trend toward constructivist learning. *Journal of Elementary Science Education, 5* (2), 52-70.

Prather, J. P., & Shrum, J. W. (1984, July). Geology has key role in science education. *Geotimes, 29* (7), 11-12.

Prather, J. P., Hartshorn, R. L., & McCreight, D. A., (1988). A team leadership program: The elementary science education institute (ESEI). *Education, 108* (4), 454-462.

Rhoton, J., Field, M. H., & Prather, J. P. (1992). An alternative to the elementary science specialist. *Journal of Elementary Science Education, 4* (1), 14-25.

Ramsey, J. M., & Kronholm, M. (1991). Science related social issues in the elementary school: The extended case study approach. *Journal of Elementary Science Education, 3* (2), 3-13.

Romance, N. R., & Vitale, M. R. (1992). A curriculum strategy that expands time for in-depth elementary science instruction by using science-based reading strategies: Effects of a year-long study in grade four. *Journal of Research in Science Teaching, 29* (6), 545-554.

Roychoudhury, A. (1994). Is it minds-off science? A concern for the elementary grades. *Journal of Science Teacher Education, 5* (3), 87-96

Semb, G., & Ellis, J. (1994). Knowledge taught in school: What is remembered? *Review of Educational Research, 64* (2), 253-286.

Sher, J. (1988). Why rural education has not received its 'fair share' of funding, and what to do about it. *Journal of Rural and Small Schools, 2* (2), 31-37.

Shymansky, J., Kyle, W., & Alport, J. (1983). The effects of the new science curricula on student performance. *Journal of Research on Science Teaching, 20*, 397-404.

Stack. E. C. (1961). The philosophical and psychological antecedents of the core curriculum in educational theory, 1800-1918. Doctoral dissertation, University of North Carolina. University Microfilms No. 604869). Dissertation Abstracts International 20: 1830-1831.

Stern, J. D. (1994). The condition of education in rural schools. Washington D.C.: U.S. Department of Education Office of Educational Research and Improvement.

Sunal, D. W. (1991). Rural school science teaching: What affects achievement. *School Science and Mathematics, 91* (5), 202-210.

Swick, K. (1992). Integrating math and computer learning through an early childhood school-home approach. *Journal of Rural and Small Schools, 5* (2), 9-17.

Thurston, L. P., McGrath, D., & Stone, D. (1992). Bringing high-tech to the heartland. *Journal of Rural and Small Schools, 5* (2), 18-23.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier.* Tucson, AZ: Research Corporation.

Vars, G. F. (1991). Integrated curriculum in perspective. *Educational Leadership, 49* (2), 14-15.

Weiss, I. (1987). *Report on the 1985-86 national survey of science education.* Research Triangle Park, NC: Research Triangle Institute.

Wolpert, L. (1993). *The unnatural nature of science.* Cambridge, MA: Harvard University Press.

Chapter 5
Blending Science, Mathematics, and Technology In The Rural School Classroom

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The challenge of teaching mathematics or science in a small rural school can be a significant one. Teachers in the typical rural setting often find themselves faced with a more limited curriculum, fewer resources, and more responsibilities and time demands than their urban colleagues (Haller, 1992). In addition, they are often less prepared and experienced than urban teachers, and usually have taken fewer college mathematics and science courses, and are less likely to have a graduate degree (Carlsen & Monk, 1992). Such a rural mix of limitations and expectations is something that confronts more than 30% of our nation's mathematics and science teachers (Edington, 1983).

A special challenge of the rural setting for the teaching of mathematics and science exists within the national challenges of overall reform for these two disciplines, and for our educational system in general. As our society enters an age of rapid change and the increased importance of information processing, new methods of teaching mathematics and science in all schools is becoming increasingly important (McGee, 1987; Stonier, 1983). Thus, with increasingly limited resources and greater time demands, the rural mathematics or science teacher may find it particularly difficult to keep up with current reform efforts.

Concerns of Rural Schools

The responsibilities of schools in general are increasing as a result of the information age. Cetron (1989) suggests that the amount of knowledge available to students will double four times by the year 2000. In a single year, the graduating class of 2000 will be exposed to more information and knowledge than their grandparents experienced in a lifetime. This places a significant burden on all schools and teachers, but in particular small and rural schools, due to their limitations relating to isolation, population, and economics.

Isolation and population are two factors that affect rural communities. Schools in rural communities typically tend to house a more homogeneus group of students and teachers than do urban areas (Carlson, 1991), and rural schools and communities often provide a context that tends to be quite different from their urban counterparts. Carlson also believes that schools in rural communities generally lack some of the advantages of those in the metropolitan areas because of the greater social, political and cultural forces inherent in metropolitan areas.

The economic decline in rural communities has also had a major impact on the students being served by those schools. The National Rural, Small Schools Task Force (1988) found that more than 2.2 million students attending over 2700 rural school districts across the nation are suffering from chronic, severe poverty. The Task Force called these students "the forgotten population," and suggested that they exist in every state. Educators from rural communities often say there is a great need to improve the academic performance of their students from low-income families. In a survey by the nine Regional Education Laboratories (Arends, 1987), two concerns rise to the top of 40 items rated by state board presidents, district superintendents, building principals, and classroom teachers: (1) academic performance of students from low-income families, and (2) students' thinking and reasoning skills identified as in great need of improvement.

Although largely supported by rural schools, educational reform efforts have placed a disproportionate burden on the capacities of rural schools to provide diverse course offerings (The effects of reform in rural school districts, 1989). The most popular reform of the

1980s was the increased graduation requirements in the areas of mathematics and science. Forty-two states added requirements in mathematics, science, or both (Firestone, Fuhrman, & Kirst, 1990). These increased requirements in mathematics and science were a precursor to the fourth national education goal adopted in 1990 by President Bush and the governors of the 50 states: "U.S. students will be first in the world in mathematics and science achievement by the year 2000."

The charge of making American students first in the world in mathematics and science applies particularly to those responsible for educating students in rural school communities, because of the changes in society and vocational opportunities for students. More than at any other time in American history, students from rural areas are being forced to leave their rural environments, learn an entirely new set of job-related skills, and compete on a national and international level rather than a local basis (Johnson, 1991). Indeed, the advance of mathematics and science in our society is proceeding at an ever quickening pace, even though K-12 instruction in these disciplines is not progressing as rapidly. This contrast, between a society that is in a rapid state of change and a process of mathematics and science teaching that is not, is at the foundation of why we have focused on the need to change the instruction of these two disciplines (McGee, 1987 & Stonier, 1983).

Integration of the disciplines of mathematics and science can be a powerful educational force for rural schools. The natural connection between these two subject areas not only allows teachers to teach cooperatively, but it allows students to apply the abstract "symbolic representations" of mathematics to more concrete situations within science applications and experiments. In the past, the learning of mathematics has been conceived as a process by which students passively absorb information, storing it in retrievable fragments as a result of repeated practice (Resnick, 1987). However, Resnick suggests that when students use prior knowledge to assimilate information in learning new tasks, greater amounts of knowledge can be stored. Within this context, the scientific process can act as a natural catalyst for applying and learning new mathematics.

New challenges facing the science and math teachers of the future will not only include the need to establish a new set of basics, (i.e. applications-based curricula and technology integration) but also the need to review belief structures about the efficacy of traditional instruction in various school settings. In particular, schools in rural community settings can often be very challenging for new teachers with respect to changing traditional school paradigms about what should be included in a math or science course (Carlsen and Monk, 1992). Applications and technology-based curriculum revisions, or almost anything new, can sometimes invite criticism from parents, students, and even teachers who, over the years, have established a personal tradition of ideas about teaching and learning.

With the hands-on nature of the science and mathematics standards (including technology), the necessary instructional materials can put an increasing financial strain on schools with limited budgets. This strain can be particularly evident in the financially limited rural areas where the students have a relatively minimal access to new services and materials (Coward et al., 1983). Monk and Haller (1986), and Ross and Rosenfeld (1988), specify that rural schools typically have less equipment to work within the classroom, and generally suffer from inadequate school facilities.

A strong partnership between science and mathematics teachers, or their respective departments, can be one way to combat financial limitations, and is a natural advantage of integration. Science and mathematics teachers can often find equipment useful to both disciplines, such as graphing calculators and computer software. Curriculum resources such as AIMS (Activities Integrating Mathematics and Science), are also becoming available to help identify quality lesson situations which integrate both the mathematics and science disciplines.

It appears that rural teachers do prefer to combine forces, if possible, in their class instruction. In a survey by Carlson (1991), rural school teachers put "more networking and cooperative arrangements" as a top response to a question relating to what changes would rural teachers make in their setting if given the opportunity.

NCTM and NCSESA Reform Documents

The new ideas about teaching and learning mathematics and science are helping to redirect the focus of education reform efforts in the elementary and secondary classrooms of today. Both the National Committee on Science Education Standards and Assessment (NCSESA) and the National Council of Teachers of

Mathematics (NCTM) have distributed documents that have been active in changing traditional paradigms about the way science and mathematics should be taught and learned. The focus, in both disciplines, is shifting from students being passive receptors of information to being active users of information thereby creating new knowledge for themselves.

The Curriculum and Evaluation Standards for School Mathematics (1989) and the Professional Standards for Teaching Mathematics (1991) are two documents that specify the curriculum structure for active, discovery-oriented approaches to learning for students, and specific approaches to professional development for teachers. The NCTM Standards (1989) have sought to redefine the traditional paper and pencil approach to learning mathematics by shifting the emphasis from learning sets of rules and memorizing structured algorithms to mathematics as problem solving, communication, reasoning, and mathematical connections (p. 123).

The National Science Education Standards, which are currently in draft form, seek to provide a "vision of what it means to be scientifically literate." This set of "standards" describes what students must understand and how they must perform as a result of their cumulative learning experiences in science. The science standards also offer specific criteria for curricular evaluations concerning systems, programs, teaching, and assessment.

Science and Mathematics as "Connected" Disciplines

Both sets of standards have defined the necessity of making science and mathematics more applicable to the real world. If students are to view mathematics and science as practical and useful, they must understand that it can be applied to a wide variety of real world problems and phenomena (NCTM, 1989). The NCTM also suggests that students need to understand that learning both mathematics and science has a purpose. One major purpose is helping them to understand and define their world, and to solve problems that occur in it. For instance, students learn to measure because measurement helps them answer questions about quantity, which in turn, helps them describe and communicate various circumstances and phenomena that relate to their everyday lives.

The common direction and goals in the disciplines of mathematics and science, and the subsequent integration of these subjects, allow students to see the interrelated nature of scientific and mathematical knowledge. It is this natural integration that provides for an enhanced understanding of the influence of science and mathematics on societal issues, both now and in the past.

The Role of Technology

The use of technology, especially computer-based technology, can help provide a useful collaboration mechanism for mathematics and science instruction in the rural environment, and can be a general catalyst to better instruction in both of these disciplines. By having students use computer to learn, investigate, or analyze mathematical or scientific concepts, they are also typically using a computer in a way that a real life scientist or mathematician uses a computer. In fact, how science and mathematics are actually done, as disciplines, is changing dramatically due to the effects of technology. The ability to process large amounts of information, by using a computer, is changing the way we analyze and quantify in the natural sciences (Davis & Hersh, 1981).

New educational technologies can help provide the depth and exploration so important to new reforms in mathematics and science coursework. By the use of such tools as spreadsheets, students can analyze data collected from science experiments to examine mathematical patterns and correlations much more efficiently then when working in the context of paper and pencil calculations. Simulation packages can also permit science classes to make maximum use of limited resources, such as using computer simulations to supplement or even replace if necessary, the traditional dissection lessons. Some simulations, especially those related phenomena in physics (rockets, levers, etc.), also have some very appropriate illustrations of mathematical principles (such as acceleration, force, etc.), which, when used effectively and creatively, can help play an important role in blending mathematics and science. This may help rural teachers combine instructional resources, and help rural students experience a more natural approach to the learning of these two important disciplines.

The blending of mathematics, science, and technology can also be a real catalyst for some innovative lessons. For instance, a class might create a computer program to propel electrical cars across the room, use a spreadsheet to calculate the average speed of the cars, and use a graphing calculator to plot distance as a function of time, and to explore velocity and acceleration. Such natural "blending" of mathematics and science, facilitated by computer-based technology, is also an excellent way to help students learn about the different ways that computers can help facilitate the solution to a scientific or mathematical problem.

New technologies are also beginning to help rural teachers better communicate with educators across the world, and access instructional resources sometimes unavailable to rural locations. The best example of this is the Internet international computer network. The Internet is the world's largest computer network, and is now resident within 134 countries worldwide and includes more than 15 million computer stations (Krol, 1993; Pawloski, 1994). The Internet links the nation's and world's computers, and provides the efficient exchange of computer-based data across the globe.

For the rural mathematics and science classroom, Internet access offers the special benefit and potential of truly "breaking down the classroom walls," and linking a classroom microcomputer with any computer on this international network. Thus, a fifth grade student in rural Fort Calhoun, Nebraska might exchange electronic mail in a problem solving activity with a fifth grade student in Melbourne, Australia, or receive actual pictures of Mars from NASA, or perhaps search a national database for the most recent weather images.

The Internet can also help rural teachers access additional instructional resources to use in the mathematics and science classrooms. Many sites on the Internet (such as NASA or the National Center for Supercomputing Adventures-NCSA) have extensive software and data resources which can be accessed freely over the Internet. Thus a mathematics teacher might download census data or free statistical analysis software, and a science teacher might receive color photographs of the moon directly from NASA, or a virtual reality simulation of a roller coaster from NCSA. The Internet represents a vast new source of free software and materials for the mathematics and science classroom.

The use of the Internet, as well as more fundamental technologies such as spreadsheets or graphing calculators, are consistent with new goals in mathematics and science education, and can help make instruction of these disciplines better parallel what actual scientists and mathematicians do. Such technologies can be a real advantage to the rural teacher, and offer a "real life" blending of mathematics and science, as well as open up a vast new set of instructional resources.

Models Supporting Integration

Some programs targeting the rural areas have recognized the natural advantage of blending mathematics, science, and technology to help provide a more effective instruction of these areas. A particularly successful inservice program is the Science and Mathematics Academy for Rural Teachers (SMART) Program, which has been conducted in Alaska, Idaho, Montana, Oregon, and Washington (Batey & Hart-Landsberg, 1993). Within this program, master rural teachers in mathematics and science are identified and brought together within a university setting to help mentor and work with more novice rural teachers. The program takes a very comprehensive approach to rural support, with detailed plans for blending mathematics and science instruction, using computer technology, building local community assistance, using student and teacher field experiences, and even helping recruit other teachers to choose job opportunities in a rural setting.

Several support programs have also used interactive video technology as another way to help address the limited resources and course offering problems that rural schools often confront. The use of interactive television has been identified as a particularly common approach (Barker & Hall, 1993) by a recent survey of 132 rural districts in 32 states, and has been used to expand both the course offerings in mathematics and science, and the inservice training available for teachers. Both satellite and cable-based mediums have been used successfully, with satellite links being the most common approach. However, such efforts are almost exclusively being conducted at the secondary level, with a less than 10% usage at the elementary or middle schools levels.

The emerging use of "teacher networks" has also been reported as a very successful way of bringing rural teachers together for supporting reform in mathematics and science. Many of these new networks, such as the "Big Sky Network" in Montana, use computer-based telecommunications, usually the Internet, as a way to connect rural teachers to each other and the outside world. Four other rural states, including Idaho, Oregon, Washington, and Alaska have reported very positive results in providing a formal teacher networking structure like "Big Sky" (Stoops, 1994). These results include a greater sense of local input, more extensive development of classroom curriculum materials, a better awareness of new curriculum standards, and a greater support for rural teachers who try new curriculum innovations.

Other support programs have focused directly on the rural student, and have blended mathematics, science, and technology. For instance, Project SCAMP (Science, Computer, and Mathematics Professions) has been developed as a year long program for gifted rural students at the junior high school level (Mason & Mason, 1991). The students from rural settings attended residential summer camps to meet with real life scientists and mathematicians, and worked on building computer simulations of mathematical and scientific topics. Subsequent networking of the students was supported through telecommunications and periodic field trips. A similar program by Tennessee Technological University focused on rural females, to help build scientific and mathematical interest with the assistance of appropriate female role models (Swindel & Phelps, 1991).

Programs in Alabama (Singh, 1990) and Virgina (Moore, 1989) have also used specialized summer programs as a useful way to combine resources to help both teachers and students in rural settings experience mathematics, science, and technology in a dynamic integrated environment. These programs have also successfully targeted special populations, such as minorities and gifted students. A similar program in Minnesota also included some specialized planning sessions for rural elementary principals to help better pool resources and aid in resource planning (Nolan & Richardson, 1985).

It would seem that rural support programs that do work, whether focusing on the teacher or the student, tend to be comprehensive in their support of systemic change, usually by blending mathematics, science, and technology, and carefully examining the use of collective resources (Hoffman, 1993; Johnson, 1991; National Rural and Small Schools Consortium, 1987). Such programs often start with a careful analysis of what resources can be combined, and work to provide instructional settings supporting innovation, and using lessons which model the essence of proposed reforms in the mathematics and science.

Looking Forward to the Future

Although an integrated approach to teaching mathematics and science, using technology, is becoming endorsed by professional associations such as NCTM and NSTA, such a curricular blend is still all too uncommon in today's rural schools. Unfortunately, in many of these schools, the instruction of mathematics and science has failed to keep up with the quickening pace of advancement for these disciplines in our society. Although these two disciplines involve dynamic and interesting concepts, the classroom instruction of these concepts has remained largely one of memorization, recalling step by step approaches for mathematical computations, or isolated scientific terms and definitions.

The traditional focus on memorization and calculation takes away valuable classroom time that might be spent on higher level activities, such as dynamic problem solving, computer analysis, or scientific investigation, and increases the likelihood that rural classrooms will fall well behind their urban counterparts in mathematics and science education reform efforts. By continuing with the computational mathematics and memorization science of the past, there is little opportunity to involve students in the technology and information rich mathematics and science of today, where these two disciplines are naturally integrated and mutually reinforcing. Until such curriculum revision occurs in individual schools, rural students will see little relevance and integration of mathematics and science into the real world in which they live. In essence, many of the "basics" that are still taught today in these traditional rural classrooms, are really "basics" for the 1940s, and not the 1990s.

In fact, the reform movements in science and mathematics education are placing greater emphasis on a whole new set of curriculum "basics". The NCTM's emphasis on problem solving, reasoning, communications, and connections to other disciplines, suggests a movement in this discipline toward the active use of mathematics, science, and technology within real world contexts. Documents representing science reform suggest a similar set of new basics, that focus on active inquiry and a dynamic new form of scientific literacy. Some authors have suggested that such discipline-related changes reflect a more generalized set of "curriculum basics" linked primarily with the expanding nature of information, and including abilities such as evaluating information, setting priorities, and making decisions (McGee, 1987).

Such new basics will demand new approaches for supporting change within the mathematics and science curriculum of the rural school. Due to their isolation, rural schools may need additional and more aggressive support for reforms. Goals such as educating teachers and administrators, keeping parents and communities informed, and the rapid adoption of new curriculum material and technologies to blend disciplines, may be important keys to the success of mathematics and science reform movements in rural schools (Johnson, 1992).

If rural students continue to sit in their neat rows watching their different mathematics and science teachers write on the chalkboard, they are truly endangered by the possible perception that these disciplines are isolated and tedious endeavors, better left to individuals capable of dealing with such tedium and isolation. Such a perception can be a real disadvantage to rural students, who may well have to make their living outside of the rural setting. Contrast this to a more integrated and dynamic approach to mathematics and science instruction, as envisioned by the reform movements, where students are engaged in information research, hands-on hypothesis testing, and mathematical modeling. Science and mathematics classes can be truly exciting places, both in rural and urban schools, and provide an excellent place for students to think, create, and share ideas. We need to provide rural students with opportunities for learning the new "basics," while doing science and mathematics in the integrated way in which they operate in the real world. In essence, the education of rural students needs to be a "springboard to the future," rather than an "entrenchment in the past."

References

Arends, J. (1987). *Building on excellence: Regional priorities for the improvement of rural, small schools* (A Report to the National Rural, Small Schools Task Force by the Regional Educational Laboratories.) Washington, D.C.: Council for Educational Development and Research.

Barker B. and Hall, J. (1983). A national survey of distance education in rural school districts of 300 students or less. Paper presented at the National Rural Education Association, Burlington, Vermont. ED 363491.

Batey, A. & Hart-Landsberg, S. (1993). Riding the wind, rural leadership in science and mathematics instruction. A technical report from Northwest Regional Educational Laboratory, Portland, Oregon. ED 365481.

Carlsen W.S. & Monk, D. H. (1992). Rural/nonrural differences among secondary science teachers: evidence from the longitudinal study of American youth. Paper presented at the American Education Research Association, San Francisco, CA. ED 350133.

Carlson, R.V. (1991). What does it mean to work in a rural setting? A study of rural influences. *Journal of Rural and Small Schools, 5*(1), 41-47.

Cetron, M. (1989). *American renaissance: Our life at the turn of the 21st century.* New York: St. Martin's Press.

Coward, R., DeWeaver, K., Schmidt, F. & Jackson, R. (1983). Distinctive features of rural environments: A frame of reference for mental health practice. *International Journal of Mental Health, 12*(1-2), 3-24.

Davis. P. J. & Hersh, R. (1981). *The Mathematical Experience*. Boston: Houghton Mifflin.

Edington, E.D. (1983). Science and mathematics teachers' needs in the rural schools. Written testimony for the United States Senate Budget Committee. ED 226891.

The effects of reform in rural school districts. (1989, September). In *Education reform: Initial effects in four school districts*. (A report to Congressional Requesters). Washington, D.C.: United States General Accounting Office.

Firestone, W., Fuhrman, S. & Kirst, M. (1990s). Implementation, effects of state education reform in the '80s. NASSP Bulletin, 74(523), 75-84.

Haller, E. J. (1992). Small schools and higher order thinking skills. Paper presented at the American Education Research Association, San Francisco, CA. ED 348184.

Hoffman, C. (1993). On the road to excellence in education. *Appalachia, 26*(1), 4-11.

Johnson, J. (1991). Reform in mathematics education: What's a rural or small school to do. *Journal of Rural and Small Schools, 5*(2), 3-8.

Krol, E. (1993). *The Whole Internet*. Debastopol, CA: Oreilly and Associates.

Mason, M. M., Mason, W. B. (1991). Project SCAMP: A young scholars program for academically talented rural youth. ED 342561.

McGee, J. (1987). Curriculum for the information age: an interim proposal. In M. A. White (Ed.), What Curriculum for the Information Age? Hillsdale, NJ: Lawrence Erlbaum Associates.

Monk, D. & Haller, E. (1986). *Organizational alternatives for small rural schools*. Ithaca, NY: Cornell University, New York State College of Agriculture and Life Sciences, Department of Education.

Moore, N. D. (1989). Rural students, regional problems. *Roeper Review, 12*(2), 112-13.

National Rural and Small Schools Consortium. (1987), NRSSC Exemplary Program Award Recipients. *Journal of Rural and Small Schools, 2*(1), 45-61.

National Rural Small Schools Task Force. (1988). *End of the road: Rural America's poor students and poor schools*. (Report to the Regional Educational Laboratories). Washington, D.C.: Council for Educational Development and Research.

Nolan, F., Richardson, M. (1985). Vistas unlimited: a success story for rural principals. *Principal, 64*(4), p. 34-46.

Pawloski, R. (1994). How I found out about the Internet. *Educational Leadership, 51*(7), 69-73 .

Resnick, L. B. (1987). The 1987 presidential address: Learning in school and out. *Educational Researcher, 16*(9), 13-20.

Ross, P. & Rosenfeld, S. (1988). Human resource policy and economic development. In D. Brown, J. Reid, H. Bluestion, D. McGranahan, & S Mazie, (Eds.), *Rural economic development in the 1980's: Prospects for the future* (pp. 333-358). Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, Agriculture and Rural Economy Division, (Rural Development Research Report No. 69.)

Singh, J. (1990s). Improving math and science for minority students. *Gifted Child Today, 13*(2), p. 6-7.

Stonier, T. (1983). *The Wealth of Information*. London, England: Methuen Publishing.

Stoops, J. (1993). *The use of peer-based support in rural settings to effect curriculum renewal*. Northwest Regional Educational Lab, Portland Oregon. ED 363489.

Swindel, R., Phelps, M. (1991). *Reaching our potential: rural education in the 90's*. Conference proceedings of the Rural Education Symposium, Nashville, Tennessee. ED 342569.

Chapter 6
STS In Rural Education

Emmett L. Wright

The most prominent ideas being purported for rural schools of the future have embedded in them many of the prominent concepts and principles that have been associated with the relationship between science-technology-society (STS) education programs. The rural community is approaching the planning process for change in the education system as a task of the parents, students, community leaders, business persons, etc., as well as educators. Groups are attempting to become prognosticators of the future; by defining the skills, knowledge, and attitudes that youth of today will need to prosper in the future. A developing consensus (Cobb, 1994; AAAS, 1990; Drake, 1991) suggests that the curriculum should be student-centered, based on hands-on activities, involve cooperative group inquiry and learning; evoke critical thinking skills, and focus on interdisciplinary and cross-curricular topics and issues that are not only concerned with national and global problems, but emphasize solutions for local problems, whether they be scientific, technological, social or some combination of these.

Figure 1, adapted from the *Foundations and Challenges to Encourage Technology-Based Science* (FACETS) curriculum outlines a set of strategies that reflect the current curricular thinking for rural schools (Benbow & Wright, 1995). The FACETS curriculum is designed to provide middle school students with choices for investigating the natural and designed world. Students work in collaborative groups to explore relevant Scientific, Technological and Societal questions and issues.

STS Defined

There are as many definitions of (STS) Education as there are organizations and individuals to conceive them (Cheek, 1992). Following three years of discussion and debate, the November 1994 draft of the National Science Education Standards (National Research Council, 1994) states in an overview that:

> Scientific literacy for all student is a national goal. The *National Science Education Standards* are a contribution toward achieving that goal. Increased scientific literacy will benefit our society: citizens will be able to use scientific principles and processes in making personal decisions; all will experience the richness and excitement of knowing about and understanding the natural world; economic productivity will increase in a society that is becoming increasingly dependent on scientific and technological skills; and informed citizens will be able to participate in debate about scientific issues that affect society. (p. XVII)

Under the category of Science and Technology Standards, it is proposed that by the time students complete high school, they would develop fundamental understandings and implied actions for most contemporary issues that relate to Personal and Social Perspectives to Science and Technology. Content Standard F-9-2 states (National Research Council, 1994):

> As a result of activities in grades 9-12, all students should develop understanding of
>
> - Personal and community health
> - Population growth
> - Natural resources
> - Environmental quality
> - Natural and human-induced hazards
> - Science and technology in local, national, and global challenges (p. V-158)

DEFINE A PROBLEM
Identifying a problem, and assessing its nature and complexity. *This strategy gives your students the opportunity to formulate a testable question, and decide which of several methods might be the best way of approaching that question.*

FINDING INFORMATION
Finding useful ideas from reliable sources. *The "Finding Information" strategy includes such activities as interviewing, using libraries, accessing on-line search programs, and other ways of collecting information.*

TEST EXPLANATIONS
Using experiments, field studies or surveys to test explanations and predictions fairly. *After defining a problem and collecting information about it, students flesh out their plan for attacking the problem. This often involves the defining of roles, timelines, and equipment needs.*

USE MODELS & SIMULATIONS
Making and using models, or designing simulations, as a way of investigating scientific questions. *In addressing problems that cannot be explored directly, students make or choose models or simulations that might inform their original research question.*

GATHER DATA
Designing and carrying out reliable ways of collecting and recording data. *Gathering data includes the design of the data gathering method, the organization of the data into charts or tables, and the grouping of the data into categories that make sense.*

ANALYZE DATA AND CHECK IT
Critically studying the data to see what they are suggesting and to check that they are reliable. *After data sets are collected and grouped, students review them, looking for patterns and relationships. Students also check their data, by repeating a study, or by comparing their findings to a standard or to the findings of another group engaged in the same study.*

DRAW CONCLUSIONS
Recognizing valid findings from the investigation's data, finding valid explanations for the results, and being able to communicate these to others. *When data analysis has been completed and findings discussed, students work to see what valid conclusions can be drawn from the study.*

DESIGN AND MAKE
Solving technical problems by designing and making objects or procedures. *For some problems there is a component that involves designing and making an object, or producing a communications piece such as a display, fact sheet, game, etc.*

REFLECT AND CONNECT
Thinking out the significance of the findings, in terms of the big picture, and being able to communicate this to others. *This final strategy is key in that it gives students a chance to revisit their work over the course of a module to see how each activity or event informs the major research question of the module. The communications component of this strategy can be used as a final assessment of student progress as a result of engagement in the module.*

Figure 1. *FACETS Strategies*

The last bulleted item is of particular interest and reflects an emerging discussion that STS education must take on a global view as well as a local and national perspective. Specific statements that illustrate the intents of the Content Standard, science and technology in local, national, and global challenges, include (National Research Council, 1994):

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. But, understanding science alone will not resolve local, national, or global challenges.
- Progress in science and technology can relate to social issues and challenges. Funding priorities and health problems serve as examples of ways that social issues influence science and technology.
- Individuals and society must decide on proposals involving new research and technologies. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions, such as: "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"
- Humans have a major effect on other species. The influence of humans on other organisms occurs through ways, such as land use—decreasing space available to other species, and pollution—changing the chemical composition of air, soil, and water. (p.V-164)

Bybee (1987) and Bybee and Mau (1986), science education, Heath (1988), social studies education, and Hacker and Barden (1988), technology education, all appear to support the proposed National Science Standards recommended for a viable STS course of study. Bybee, based on a survey of one over 250 science educators in 41 countries, lists twelve issues that appeared relevant: world hunger and food resources; population growth; air quality and atmosphere; water resources; war technology; human health and disease; energy shortages; land use; hazardous substances; nuclear reactions; extinction of plants and animals; and mineral resources.

Heath (1988) proposes five major topics or themes that social studies educators can provide to an STS focus:

1. Critical public issues that affect the well-being of individuals and societies throughout the world.
2. Processes and skills in thinking about critical public issues associated with science and technology.
3. The utility of trade-offs in decision making on STS issues.
4. Knowledge and skills in civic action.
5. Interrelationships and integration of knowledge and cognitive process skills from several academic disciplines.

Hacker and Barden (1988), from a technology education perspective, emphasize the social impacts of technology; communication systems and technologies; production systems; energy; power and transportation systems; and the design, fabrication, testing, and improvement of technological devices.

A Rural STS Focus

Education regarding wise utilization of natural and human-developed resources is essential for every rural school student. It is the core of (STS). Citizens possessing a sound knowledge of the environment, expressing an awareness of the problems and potential solutions associated with natural and human-developed resources, are motivated to work toward the implementation of viable solutions to those problems.

The ultimate goal of STS education in rural schools is to improve students' knowledge about the natural, historical, social, economic and political environment forces that shape society; how technology and humans (society) affect the natural environment; and ways they can improve the natural environment now and for the future. To achieve this goal the STS curriculum should provide rural students with educational experiences:

1. To comprehend the significance of critical environmental, technological and social issues that relate to the overall quality of life in the biosphere.
2. To develop a broad understanding of how these critical issues are inter-related and addressed by society.
3. To identify critical environmental, technological and social issues in the local environment that are appropriate for study by rural students in the rural setting.
4. To explore viable solutions toward resolving the identified local environmental problems.

Learning Outcomes

Rural students who have participated in an STS-focused program should ultimately be able:

1. To comprehend key scientific, social, political, economic, and historical components of issues related to the misuse and abuse of natural and human-developed resources in the biosphere.
2. To identify and describe important biospheric environmental issues facing humankind (e.g., endangered species, a lack of diversity, water pollution, ozone depletion, greenhouse effect, soil depletion, diet and human health).
3. To be able to research and report on a specific and relevant environmental issue affecting the local rural area.
4. To propose both direct and indirect strategies to resolve persistent environmental issues in the local rural area.
5. To develop an action plan of citizens' roles in becoming involved in the resolution of both local and global environmental issues and their solutions. "Think globally, act locally."

Problem Solving and Thinking Skill Development Through the STS Curriculum

The STS curriculum should focus on developing creative thinking and problem-solving skills aimed at applying viable solutions and strategies to deal with persistent environmental issues in both the local and global context. The topic of environmental issues is well suited to an interdisciplinary STS approach and encourages the use of problem solving/ decision making concepts and skills, examples of which can be found in Figure 2.

In addition, a variety of concepts and interdisciplinary skills should be applied from a number of subject areas including social studies and language arts (Figure 3), and mathematics and graphic arts (Figure 4).

These types of skills are especially useful in challenging the gifted and talented. It is felt that once the students are involved in thinking about the STS issues and working collaboratively with their peers toward designing testable strategies and solutions, parents may also become more aware and involved; thus, community awareness is improved. Whenever possible, professional specialists who have an extensive knowledge on a local issue should be invited to interact with the students.

STS Focus Rural Setting: Personal Overview

This section outlines the author's synthesis of ideas concerning a (STS) curriculum for the rural school setting. The synthesis is based not only on personal beliefs, but is also an attempt to provide a holistic overview of what should and can happen in a small, rural school setting. The STS content examples are limited somewhat to th STS issues associated with the great plains, an area of the United States with which the author is intimately knowledgeable.

Even though teachers in rural areas are somewhat physically isolated from the major metropolitan areas and from many world environments, their students are still a part of the global community. We need science programs that provide rural students the opportunity to study both present and future needs, and interactions within the large system we call Earth. The biosphere is the major organizational scheme we associate with the Earth. Within this system, we have other ways of looking at human beings and how they interact not only with one another but also with plants and animals.

Change is occurring throughout the biosphere, and as teachers of science we should have real concerns about what we discuss with students in terms of human relationship to the natural world as well as the world's societies. Of course, we have to focus our attention on how social, scientific and technological change affects the individual organism, whether it is a human being, a wheat plant, a sorghum grain, a cow, or a pheasant.

We need to study science in the context of being concerned not only with the individual and the conventional topics associated with the individual, but with how science links understanding the biosphere with human interactions within the biosphere. The major organizing theme for the STS program in rural schools is to promote an experiential approach to understanding and appreciating the dynamics of natural ecosystems interacting with human systems. This is a first step in analyzing and appreciating how human activity has affected these systems. The great plains region, for example, is predominantly a series of prairie ecosystems consisting of remnants of the tall grass prairie, short grass prairie, or a mixed grass prairie system, which is what existed before the European settlers arrived. Although these have been maintained as grasslands, they have been replaced by non-indigenous wheat, corn or milo. Corn, which is grown with the support of irrigation systems, is an example of a grass that needs lots of water, and forms a monoculture at the expense of diversity.

Monocultures are human creations which require considerable effort and expense to maintain. Tremendous amounts of fossil fuel energy are expended in plowing, cultivating, and spraying chemicals on the ecosystem to destroy weeds and insect pests. In short, we are fighting diversity, which leads to many problems. The water, the soil and even the air are negatively affected. All become forms of "pollution" that are being recognized as very serious problems for the 21st century.

Until ten years ago, people throughout the great plains thought they had plenty of water. They also thought that the soil conservation practices of the 19th and early 20th centuries were adequate. The Midwest states have always advertised as having crystal clear air quality. The situation has changed and these states are now facing many environmental and societal problems. Population increases are placing stress on the Great Plains as they are not the type of biome which naturally supports large numbers of human beings.

Scientists at Rutgers University have suggested resettling all present inhabitants to turn the grassland ecosystems into a buffalo park leading to positive impacts on the ecology of the region. Of course the trade off would have negative impositions on the lifestyles and welfare of the people. Issues and problems associated with an agricultural-based economy should be the focus of science and social studies as such topics relate to the students' world. Rather than only discuss ocean pollution, the destruction of the Brazilian rainforests, and the other global issues (that are all important in their own right), the STS curriculum can focus on how humans are impacting the land, water, and air in the local, rural setting. The STS curriculum must include ways of learning to examine the social and technological aspects of human activities through a focus on applications of basic and fundamental biosphere concepts and principles. For example, what is the impact of automobiles, trucks, and airplanes on the rural setting? They have had a tremendous impact on the railroads, and a considerable number of grain elevators have closed because trains no longer service them. Recently a teacher in an area rural high school expressed a desire to preserve an abandoned railroad right-of-way. Walking the railroad roadbed would be a wonderful way to see the tall grass prairie. However, because a historical law requires the railroads to return the abandoned right of way to the adjacent landowners, the opportunity will be lost to have a wonderful environmental study area for camping,hiking,and so on. Landowners argue that such access leads to anti-social activities such as common theft.

A major educational goal today is the development of critical-thinking skills. An STS curriculum is a natural place for developing critical-thinking skills. A variety of scientific, technological and ethically related issues can be discussed throughout an STS organized curriculum. For example, if a farmer in western Oklahoma cut down all of the windbreaks to increase agricultural production, what would be the resultant soil erosion? It greatly enhances it. Such an important topic, appropriately used, can aid in the development of critical thinking skills. Data could be gathered about soil erosion rates in conservation and non-conservation ar-

PROBLEM SOLVING & DECISION-MAKING CONCEPTS & SKILLS	
observing	inferencing
recording observations and other data	categorizing observation and other data
analyzing observations and data	interpolating
finding correlations	recognizing patterns, sequences
experimenting	communicating information
testing hypotheses	controlling variables
coming to conclusions	deciding on the "next logical step"
measuring	evaluating ideas, outcomes, products models
modeling	simulating

Figure 2. *Critical Thinking Concepts & Skills for STS Education*

eas and analyzed. The students could evaluate the effects of chisel plowing, no till planting, or other kinds of conservation activities, such as planting windbreaks, rotating crops, etc. The impact of plowing differently, intensive management, and tree-cutting could also be studied. Students could address the question of "Why do farmers cut down windbreaks? What is their motivation?"

After the 1930s dustbowl disaster, the federal government subsidized, with hundreds of millions of dollars, the planting of thousands of miles of windbreaks for soil conservation practices. Now farmers are cutting them down. If one can gain another hundred acres on a three thousand acre wheat farm, there is another hundred acres of production. It is a short-term gain and a long-term loss. This is an example of short-term economics. In the long-term, the soil will erode much more rapidly and the economic value of the land will eventually be depressed. In the short-term, though, somebody gains economically.

Although the historical perspective is quite valuable, the associated economics, the political decision-making, and the social values can be equally important and are natural topics for discussion. Such learning experiences should be data-based rather than speculation based on opinion or heresay. Questions can be posed as "What are the real erosion rates that occur before and after a certain practice is followed?" The data are obtainable from the soil conservation service of any land grant university or from a local county agent. A rural STS science curriculum focused on specific, rural topics can do much to add relevance to the learning of science. Such a curriculum can be developed locally rather than depend on national curriculum designed for teaching about issues in which our students have little or no vested interest.

Components of the Rural STS Program: Short and Long-Term Laboratory Activities

Let's examine specific criteria of excellence in a rural, small school STS program. There should be an emphasis on short and long-term laboratory activities in the STS classroom, which promote both the experiential and the experimental branches of science. Experiential science provides for experiences which allow one to interact with the local environment. In a rural setting, a teacher can walk behind the school building

SOCIAL STUDIES CONCEPTS & SKILLS

map-reading skills

latitude and longitude

laws and ordinances

public policy development

community issues

societal, political, economic, and ecological impacts of science issues

distribution of resources

cultural and ethnic diversity and values

human interactions

human needs

human rights

some aspect of psychology of teaching and learning

analysis of qualitative data

land use

environmental issues and ethics

LANGUAGE ARTS CONCEPTS & SKILLS

writing proposals

analyzing arguments

writing public policy statements

writing directions for games

preparing debates

analyzing articles

writing letters

designing ad campaigns (persuasive arguments)

recognizing the elements of propaganda in advertising, persuasive arguments

developing educational materials

writing poems

writing fact sheets

writing public policy statements

writing directions for games

communicating through informative speeches, persuasive speeches

taking notes

writing descriptive paragraphs

designing ad campaigns

writing scripts

Figure 3. *Social Studies & Language Arts Concepts & Skills for STS Education*

and find an ecosystem or representation of an ecosystem available for study.

Through experimental activities, students learn to design experiments as well as gather and process data. Such activities are part of developing critical-thinking skills. There is no reason why seventh grade students and above cannot design and implement experiments. Because not every student may be at a formal level

MATHEMATICS CONCEPTS & SKILLS	
distinguishing and naming shapes and volumes	measuring (length, area, geometrical, volume, time, temperature, mass)
estimating and verifying estimates	calculating (both with and without hand-held calculators)
grouping data	displaying data (bar graphs, line graphs, circle graphs)
designing and building scale models	making blueprints to scale
fractions	ratios
percentages	taking random samples
probability	significant difference
GRAPHICS ARTS CONCEPTS & SKILLS	
drawing posters	drawing cartoons
designing a game board and component parts	working with modeling media
drawing blueprints	drawing maps
designing a storyboard for a video	designing layout for educational materials

Figure 4: *Mathematics and Graphic Arts Concepts & Skills for STS Education*

where they can think logically about cause and effect, and learn to design controlled experiments, the teacher needs to have students work in groups.

There are always enough formal operational students in a class so that activities can be designed around them and the other students in their groups. Science is the natural place to put cooperative learning strategies into place. The students who are formal thinkers can do the designs and data analyses. Those who are not formal thinkers can participate by assisting with gathering data, and setting up equipment. There are various opportunities for students to use their diverse talents in the cooperative learning setting; talents that fit perfectly with teaching STS as a field and laboratory activity.

An excuse that STS teachers give for not involving students in laboratory/field experiences is that the students are unmanageable. They believe that to turn them loose on an activity is to lose control. Teachers need to develop skills to manage behavior in an activity-based setting in addition to managing students who are placed in neat rows, attending to a lecture. It takes a very different set of skills.

Most behavior management strategies used in cooperative learning can be directly applied to the science classroom. If laboratories are hands-on and open-ended, they become positive, motivational experiences for the students. In all of the author's teaching, reading and research, highly motivated students consistently have been found as an ultimate tool for management. If students are not motivated to enjoy what they are learning, they tend to be turned off and even become rebellious.

The development of skills and concepts to foster creativity and critical thinking, particularly about today's problems and their solutions, are very important in promoting the success of all students in the STS classroom. Students can go outside and measure soil erosion rates from a natural system versus drainage from a wheat field. There is a significant value in having the students do a hands-on activity and monitor the changes in a situation over an extended period of time. The experience involves very simple techniques and the teacher can promote those kinds of activities. Also, if you are actually dealing with the local ecosystem and associated environmental problems, these activities encourage, I am sure, leisure time pursuits as well as hobbies.

STS instruction needs to integrate quantitative methods such as mathematics, statistics, and computers to support student problem solving and research activities. Natural and social scientists today use many aspects of mathematics, including statistics as the basis of all decision making. Probability theory and thinking are frequently combined with computer programming. One cannot go to a research lab where qualitative logic is the only basic tool in learning and problem-solving.

In many rural schools, the computers are not in the science room, but are instead in the business education section. Teaching students word processing and the use spreadsheets is one thing, but teaching them to use the computer as a tool for scientific investigation is another. If you are not teaching students to use technology tools, when they enter the university they are going to be greatly disillusioned. The university is rapidly instituting the computer as a core for all learning in the sciences.

STS needs to be taught by questioning as much as by telling. Teachers need to ask questions to promote student thinking, both divergently and convergently. Appropriate learning activities should be conducted to enhance the quality of both deductive and inductive thinking to enable them to be effective contributors to the progress of science and society. If, as an STS teacher, 90% of what you do is tell and only 10% of what you do is question, then probably you are not effectively engaging your students. Effective STS teachers need to ask students about what they have read and experienced, and try to tease out their conceptions.

Students need to identify and work on major issues relevant for rural settings that attempt to tie together science, society, and technology in an interdisciplinary manner. One major issue might be water for all in the 21st century and beyond, which is apropos to the great plains. Soil erosion may be another issue. Endangered species could be a third issue. The impact of technology on personal health could be a fourth issue.

There are major issues which could lead to an extended period of study throughout the course of the year and promote students to apply their ideas. At present, very little curriculum exists to do that. Individuals are encouraged to look at ways to develop a unique curriculum for rural schools; a curriculum which will allow students to deal with primary and high priority issues faced in rural settings, not the tertiary issues. If the lack of information, curricular creativity, or developmental time inhibits local STS curricular development then there are instructional materials available from various national curriculum development projects that could be adapted for rural schools, which deal with environmental issues throughout the world. Students should be dealing with persistent problems that are facing humans; issues which are open-ended and not yet resolved. The issues may not even be solvable within our lifetime. The Earth may self-destruct, but until then it is important for us to seek solutions to our current environmental problems. Of course, humans have always littered their own nests.

Resources for the STS Curriculum

Science Teachers in rural schools need resources, equipment and supplies, but sometimes science is the last to be considered for such necessities, which is a real travesty. In fact, science teachers in rural schools have become timid in asking about anything instructional, and use "lack of funding" to justify why they do not teach laboratories or conduct field activities. On the other hand, rural teachers do have some advantages; it is easier to get a bus for field trips in a small system, compared to a large system fraught with paperwork and many-layered bureaucracies. There is a lot of flexibility in rural schools. Sometimes the money is not there, or is being allocated to other resources. The administrator in a rural system must understand that the laboratory needs to be equipped just as well as the athletic and vocational programs. The rural STS teacher must be very aggressive in requesting support for the total course of study.

STS Curriculum Strategies: Using Local Resources

To offer an enlightened, current program a teacher should implement three major strategies. The first is the use of community resources. A teacher in a rural area may find it difficult to find a guest speaker from a university, museum, or zoo, so one needs to tie into local available resources. County extension agents have soil conservation backgrounds, and there are people in rural agriculture who possess a sound academic preparation in science. In fact, many rural agriculture people and many farmers have degrees and strong backgrounds in the sciences, and should be tapped. Uses of print and non-print media are other related resources that can be used while emphasizing participation in the derivation of viable solutions to various environmentally-related and STS-related issues. The emphasis should be placed on such activities rather than the textbook. At the time a new textbook is adopted for use, its contents are already out of date. Because most textbooks have already been in the classroom for 5-10 years, you are teaching the history of science rather than science. Other resources that reflect current knowledge have to be made available to the rural teacher of science.

Relevant Curriculum

A second strategy for an enlightened, current STS program is the curriculum. Much of what can be said about curriculum has already been said about instruction. A curriculum is needed to support that instruction. Science is viewed as a process rather than a product. It is an ongoing discipline that promotes skills of discovery and explanation, to the best of our abilities, with the understanding of our time, and knowledge of how the world functions.

The curriculum should indicate throughout that all explanations are tentative, not absolutes. In most examinations observed by the author given by rural science teachers, it appears as if they are evaluating the students' knowledge of a collection of absolutes. One of the questions a teacher should ask is how to deal with student feedback from a test. The teacher needs to be willing to listen and accept alternative explanations, giving credit for them, rather than replying "No the book said...."

The curriculum must be written so students can progressively come to understand "the big picture" and then stand back to see the individual and his or her role in all of this. Many textbooks and teachers do not present this view of curriculum.

The preponderance of textbooks tend to be organized around an encyclopedic, conceptual approach to understanding science. Rather than addressing major organizing themes, one should organize a curriculum around holistic scientific themes and the related domains of conceptual knowledge. The four themes recommended by the author are: the atmosphere, as climate changes; the hydrosphere; the lithosphere; and the biosphere. Although the themes appear to be organized around earth science, in reality all areas of science can be incorporated in the STS sense. Once the subject matter has been taken from the foreground and the focus placed on science, technology, and societal interactions, important concepts can be incorporated along them. Furthermore, it then becomes a short step to integration with the sciences and particularly with social studies and the humanities.

It is common to find high school students graduating with the concept that science is totally alien and separate from other human enterprises. Curiously, they do seem to realize that when social issues are the basis for the study of science, their learning invariably involves the concepts of social studies. In all of the formal study of the different disciplines by the author, the two most closely related subjects appear to be science and social studies. Both use the same methodology of instruction and the same evaluative process. While at an east coast university, the author was designated a co-instructor for an Environment and Human Ecology course in the College of Agriculture. As the ecologist for the course, co-teaching with an economist, I have learned a great deal about the applications of economics and social studies, to say the least.

Evaluation

A third major strategy for an enlightened, current STS curriculum has a basis in a festering problem which appears to contribute significantly to students' poor performance on tests. High school teachers in rural areas particularly, because of their students' limited exposure to communication, writing skills, and verbal skills, need to ensure that their students are writing as much in the high school science classroom as they do in sophomore composition. Student evaluation should be more than short answer, true and false, and multiple choice, and fill in the blank types of tests. To teach critical thinking, and help students organize their thoughts, one needs to provide them with application-oriented skills that will enhance their quality of expression in writing, speaking and reading. Students need to write essays on ideas that are important to them. For example, they can interview their grandparents about the dustbowl and bring the story back to class for a historical perspective. The experience of the dustbowl has had a great impact on our desire to understand the dynamics of the natural system. It would be nice to hear grandparents and great grandparents talk about the impact the drought had on their lives during that period of time. "How did it change farming practices?" Have the students research and document their findings. Then, have them verbalize their written reports to the class. This sharing of research information is mutually beneficial.

Conclusions

In summary, from the author's perspective, a rural school STS program should be based on the major holistic themes and conceptual domains that relate to a biospheric perspective, with the incorporation of many examples from the local, rural, natural, and humanly created environments. These issues should not only be addressed scientifically, but should also be linked to economics with connections made to social and historical settings in order to develop critical-thinking skills of the learners. As a result of such experiences, when they serve in the future on the county commission, on the local school board, or in other decision-making positions, they can rely upon this perspective and make judicious decisions about the society in which they exist. This is in contrast to providing students with a "good" scientific education, however well intended, so they can perform well as students at a university. The latter is in competition with the STS notion of the primary purpose of schooling for rural students. The reason we should teach biology, chemistry, physics, mathematics, and history, is not so most students can get high SAT or ACT scores, but to have them develop perspectives and a set of skills that enable them to flourish in a democracy, not just prosper at a university. These contrasting goals should not be opposed. It seems reasonable that if rural schools develop critical thinkers who can logically reason through a variety of high priority issues in society, the students will also to be better prepared for university studies. As a university professor, I have found that students may know a lot of isolated scientific information, but they do not necessarily know how to synthesize and communicate what they know. They cannot express themselves. They have poor verbal skills and very poor writing skills. There is a myth among the general public that we are doing a fine job in rural high schools because our primary goal is to prepare students for a university education. On the contrary, the evidence would lead to the conclusion that in the area of rural science we need to be educating students so they are well-equipped in terms of application-oriented knowledge and skills for the future, particularly if those students intend to stay in a rural setting.

References

AAAS (American Association for the Advancement of Science) (1990). *Science for all americans: Project 2061*. New York: Oxford University Press.

Benbow, A. & Wright, E. (1995). *Foundations and Challenges to Encourage Technology-Based Science*, Washington, DC: American Chemical Society.

Bybee, R. (1987). Teaching about science-technology-society (STS): A view of science education in the United States. *School Science and Mathematics*, 87 (4), 274-285.

Bybee, R. & Mau, T. (1986). Science and technology related global problems: An international survey of science educators: *Journal of Research in Science Teaching* 23, (7), 599-618.

Cheek, D. (1992). *Thinking Constructively about Science, Technology and Society Education*. Albany, NY: State University of New York Press.

Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher*. 23(7), 4.

Drake, S.M. (1991). How our team dissolved the boundaries. *Educational Leadership*, 49(2), 20-22.

Hacker, M. & Barden, R. (1988). Living with Technology. Albany, NY: Delmar Publishers.

Heath, P. (1988). Science/technology/society in social studies. *ERIC Digest*, September, Bloomington, IN: ERIC Clearinghouse for Social Studies/Social Science Education.

National Research Council. (1994). *National Science Education Standards* (Draft). Washington D. C. : National Academy Press.

Chapter 7
Rural Science Education: Water and Waste Issues

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Making the Case

Science education, to be effective, must respond to the special needs of rural communities, schools, teachers, and students. This focus is upon appropriate science for rural communities using the same definitions, research base, and rationale that can be made for any other setting.

Among the major problems of schooling in rural settings are: (a) the feeling of isolation, (b) too few students within a school to permit specialization and appropriate foci for all interests and needs, and (c) fewer teachers to provide a breadth of expertise and experiences for students to draw upon. Many of these problems are being ameliorated by funds to deliver better and continuing in-service, computer linkages, and distance learning capabilities exemplified by fiber-optics networks which allow two-way visual and audio communication.

Science education is in continuing crisis as it is redefined in ways that are more appropriate for all. It is becoming more and more apparent that a single science curriculum does not serve all people well. Even though Americans take pride in local control of the nearly 16,000 independent school districts in the United States, what is taught continues to be determined by curricular materials made available nationally. Usually these mainline textbooks in a given curriculum enjoy 85% of the market (Harms, 1977). Further, when textbooks are analyzed, there is less than a 10% variation in the content. This similarity does not serve rural schools well.

Project 2061 (Rutherford & Ahlgren, 1989) has established a reform agenda in science education for the 90s with its publication *Science for All Americans*. This statement was also adopted by the huge Scope, Sequence, and Coordination (SS&C) Project of the National Science Teachers Association. With nearly $30 million now involved in 2061 and SS&C, the direction for current reforms is established. Further, these projects are affecting the emerging national *Standards* (National Committee on Science Education Standards and Assessment, 1992, 1993a, 1993b, 1994a, 1994b) which clearly define science in broader terms. Science content is now defined with eight facets, including:

1. Science as Inquiry.
2. Physical Science.
3. Life Science.
4. Earth and Space Science.
5. Science and Technology.
6. Science in Personal and Social Perspectives.
7. History and Nature of Science.
8. Unifying Concepts and Processes.

These efforts elaborate on the NSF-sponsored Project Synthesis which issued a report more than a decade ago. Project Synthesis was conceived utilizing four goal clusters (actually justifications) for school science. These four were:

1. Science for Meeting Personal Needs. Science Education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.
2. Science for Resolving Current Societal Issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3. Science for Assisting with Career Choices. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
4. Science for Preparing for Further Study. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs (Harms 1977).

The National *Standards* seem to exemplify how the first three goal areas must also define teaching, professional development, assessment, content, and program sequence. In the past, science has been defined by specific discipline-bound concepts and generalized (and glamorized/generic) process skills used by practicing scientists.

Of course, concept and process skills remain basic to science programs. However, they do not provide the structure, a direct line to curriculum planning, and/or the only aspects used in assessing student learning. For the 90s, the power and centrality of context is emerging as the most important consideration. How are students engaged with their own minds? Do they think, analyze, debate, or identify with the things that characterize the science curriculum? In typical situations students do not; they merely perform as they are asked to do without any thought as to why or how it can be used outside the classroom or laboratory.

Perrone (1994) has recently discussed how student engagement can be attained. His eight points provide another view of the needed content and theoretical foundations for science teaching. Perrone's summary of experience and research indicate the ways students can be/are engaged for real learning:

1. Students help define the content.
2. Students have time to wonder and to find a particular direction that interests them.
3. Topics have a "strange" quality—something common seen in a new way, evoking a "lingering question.
4. Teachers permit—even encourage—different forms of expression and respect students' views.
5. Teachers are passionate about their work. The richest activities are those "invented" by teachers and their students.
6. Students create original and public products; they gain some form of "expertness."
7. Students *do* something—e.g., participate in a political action, write a letter to the editor, work with the homeless.
8. Students sense that the results of their work are not predetermined or fully predictable.

Rural students are more isolated than their urban counterparts. However, they are also closer to nature and to many problems associated with the natural world and human plundering of the environment. Rural students often do not have access to as many scientists, engineers, researchers, or industrial professionals as students in large urban centers. Of course, modern communication technology is beginning to reduce this problem. However, there is a continuing need for more support to provide the needed communication via modern technologies. There is richness in rural students learning from other students in non-rural environs. Where numbers are a problem, sharing of data collected—and data from wide geographical areas—can add to the significance of technological devices—and a reduction of the isolation that occurs in the rural settings. Experts from around the world can be used as sources of information. Surely information from computer retrieval systems has never been easier to access. But the hardware, software, and expertise needed to utilize such advances remain a problem for many teachers and schools.

The last decade has resulted in much new information concerning how all humans learn. Interestingly, the decision was made in 1983 to conduct definitive research into how learning occurred as needed information to reform U.S. science and mathematics education and to help resolve the perceived economic crises that was putting the U.S.A. into jeopardy in worldwide trade and general economic competitiveness. Our national problems were seen as related to the quality of science education in the nation's schools.

The emerging research (Mestre and Lochhead, 1990; Resnick 1986, 1987) seems conclusive that instead of finding how our best students learned science (undergraduate science and engineering majors) it was found that these most successful and motivated students had not learned. Instead they were merely committing definitions and explanations to memory and repeating them when asked in class or on examinations. Skills taught in the laboratory were the same. Students could follow directions and demonstrate mastery. However, they could only repeat the skill. The best students could not transfer the concepts or processes to use in new situations.

These discussions led more cognitive scientists to new questions of learning and eventually to research reports dating back to Vico (1858) nearly 300 years ago. A new interest and respect for Constructivism as a theory of learning has emerged. Most professional societies now advance constructivism as a learning model and have defined new teaching strategies that promote such learning.

Basic to the theory is the belief that all humans construct their own meaning from their own explanations of things they see, do, or ponder. The Association for Supervision and Curriculum Development has led this movement with articles in *Educational Leadership* and special publications like *The Case for Constructivist Classrooms* (Brooks & Brooks, 1993). Constructivist teaching practices consist of:

- Encouraging and accepting student autonomy, initiation, and leadership.
- Allowing student thinking to drive lessons; shifting content and instructional strategy based on student responses.
- Asking students to elaborate on their responses.
- Allowing wait time after asking questions.
- Encouraging students to interact with each other and with the teacher.
- Asking thoughtful, open-ended questions.
- Encouraging students to reflect on experiences and predict future outcomes.
- Asking students to articulate their theories about concepts before presenting teacher understanding of the concepts.
- Looking for students' alternative concepts and designing lessons to address any misconceptions (Yager, 1991, p. 56).

Constructivist practice involves students to a greater degree in terms of identifying questions, offering personal explanations, and devising tests for the validity of such hypotheses generated by students. These actions have all been used to define science. For example, Simpson (1963) has offered a single precise definition of science:

> Science is an exploration of the material universe in order to seek orderly explanations (generalizable knowledge) of the objects and events encountered: *but these explanations must be testable* (p. 82).

Such a view of science exemplifies constructivist teaching practice and learning that can become a part of each student's thinking/learning framework.

In so many ways small rural communities (with the smaller class sizes that are often found and the ties to farms and farming communities) are ready-made for trying constructivist teaching. With a means of communicating with persons around the globe (modern technologies, including the computer), students in rural settings are in prime position for better opportunities for real learning. Indeed, rural science education may provide answers for some of the complex problems which are found in urban settings.

In Iowa, efforts have been underway since 1983 when the Chautauqua Program was initiated with major NSF support and sponsored by the National Science Teachers Association. Although only funded nationally for three years, the Iowa Chautauqua Program has flourished in Iowa, serving over 2,500 teacher since its inception. The model has now been validated and accepted as an exemplary in-service model by the National Diffusion Network (NDN). The model consists of the following features:

1. A two-week leadership conference for 25 of the most successful teachers from previous years who want to become a part of the instructional team for future workshops.
2. A three-week summer workshop at each new site for 30 new teachers electing to try Constructivist practices and strategies; the workshop provides experience with such practices where the teachers are the students. Time is provided to plan a five-day constructivist unit to be used with students in the fall.
3. Use of a five-day STS unit in the classrooms of all summer participants during September or early October.

4. A three day fall short course for 30-50 teachers (including the 30 enrolled during the summer); the focus is upon developing a month long module where constructivist practices are used along with an extensive assessment plan.
5. An interim communication with central staff, lead teachers, and fellow participants, including a newsletter, special memoranda, monthly telephone contacts, and school/classroom visits.
6. A three day spring short course for the same 30-50 teachers who participated in the fall; this session focuses upon reports by participants on their experiences with constructivist teaching and the results of the assessment program.

Arising from the Iowa Chautauqua are several examples from rural schools that exemplify the reforms discussed above. With the "flood of 1993" dominating life in Iowa for a whole year, it is not an accident that this real world issue provided a focus for science study that readily exemplified the new goals for science education, including those characterizing the National *Standards*.

An Integrated Model With a Rural Focus

Given the special needs and circumstances in which students and teachers in rural settings find themselves, how can science programs be designed to personally engage students? What does a science program look like when the criteria for excellence discussed in the first part of this chapter are considered? How do rural programs differ from those created with students in urban and suburban settings. We argue that the notions which are personal, relevant, and local apply in all settings. The differences lie in the issues and problems that students are trying to resolve and the local cultural dimensions. This type of thinking challenges long held beliefs about curriculum design, not to mention our thinking on teaching, learning, and assessment (Hurd, 1991). The typical science program offers very few opportunities for making connections to the real world.

Interconnections between science disciplines are limitless and seem to merge when they are set in a real-world context. Disciplines are transcended and become embedded naturally within the connections as they are uncovered in the natural world. The following model (see Figure 1) serves as the conceptual foundation for the examples from practice that are included in this chapter. This model is centered upon the idea of using a kaleidoscope—each time the scope is rotated, new connections are formed, creating a different pattern—always the same pieces reconnecting to form a new whole. The pattern possibilities are endless.

Personal experiences are the forces that move the model, driving the instructional processes. Learning becomes a "knowledge-based" event, linked to the here and now. Knowledge is explored in a real-life context. The content is not considered to be intrinsically important; in fact, it is determined by the issues and student interest rather than predetermined guidelines. The process results in many "personal" and "cultural stories" (Drake, et al., 1992).

The following teacher stories capture how this model can be put into action in rural settings. The Iowa Scope, Sequence, and Coordination Project (SS&C) encourages teachers to develop stories about their practices as part of the curriculum transformation process. Teachers are asked to create eight of these stories each year—two per quarter. They add an important contextual dimension to what otherwise would simply be a traditional outline of major concepts and a listing of activities. The context we feel is the key for making science experiences personal and relevant. These stories have become the centerpieces for creating curriculum materials that go beyond t' status quo and serve to stimulate an exchange of ideas among teachers in Iowa. Sharing of the stories occurs on a regular basis within the local school districts, at SS&C statewide meetings, and across the fiber optics network. Teachers come to see themselves as master learners involved in analyzing and reflecting on their teaching practices, always concerned with improving. These personal teaching stories serve as powerful change forces (Fullan, 1993).

The Model in Action: What a Tragedy! A Middle School Example

Iowa and much of the midwest suffered through what climatologists and meteorologists termed a "one hundred year flood." The flood of 1993 has left scientists, as well as students in Curt Jeffryes middle school

Rural Model: Integrated Curriculum

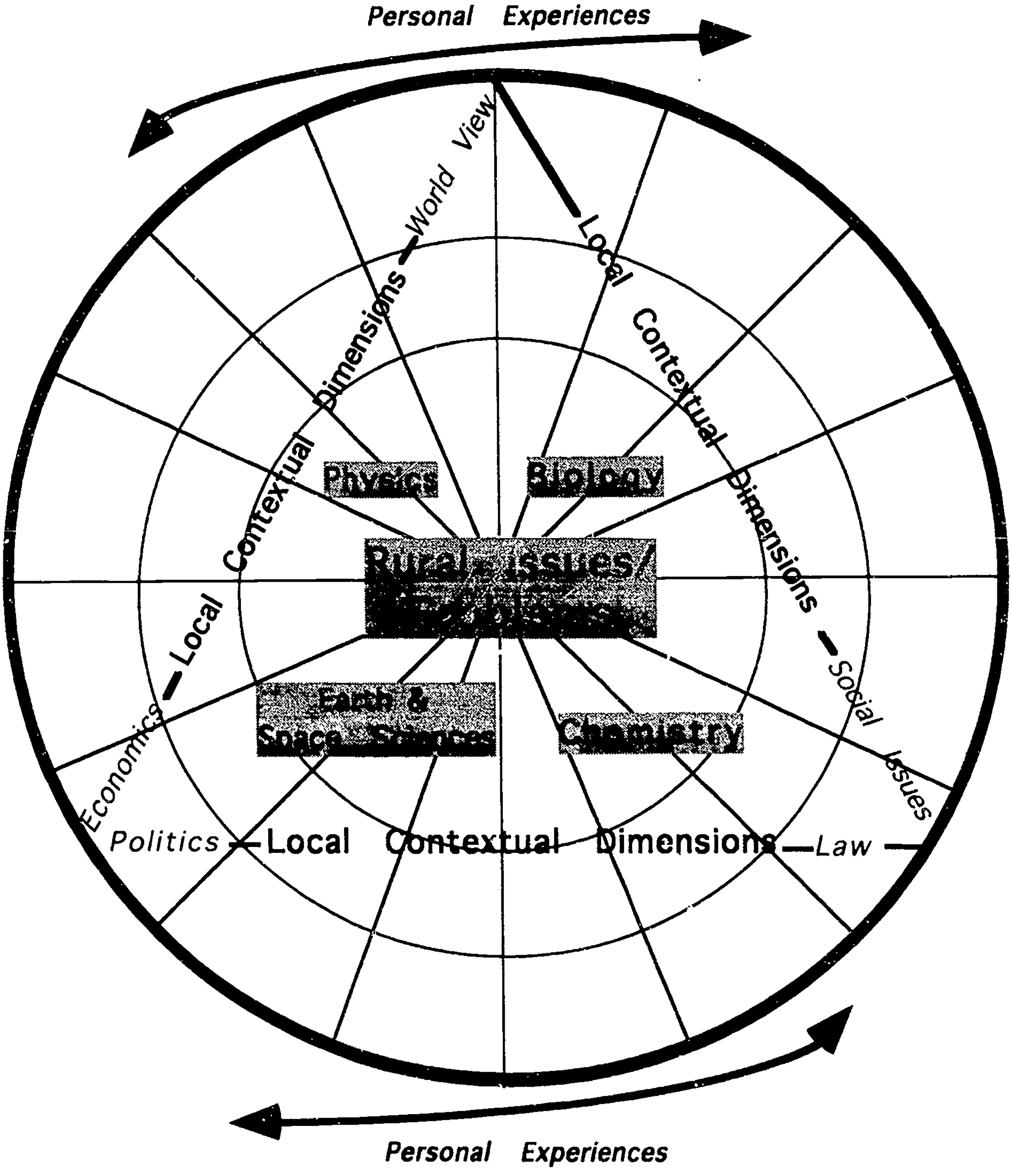


Figure 1. *Model*

classes, with questions that relate to all science disciplines. Scientists have hypothesized the long-term effects and short-term effects of the flood and several new theories have emerged. Students at Burton R. Jones Middle School in Creston, Iowa, took a look at the flood of 1993 and were challenged to examine some of the flooding problems in their local area.

The Teacher's Perspective: Curt Jeffryes's Story

On the first day of school I started classes with a simple question. "What was the most significant event that happened in Iowa this past summer?" Without fail the students replied, "the flooding." Then I asked, "How did the flood effect Creston?" This was a more difficult question because Creston has no major river running through it and the fact that Creston is the highest point of elevation between the Mississippi River and Missouri River in the southern part of the state. The questions began to flow.

Wade said, "I have a question. I live by the creek and it didn't flood, but our basement filled with water several different times and ruined lots of stuff. Was that an effect of the flood?" Other students asked: Why were some areas affected and others not? Did anyone really escape the flood of '93? Could the devastation suffered during the flood have been prevented or minimized? Does mankind have the ability to control natural events like floods? What caused the flood and will it come again? Could we have prevented or controlled the flood? In each class student questions about the flood began to form. These questions would become the basis for the investigations of the flood of '93 and also a basis for the active inquiry that we would be doing during the first semester.

I could clearly see how the water cycle, the topography of Iowa, historical perspective of past floods and prevention of flooding resulting from these floods, and environmental questions of soil erosion, water quality, and land use could be explored. I began to map the unit in my mind and to anticipate the directions our study might take. This mapping is something that I do with all my students. The following mind web (see Figure 2) was created by putting our ideas together at the beginning of this experience.

The challenge was to keep the web growing as we moved through the student investigations in the module. The mind web becomes the centerpiece for monitoring interdisciplinary connections. Through class discussion and teacher mediation, each class decided on the directions of inquires for the module. My curriculum is made up of a series of these modules, usually eight in the series. There were whole class projects and small group inquiries as part of this module.

During the inquiries, the students had to seek out a number of resource people within the community who could provide various forms of data and answer specific questions in relation to the flood. Beau, whose father works at the water treatment plant, provided us with detailed information and models which explained the changes that occurred with the source water during the flood and how it is cleaned and purified. Another student talked to the wastewater treatment plant manager and found information on how the flood affected its operation and also how wastewater is cleaned. Another student contacted a local college biologist who was doing a similar companion study in his microbiology classes and learned about the changes that seemed to be occurring in the source water and its ramifications for people. One group of students contacted a soil scientist at the local ASCS office and engineers at a local firm in relation to looking at how to read topography maps and building flood control structures. Another group of students and teachers planned an interdisciplinary field study to look at flood damage in one of our county parks and at the success of how earlier conservation work had been affected by the flood. Student inquiries were assessed using a pre/mid/post scheme.

Putting our ideas into action became the concern when the student inquires were completed and the results shared with the class and community. The students decided to continue a soil erosion project that had been started several years ago at a county park. They also decided to repair any damage structures at the park as a result of the flood. They were particularly interested to see if the check dams of the past had survived and if they had done their job of preventing soil erosion. They shared with their parents the knowledge of soils and building location in Creston and the potential risks that accompany building in areas like this. Several donated their time to work through church organizations in flood cleanup projects in Des Moines.

It would be difficult to predict how I would change or modify this unit of study for another year. The great flood of '93 was by all accounts an event that might not occur for another 100 or more years. The story, however, has not ended. The effects of the flood continue to unravel before our eyes and next year maybe something new will emerge for us to investigate.

What an Odor! A High School Example

Clayton, and most counties in Iowa, are facing a new controversy involving livestock production. Issues are being raised statewide that call into question problems with odor, and water pollution caused by animal production. Why isn't there a law to stop the dumping of waste into streams? Can't the odor be controlled? What is the real cause of the odor? Does the DNR have anything to do with regulations? Are more than farmers to blame? Even "rural" America is not immune to issues of pollution and odor. Many technologies seem to be available that would help alleviate the problems. The question then is why aren't they being implemented? Elkader high school students in Bill Crandall's science classes are busy taking a closer look at these questions.

From the Teacher's Perspective: Bill Crandall's Story

Like most teachers preparing for a new term with a new group of students, I was concerned about how to start the semester in a meaningful way. What would capture students' attention and provide a venue for modeling an image of science truer to its nature? I began the year certain that I could excite most of the students with an issue dealing with water quality. I took a group of students to a cold water stream to do some measurements that coincided with an ongoing DNR study. As we traveled to the study site with the windows rolled down, we passed several farm sites that gave off the pungent odor of Iowa's number one livestock commodity, hogs.

The students immediately asked the questions that had been in the news all summer. Dan: "What *does* the feedlot runoff do to the environment?" Ann: "Can't something be done to stop the smell?" Tom: "My relatives in Wright County say there is a guy building chicken and hog confinement places all over the county. They're worried about the smell and water pollution. Should they be?" Jim: "Is anybody trying to figure out how to solve some of these problems?" It became obvious from the outset that this issue would not be easy to keep focused in one area. The students as usual were already verbally exploring several issues related to farm waste management that in and of themselves would make for exciting student investigations.

Students were responsible for keeping track of the questions that arose during their investigations. The following web (see Figure 3) illustrates the connections that they uncovered during the module investigations. The students worked in groups—each group tackling a different aspect of the problem.

Perhaps the greatest challenge we have to overcome being in a small community is the isolation factor and lack of local resources. During the information gathering phase, the students took advantage of the resources at hand and gathered information and data tied to their specific questions. The CD ROM in the school library provided the students with a listing of magazine articles (mostly in *Successful Farming*) dealing with the issue of farm odor. They connected to the Internet and gleaned information and expertise from other states using the Turbo Gopher program which allowed them to build a multimedia database with pertinent e-mail addresses, mailing addresses, and telephone numbers. In the database the group entered the area of interest or expertise of each human resource. The students designed a survey to assess attitudes, and understandings about issues associated with farm waste management. The results were then transferred to a database and graphs of the results were produced. We were beginning to realize the scope of this problem.

The second phase of the inquiry process focused on the actual testing of water for substances coming from waste sources. The group decided to look at the problems with surface run-off carrying waste. One of the students said "I heard that the trout hatchery has to monitor its water because the spring that feeds it drains a large area of farm land." We were shortly in transit to the Big Spring Trout Hatchery northwest of Elkader, Iowa. When we arrived, we were able to interview some of the technicians at the hatchery who explained the history of the hatchery and some of the problems involved in using spring water to hold trout. They also conducted tests on the water from the spring as well as the Turkey River that the spring flows into. We were looking for any evidence of high nitrates in the water. This would mean that some form of fertilizer was escaping into the water which could come from agricul-

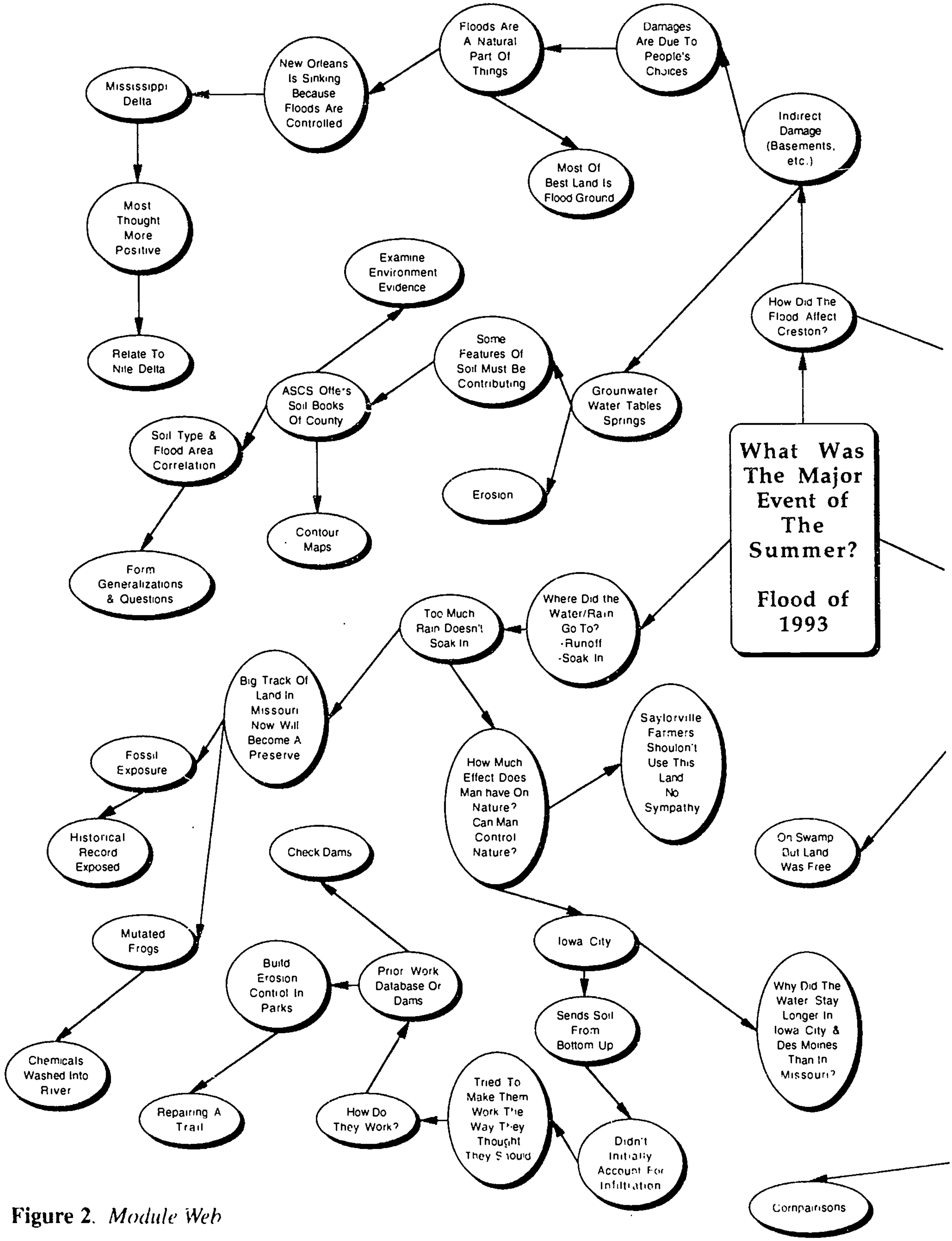
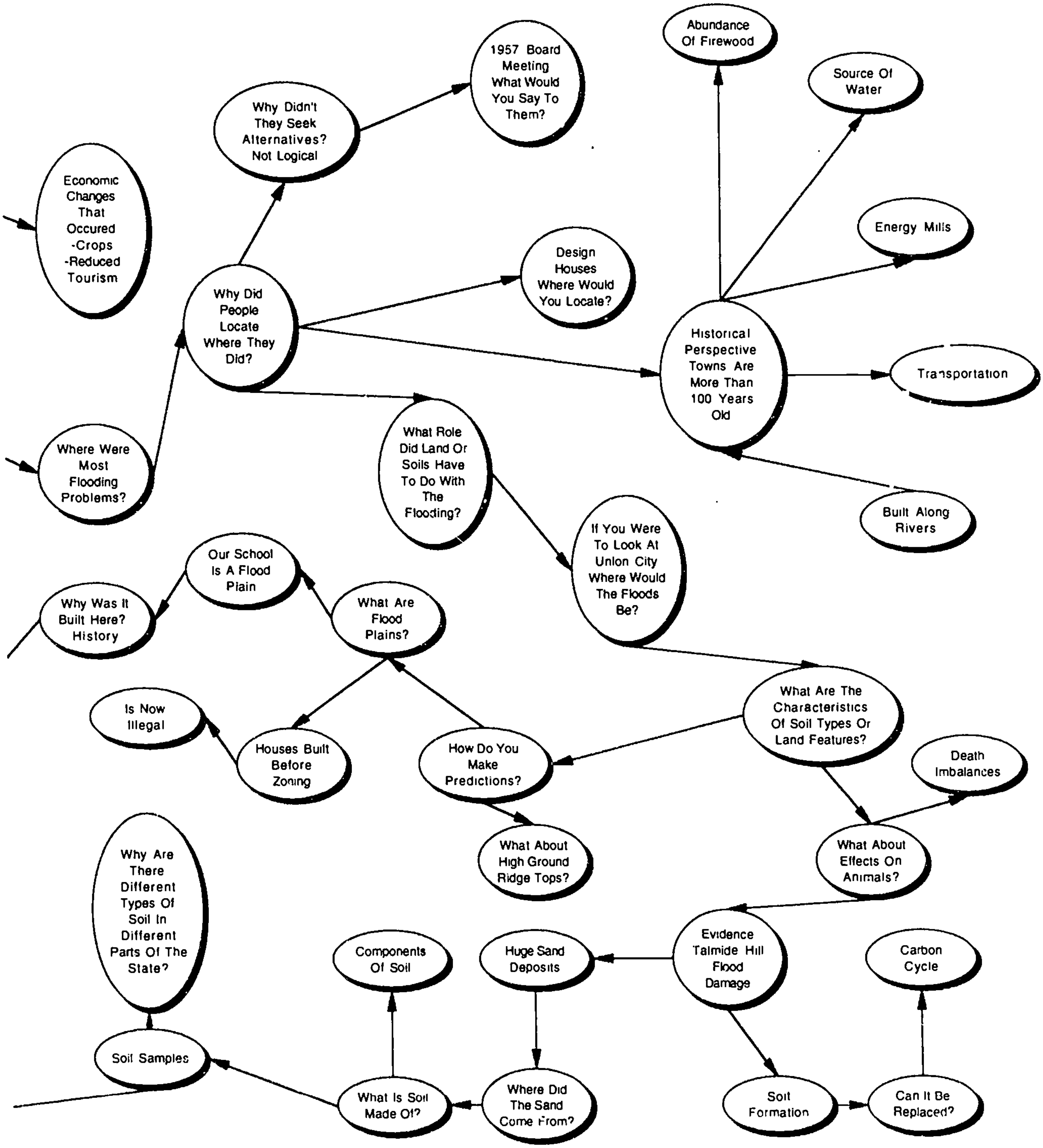


Figure 2. *Module Web*

The Flood '93 Module Web



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QUESTION WEB: FARM ODOR

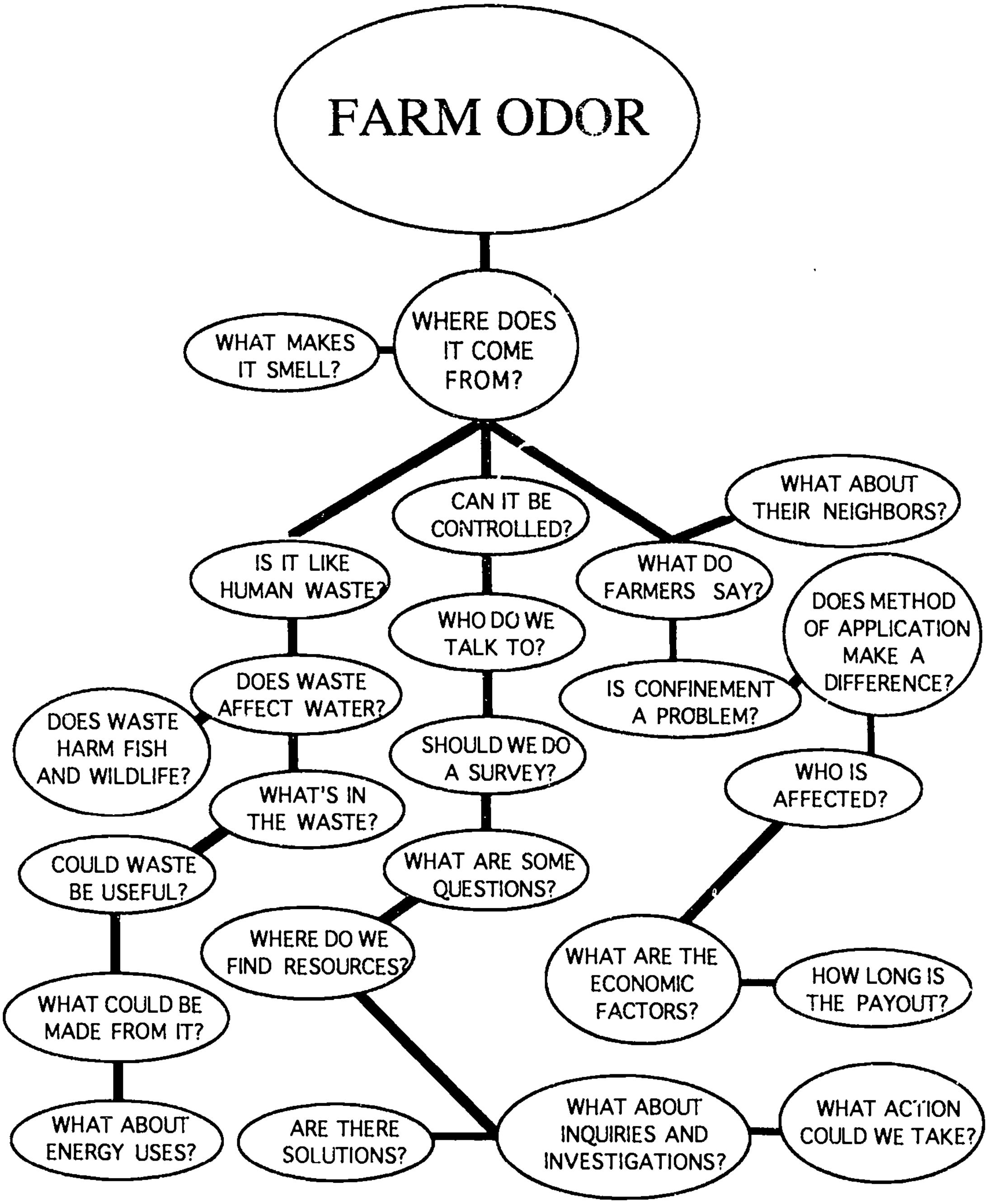

Figure 3. *Question Web*

tural fertilizer or from farm feedlot (manure). A data table was started to help monitor the quality of the water over a long period of time. When our visit to the trout hatchery was complete, the group decided to investigate ways to use the waste in a manner that was environmentally conscious.

The students began to wonder about a film they had seen called "Kilowatts From Cowpies." The film had illustrated how people were producing methane from animal manure at farm sites in Florida and California. One of the students wondered "Why can't we do that in Iowa?" The second strand of our issue had been established. What were the possible alternative energy sources that could be derived from farm waste? Could this manure be used to produce methane? We moved on to explore the possibilities. Students visited a farm to see the process of methane production in action. Tom and Bill took a video camera and set out to interview people about using existing structures to produce methane. In their travels they taped several types of structures commonly used to hold waste. Steel, earthen, and concrete lagoons are all being used, and appear to be able to be retrofitted for capturing methane. Education and economics are key to a change in the way we look at managing this resource.

The issue of farm odor and waste management is complex. What may be a solution in one place won't work in another. Each problem needs to be carefully studied and the most practical methods for abatement applied. Our group strongly feels that the future will see multiple uses for waste as a resource on farms, in cities, and in towns. Our studies have shown that there are many ways for both farmers and municipalities to deal with this issue.

During the final phase of this project, the students moved into action to produce a multimedia presentation of their research findings. The data from the survey graphs were transferred to the Astound computer program which allowed them to add sound and graphics to the graphs. The students made a presentation to the school board when the AV program was done. Copies of the program were made available to the community and were used by the county agricultural extension office.

What a Waste: An Elementary Example

The possibilities of recycling were being discussed in Charles City, IA. Even though many of the municipalities throughout the state had recycling programs, Charles City had yet to act. Some of Iowa' communities were operating under the assumption that recycling was not needed in Iowa. This article raised the serious questions: How can we reduce the amount of waste being taken to the landfill? What types of waste could be recycled, reused? How do you distinguish between different types of plastics? Are we running short on landfill space in Iowa? The sixth grade students at Jefferson Elementary decided to take the problem into their own hands and started looking at the possibilities for making recycling a reality in Charles City.

The Teacher's Perspective: Janet Dunkel's Story

Our recycling module began with a headline in the newspaper: "Charles City to Consider Recycling Options". The students were captured by the idea. I knew this issue was one that could take us in many different directions. I asked the students to bring in items from home that they thought could be recycled. We really collected an amazing assortment. Many plastic items were part of the collection. One student asked: "How can you tell which plastic items can be recycled? What do those markings on the items mean?" These questions led us into a number of inquiries related to density and volume. The students generated questions related to the decomposition of the items brought to school. We decided that our challenge was to uncover the aspects of this issues that were unique to Charles City. We were ready to begin our investigations.

The students worked in small groups which really promoted cooperation among them. The students began to collect information and data related to their questions. The class created a survey that they sent home to their parents. This gave us valuable information on personal viewpoints regarding the issue. The other students in the school were interviewed as well. The data were entered into the computer and analyzed. The students contacted outside resources—plastics engineers, city/county waste management officials, waste management workers, DNR officials, and health officials. The list kept growing. During this phase we explored many key science concepts related to the issue. I found that many of the activities from the textbook or other supplemental curriculum material worked well to illustrate these concepts. I found student interest to be much higher when activities were embedded in a creative context.

A portfolio assessment scheme "as used to help the students keep track of their progress. This portfolio housed the results of their lab investigations, a written record of the process, computer disks, graphs, charts, reports, full-group assignments, and written tests and evaluations.

The students decided that there was a definite need for recycling in the Charles City area. They had been bringing milk jugs to school for one of our investigations related to volume. They realized that these jugs were "space hogs" in the landfill—not to mention our classroom. The students wondered how to get a milk jug recycling program going. We knew we needed space to store the jugs, some way to crush them, and someone to haul them to the recycling center in Wisconsin. A school neighbor got us started by providing an empty garage where we could store the jugs; the local grocery store provided a machine to crush and bale the plastics; and a student's parent provided the semi to haul the plastics. We were in business. Soon though the project grew beyond our limits. The Boy Scouts had already come to our rescue lending a helping hand. We decided to take a proposal to the city council. The students were able to convince the council members to take action and today our class can be proud of the fact that Charles City has a multifaceted recycling program that we started.

Final Perspective

Each of these examples provides a glimpse of the integrated model to science instruction in action. Students are engaged in purposeful learning experiences. They have the opportunity to use what they learn to solve real world problems. The teachers have come to realize that the questions the students should be testing are their own. Science teaching becomes a matter of helping students realize that indeed all knowledge is interconnected, available, and useful in dealing with problems. For these reasons, teachers of science in rural settings have great potential for leading in science education reform. Successes of teachers in rural settings have been astounding in the Iowa Chautauqua Program. The revision of the total science program in SS&C school has also been easier and more striking in rural Iowa schools in terms of the effects of their studies in making a difference in the quality of life in the communities as a whole. Perhaps science education in rural settings will provide the most conclusive and useful examples of reform. The examples provided here are indications that this may be true.

References

Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Drake, S. M., Bebbington, J., Laksman, S., Mackie, P., Maynes, N., & Wayne, L. (1992). *Developing the integrated curriculum using the story model.* Toronto: OISE Press.

Fullan, M. (1993) *Change forces: Probing the depths of educational reform.* London: The Falmer Press.

Harms, N. C. (1977). *Project Synthesis: An interpretative consolidation of research identifying needs in natural science education.* (A proposal prepared for the National Science Foundation.) Boulder, CO: University of Colorado.

Hurd, P. D. (1991). Why we must transform science education. *Educational Leadership, 49*(2), 33-35.

Jeffryes, C., Crandall, B., Irelan, S., & Lawrence, C. L. L. (1994). The flood of '93: SS&C module. Iowa City, IA: The University of Iowa, Science Education Center.

Mestre, J. P., & Lochhead, J. (1990). *Academic preparation in science: Teaching for transition from high school to college.* New York, NY: College Entrance Examination Board.

National Committee on Science Education Standards and Assessment. (1992). *National science education standards: A sampler.* Washington, DC: National Research Council.

National Committee on Science Education Standards and Assessment. (1993a). *National science education standards: An enhanced sampler.* Washington, DC: National Research Council.

National Committee on Science Education Standards and Assessment. (1993b). *National science education standards: July '93 progress report.* Washington, DC: National Research Council.

National Committee on Science Education Standards and Assessment. (1994a, January). *National science education standards: State focused review inquiry.* Paper prepared for the Joint State Conference Meeting. Washington, DC.

National Committee on Science Education Standards and Assessment. (1994b). *National science education standards: November 1994.* Washington, DC: National Academy Press.

Perrone, V. (1994). How to engage students in learning. *Educational Leadership, 51*(5), 11-13.

Resnick, L. B. (1986). *Cognition and instruction: Theories of human competence and how it is acquired.* Pittsburgh, PA: Learning Research and Development Center.

Resnick, L. B. (1987). *Education and learning to think.* Washington, DC: National Academy Press.

Rutherford, F. J., & Ahlgren, A. (1989), *Science for all Americans.* New York, NY: Oxford University Press.

Simpson, G. G. (1963). Biology, the nature of science. *Science, 139*(3550), 81-88.

Varrella, G. F. (1994). Using water-testing data sets. *activities: classroom projects and curriculum ideas, 31*(3), 9-14.

Vico, G. (1858). *De antiquissima Italorum sapientia.* (1710). Naples, Italy: Stamperia de' Classici Latini.

Yager, R. E. (1991). The constructivist learning model: Towards real reform in science education. *The Science Teacher, 58*(6), 52-57.

Chapter 8
Distance Learning for Rural Schools
Distance Learning Defined

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When one mentions "distance learning," any of a number of mental images may be conjured within the mind. Most, if not all, of those images will share a particular trait, however: distance learning is instruction delivered over some distance other than within the normal classroom or school district. At times, distance learning may come to encompass such instruction when the sender and receiver are separated by time as well as by distance.

The concept of distance learning is not a new one. The original target groups were adults having commitments of an occupational, social, and/or familial nature. Holmberg (1986) described correspondence courses of study established in Sweden in 1833 and 1866. Hermod's English course in Sweden, started in 1886, became one of the world's largest distance learning organizations of the era, and emphasized progression at individual students' paces. Other early correspondence courses were established in England in 1840 and soon thereafter in Germany. Two prominent correspondence colleges were established in England, one in 1978 (Skerry's College, Edinburg) and another in 1887 (University Correspondence College, London).

By 1873, correspondence course offerings were available through Boston's Society to Encourage Studies at Home, which attracted over 10,000 students in its first 24 years of existence (Watkins, 1991). The state of New York authorized academic degrees via correspondence through the Chautauqua College of Liberal Arts beginning in 1883 and continuing through 1891 (Watkins, 1991). In 1891, Thomas J. Foster started Pennsylvania's International Correspondence Schools, which grew to enrollments totalling two million by 1920 (Rose, 1991). Illinois Wesleyan began offering correspondence degrees in 1877 and had nearly 500 students enrolled by 1900. Program quality concerns prompted termination of the program by 1906. By 1890, the University of Chicago's Extension Department founded its correspondence programs, which began offering courses in 1892 (Schmidt & Faulkner, 1989; Watkins, 1991), and provided a somewhat rigid schedule of weekly lessons. This was the first extension division in an American University (Watkins, 1991). The University of Wisconsin established its extension correspondence programs in 1891, but waning interest caused program termination by 1899 (Watkins, 1991). Vocational educational courses for secondary school students were offered via correspondence by the University of Michigan in the 1920s and by the University of Nebraska shortly thereafter (Holmberg, 1986).

Early in the 1900s, distance education in Europe saw more refinement with the use of audio recordings and laboratory kits (Holmberg, 1986). During the 1920s and 1930s, some U.S. colleges attempted to implement course instruction via radio. At this time, at least 176 educational institutions had radio stations. These efforts met with limited success and were generally discontinued by the 1940s (Schmidt & Faulkner, 1989). The few that remained tended to be located at land grant colleges (Buckland & Dye, 1991).

The University of Iowa, Purdue University, and Kansas State College began producing experimental television programs in the early 1930s, but it was not until the 1950s that college credit courses were offered via TV. In 1951, Western Reserve University became the first U.S. university to offer a continuous series of television courses for credit. New York University followed with a series aired by CBS between 1957 and 1982 (Buckland & Dye, 1991).

During the mid 1970s, the Appalachian Education Satellite Project began providing teacher inservice through a combination of television and satellite technologies (Hoyt, 1981). The first state educational satellite system was Learn/Alaska, established in 1980, offering six hours of instruction daily to 100 villages (Johnson, 1989). Today, various other satellite television networks exist, as do "hard wired" fiber optic and cable systems, dedicated exclusively for educational uses. Some are noncommercial (such as TI-IN, which started in 1985), whereas others are not (such as Whittle Communication's Channel One).

In other parts of the world, the University of South Africa began distance learning programs in 1962, the British Open University began offering full degree programs in 1971, and other notable distance learning programs were started in West Germany (particularly the German FernUniversitat), Japan, Canada, Sri Lanka and Pakistan (Holmberg, 1986).

Technologies Embraced for Distance Learning

Distance learning can be accomplished in either a classroom-focused or a network-focused mode. The instructor teaches during a live telecast sent to multiple classrooms in various locations in the classroom-focused mode (Barker, 1993). Some such arrangements are limited to only one-way transmission (instructor to student), but most include some method by which students can communicate with the instructor, and perhaps with other students. More and more, such interactive arrangements may be through two-way audio only with one-way video, or two-way audio and video linkages. This is the most commonly identified mode used in today's classrooms. Network-focused modes provide information via microcomputers and modems, accessing databases and electronic bulletin boards and making it possible for students to communicate with others at their convenience rather than during set instructional periods.

Delivery modes utilized for distance learning can be quite varied. Today, one commonly thinks of educational television, whether via satellite technology, cable systems, or open air broadcasts. However, other viable delivery modes include traveling teachers, correspondence (mail), radio, teleconference networks, computer conferencing, electronic networks, and audiotex (Schmidt & Faulkner, 1989). (Audiotex is a mode by which information is stored by computer via digitized sound, and is accessed by dialing with a touch-tone telephone. The computer then gives the caller specific instructions or information.) Some of these are cost efficient, such as correspondence courses, radio, computer and electronic networks, and teleconference systems. Some are easily open to unlimited enrollments. Several suffer from lack of interaction between the instructor and students. Interestingly, in a study conducted by Beare (1989), no significant differences in student achievement were found when various instructional formats were compared. Table 1 provides some comparisons between these distance learning modes.

Even television has its positive and negative aspects. In the positive vein, television can reach large numbers of people. Interactive television allows instructors and students to interact, albeit on a somewhat limited basis; students can see the teacher; and real-time print distribution of handout material is possible. Satellite television offers signals which are distance insensitive (in fact, the larger the system and more sites that can be covered simultaneously, the lower the cost of the system), most are "turn key" operations in which a satellite vendor provides most of the necessary services, and satellite programs have a good track record for receiving federal and state funds. Depending upon the particular system in use, the disadvantages vary. For systems most commonly in use, the teacher cannot see all the students because most satellite technology incorporates only one-way video and two-way audio components. Students are unable to see students at other sites, and cannot talk with one another from one site to another. When telephones are used as the interactive contact apparatus, there is often a delay in getting the call through and, once through, being recognized by the teacher. At times, telephone conversations on air tend to have an echo effect that may be bothersome. Some receiver dishes are weather sensitive, particularly those using the KU band frequencies. Scheduling difficulties arise due to available transponder time, time zone differences between receiving sites, individual school holidays, and so forth. In addition, the start up costs for a satellite dish and equipment may prohibit some schools from obtaining the technology. And for those that do, annual subscription fees may be assessed which must be paid to vendors, often amounting to several thousand dollars.

Bringing Resources to Rural Schools

Historically, rural schools have been characterized as being, among other things, geographically and socially isolated, as well as suffering economic and aca-

Table 1
Characteristics of Distance Learning

Characteristics	DELIVERY MODES								
	Correspondence Courses	Radio	Interactive/Pre-produced television		Audio teleconferencing	Audiographic	Video	Computer conference	Audiotex
Cost	low	medium	extensive	high	low	medium	high	high	medium
Complexity of delivery	low	some	high	medium	medium	high	high	medium	medium
Speed of delivery	low	high	high	medium	high	high	high	high	high
Delivery time flexibility	high	some	low	high	low	low	low	medium	high
Participant-trainer interaction	low	low	high	low	medium	medium	medium	some	some
Special equipment needed by trainer	none	low	extensive	high	some	high	high	high	high
Special equipment needed by participant	none	low	extensive	low	some	medium	high	high	medium
Trainer travel	none	low	low	low	low	low	low	low	low
Participant travel	none	none	low	none	low	low	low	low	none
Geographic range of delivery	extensive	medium	high	high	high	medium	medium	high	high
Adaptability for delivery to remote locations	high	medium	medium	high	high	medium	medium	medium	medium

**Rating categories of low (none), medium (some), high (extensive) are assigned on a relative basis

Note: After Schmidt, B.J., & Faulkner, S.F. (1989). Staff development through distance education, Journal of Staff Development, 10 (4), 3. Used with permission of the National Staff Development Council, Box 240, Oxford, Ohio, 45056; phone (513) 523-6029

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demic poverty in terms of available resources (Augenblick & Nachtigal, 1985; Horn, 1985; Jess, 1985; Davis, 1987; Weiss, 1987). Many difficulties in providing equal access to quality education in these schools have been directly attributable to the same characteristics which make schools rural. Barker (1985) cited strong evidence of rural students being deprived of educational opportunities due to limited curricular offerings and resources. Martin (1983) reported that rural student test scores in nearly every subject were below the national mean during the 1970s. In a similar vein, Enochs, Oliver and Wright (1987) reported rural teachers lacked knowledge and understanding of the latest innovations and instructional techniques. The lack of resources for teaching in rural settings was examined by Baird, Prather, Finson, and Oliver (1994), and the difficulty of providing inservice for these teachers was discussed by Finson and Beaver (1990).

Distance learning technologies have helped address these issues. Across the nation, at the elementary and middle school levels, the technologies have been primarily used for enrichment. The impetus for using them at the secondary level was and is largely the result of the needs of small rural school districts (U.S. Congress, 1989). Numerous initiatives to enhance rural education through distance learning arose throughout the 1980s and 1990s. Many have included state-level efforts, federal grants through the U.S. Department of Education, (and more recently through the National Science Foundation's Rural Systemic Initiative), and programs through national professional organizations and some private foundations or corporations. As a result, rural isolation seems to be less of an academic problem today than in past decades.

Resource availability remains a persistent problem, however. Often, the smallest schools which are most in need of distance learning courses are the least able to afford them (McGreal & Simand, 1992). Distance learning technologies coupled with external funding have enabled many rural schools to reallocate scarce resources to better utilize available funds and materials. An instructor can now teach physics to students in distant rural schools without the schools struggling to find and support qualified teachers to teach the course. Such scenarios have been played out repeatedly over the last ten years, and the results have been encouraging. Whether through the utilization of improved distance learning technologies or by some other means, rural students were scoring at or above national means for most subject areas assessed for the 1980s by the National Assessment for Educational Progress (Welch and Wagner, 1989).

Distance Learning and Equal Access to Information

The need exists for providing equal access for rural schools to the latest in instructional methodologies, content knowledge, and information resources. New standards for teaching science, such as the American Association for the Advancement of Science's Project 2061 and Benchmarks and the National Science Teachers Association's Scope, Sequence and Coordination (AAAS, 1993, NSTA, 1992) must be articulated to rural schools if they are to continue to offer their students up to date educations. Distance learning technologies can well serve educators' needs. Through distance technologies, both teachers and students can obtain and share information with others beyond their own buildings. Courses can be delivered enabling students to learn subject matter not otherwise available to them, and teachers can learn from these and other courses and inservice offerings via distance learning technologies. Further, continual updating of knowledge in science becomes more practical when distance learning technologies are in place and used within a school.

Unique Demands of Science Instruction Via Distance Learning

Science instruction via distance learning places some unique demands on those preparing the courses. Provided the science courses are designed along the guidelines established in Benchmarks/Project 2061 (AAAS, 1993) and similar standards, few will entail only lecture. In the following few paragraphs, several examples of science course components are discussed which may present unique difficulties to science instruction via distance technology.

The necessary laboratory components for many science courses place demands on course organizers which typically do not exist for other types of courses. Laboratory equipment and materials must be duplicated and supplied to each remote viewing site. The logistics of managing the acquisition and transfer of these items often prove difficult and time consuming. Once the materials are at remote sites, on-site facilitators who are trained in the use of the equipment/materials and laboratory protocols are usually necessary. Scheduling training sessions with numerous facilitators from an expansive geographic area may also prove difficult, particularly when more than one session is required per term. If the laboratory activities are designed with the intent that students can work through them without a facilitator, extra effort must be put into the compilation of directions and materials to eliminate ambiguities. Further, once such materials are in students' hands, there is little guarantee that students will actually conduct procedure as intended by the instructor. This may result in students getting off track and/or failing to arrive at conclusions appropriate for the concepts of the lesson. As an example, in the mid-1980s a television physical geology course was offered through a college in North Dakota. One part of the course involved the study of minerals and their physical properties. Students were sent sets of minerals, physical testing materials, and instructions on how to conduct each test. Proper determinations of minerals' hardness and cleavage proved to be difficult without the instructor's immediate presence to show students subtleties in how to do and interpret the results of the tests.

Many science instructors make use of demonstrations. Sometimes, the purpose of demonstrations is to show how to perform a particular procedure or operate a piece of equipment. Unless carefully planned, the details of such demonstrations are difficult to see via television, or may proceed at rates too fast for viewers to grasp. If the demonstrations involve student participation, visibility for viewers may become problematic, and students at remote sites will not be directly involved with the activity.

Visual aids are also commonly used in teaching science. While instructors in the traditional classroom can quickly point to objects, hold up charts or diagrams, or have students quickly scan a collection of materials, these actions require more time via television. Care must be taken that visuals are deliberately posed for the cameras, and that the cameras can focus on each of the visuals for appropriate lengths of time. This has the overall effect of slowing the progress of course sessions compared to that in traditional classrooms.

Field work, including outdoor laboratory work and field trips, is difficult to arrange and conduct for groups geographically separated from one another. Similarly, it is not usually possible to televise from the field, and when it is, most students must be in classrooms at receiving sites to view the class, thus depriving them of the field experience. Some instructors have attempted to videotape field trips for telecasts so that all students can view the trips, but this again is limiting in terms of students getting the feel of actually being in the field and having opportunities to practice field techniques under supervision of the instructor. To overcome such problems, instructors may visit individual sites or clustered groups of sites and conduct field trips/field work with those students at times other than scheduled class times, or trained facilitators may conduct the field experiences for the instructor.

Utilization of Distance Learning

With any given distance learning system, there are those persons who originate the programming and those who receive it. Depending upon which end of the system one finds himself/herself, there is specific knowledge which is needed if the system is to operate successfully. With the advent of interactive distance learning, students at the receiving end can no longer simply be idle viewers, and instructors must commit more thought, planning, and time to the development and production of programming and courses. Grinvalsky (1990) would remind us that although the potential for live interaction and spontaneity is good reason to use distance learning technologies, that potential is difficult to realize unless efforts have been expended and time invested in the education of all participants in the use of the medium.

Teaching With Distance Learning Technologies

Although the technology removes barriers and expands learning opportunities, the teacher — not the technology—is still the one who teaches. Teachers using distance learning technologies find that they must often change their method of teaching and must give more attention to advanced preparation. Few teachers have received appropriate training to teach via distance learning technologies. Such preparation will become more critical for a larger segment of the education community as distance education becomes more prevalent throughout the world (Schlosser & Anderson, 1994). To begin, teachers should give increased attention to desired student interactions, visual materials to be used (and how they will be used), activities, and follow-ups. In addition, preparing for distance learning courses generally requires more time than preparing for identical courses taught in traditional classroom settings. Although some efficiencies can be implemented over time for a course taught repeatedly, some extra time commitment is the rule rather than the exception. In the first semester of a science enrichment course offered through Western Illinois University, the two instructors kept a log of the time required to prepare each session. Analysis of the log revealed that an average of 45 hours of preparation time per one hour of televised time were needed to produce the sessions. In ensuing semesters, this time was reduced to an average of 23 hours per session. Other instructors may be able to prepare their courses with more economy of time, but they must be prepared to commit more time than traditionally devoted to course preparation. In the same vein, administrative personnel must allow for this additional time and provide for appropriate compensation for the instructors involved.

One must use some caution when preparing to provide courses or inservice over television. Barker and Platten (1988) noted that satellite delivery of instruction was not a substitute for traditional classroom instruction, particularly if the face-to-face classroom environment is available. However, satellite-delivered instruction is preferable to older modes of distance instruction. What typically works in a single classroom may fail miserably when transmitted via satellite or cable. An erroneous assumption is that television technologies create environments close enough to those of traditional classrooms that special training in their use is not necessary (Baker, 1994).

Baker (1994) reported that a review of the five major distance education journals and the ERIC database yielded 225 articles related to faculty issues. Of this number, only 24 dealt with instruction, and only 3 of these examined effective instructional strategies for interactive television. Four instructional strategies emerged from a study conducted by Keller (1994) as effective for all courses: using a variety of activities, promoting interaction between receiving sites, using visuals, and using effective presentation techniques. Important components of these strategies included adequate rates of speech and body movements by the instructor, visibility on the screen, and communicating directly with remote receiving sites for comments or question responses.

The planning and preparing of a distance learning course is facilitated if (1) approximately six months ahead, an instructional designer observes the instructor's traditional classes; examines content, objectives, and visuals that already exist; and brainstorms (with the instructor) additional visuals and course adaptations, and (2) approximately three months ahead, the instructor receives training in facets of distance learning; additional visuals are developed; and the instructor is provided practice in the distance classroom with the technical/production staff, and goes through a planning checklist. The planning checklist might include items such as the syllabus (adapting it for distance teaching), handouts, visuals (consider font size, color, and type of print; horizontal visual orientation; and blue paper color to reduce harsh contrasts between the paper and letters), copyright issues (obtain clearances for use of commercial videotapes, etc.), logistics, and instructional/evaluation planning.

Seven dimensions of the actual teaching process via distance learning technologies have been identified by Baker (1994): nonverbal "immediacy" behaviors, verbal "immediacy" behaviors, personalizing the class, technology management, feedback methods, management of student participation, and active learning strategies. These dimensions present a relatively comprehensive view of variables that can influence the type and amount of interaction that exists in an interactive television context. Except for technology management, none of these dimensions is unique to interactive television.

According to Baker (1994), immediacy refers to the degree of perceived warmth or closeness between people. Television is not typically perceived as being a warm medium. The more an instructor is sensitive to immediacy concerns, the warmer will be the students' perceptions of the course through the television medium. Nonverbal immediacy behaviors refer to such things as the amount of the instructor's body which can be seen on the screen (i.e. the camera shot), facial expressions, eye contact with the camera, and posture. Instructors using interactive television can improve the class "climate" by doing the following:

- Maintain a relaxed body posture.
- Use demonstrative facial expressions and gestures to communicate emotions.
- Choose a close-up camera view so facial expressions are visible and eye contact can be established and/or simulated.
- When talking, shift camera views back and forth between on-and off-campus students to establish eye contact with students.
- Lean slightly toward the camera when listening to remote-site students.
- Read the nonverbal behavior of students at the origination site.

Verbal immediacy behaviors include instructors' verbalizations, tone of voice, use of humor, personal examples or examples highly relevant to students, reinforcement and encouragement, and so forth. Baker (1994) suggested interactive television instructors should:

- Praise students' verbal contributions.
- Show genuine interest in student ideas and use those ideas.
- Introduce and use humor.
- Use friendly banter with students prior to class, while taking roll, during breaks, and so on.
- Choose many examples that are drawn from the instructor's own experiences.
- Choose many examples that are relevant to students' daily lives.
- Every ten to fifteen minutes, ask if there are any questions.
- Ask if there are any questions before moving on to a new topic.
- Make sure a student who asks a question hears the instructor's answer and understands it.
- Ask for student input into class processes, such as whether to continue or take a break.

The strategies instructors use to make the learning experience personal, relevant to students, and sensitive to individual student needs comprise the personalizing dimension. Such things as learning students' names and voices, use of get-acquainted activities, instructor availability (or access to him/her) by being on-line before and after class as well as during breaks (plus arrangements for out-of-class contacts), and instructor visits to receiving sites all contribute to the personalizing dimension (Baker, 1994).

Technology management components means the instructor can effectively switch video signals from site to site and/or from himself/herself to instructional materials and vice versa. Additionally, the instructor can make smooth and frequent camera view changes, connect two or more receiving sites together, and orient students on how to use the equipment at their sites (Baker, 1994). Simply knowing how to press the proper button in order to speak and be heard by the instructor can alleviate much student frustration. The instructor should:

- Use the technology to silently check on group progress during break-out sessions.
- Leave the camera view on the instructor to keep from shutting down the conversation or breaking momentum.
- Make sure everyone can hear and see the instructor.
- During the first week, train students how to participate, interrupt, and respond using the technology.
- Use an overhead camera to post directions, show time, an so on.
- Use an overhead camera to show quizzes, and so on during discussions about those quizzes.
- Switch the cameras to a site to call on students there to elicit participation, feedback, and so on.
- Handle technical glitches (eg. If audio is out for more than a few minutes, call the sites and have them discuss something in small groups until the system is on-line again).

Feedback methods have been of major concern to instructors, particularly those who depend upon student nonverbal reactions to guide them during their teaching (Baker, 1994). This becomes particularly problematic if there is not a student group at the site of origin. If two-way video linkages are avail·ble, the instructor can view students at each site to obtain nonverbal cues. Otherwise, instructors are largely limited to questioning and verbal and written student comments.

Management of student participation included inviting student contact, using verbal techniques to encourage reflection, providing frequent positive feedback, clarifying and summarizing student responses, establishing routines, and using directed questioning techniques. Student familiarity with norms and rules for the course is also important here (Baker, 1994).

The last dimension is active learning strategies. Changing the pace regularly, attention-getting strategies such as frequent changes in camera views, focusing student attention, student sharing, and so forth are important (Baker, 1994). Overall, students need to be actively engaged and need to experience frequent changes in focus or pacing. The instructor should:

- Use activities that demand student involvement other than the "sit and watch TV" approach.
- Change activities every ten to twenty minutes.
- Change monitor images every ten minutes or so.
- Use visuals that focus attention on content.
- Help remote site students locate print material that has been sent to their sites.

Staff Development and Teacher Inservice

No matter how excellent an inservice is, it can only be of benefit to teachers if they have access to it. Factors such as geography, scheduling, and availability of substitutes impact teacher opportunities to participate in inservice programs. In some locales, teachers have been faced with one to four hours of driving to reach an inservice location. Often, this must be accomplished over rough terrain or through inclement weather. Obstacles such as these deter teachers from participating in oft-needed inservice. One answer is to provide staff development programs at the teachers' schools or nearby locations through distance learning technologies. Distance learning technologies are today greatly expanding flexibility for delivery of inservices and courses, limited largely by the availability of a satellite receiving dish. Some satellite dishes which can be mounted on a window sill are now available for around $400 (Hixson & Jones, 1991).

In the past, teachers wanting to expand their knowledge of the latest science teaching techniques could either attend night courses at a college or university, enroll in summer school, or be lucky enough to have a series of science inservices conducted within their districts. Today, many more avenues exist through which teachers can attain these goals. Now, teachers can make use of a variety of distance learning technologies; satellite television, interactive teleconferencing, computer networks, and the like can provide a multitude of opportunities for educators. Schiller (1993) noted that distance learning approaches for staff development can be very cost-effective as well as timely. Ideally, these approaches can provide teachers new knowledge as well as laboratory and class activities; put them in touch with other science teachers and experts in the field; and allow them to do so at flexible times more convenient to their schedules.

Instructional ideas, materials, and strategies can be shared rather quickly using these media. Networking provides educators continuous access to new information, and can serve as pre- and post-inservice learning and reinforcement rather than limiting access to the one time a session is conducted. One example of a computer network useful for distance learning is NEA Online. The Public Broadcasting System offers staff development teleconferences in which participants interact with presenters via telephone. Mind Extension University offers staff development via cable television, with some courses utilizing computer bulletin board systems (Schiller, 1993). The Satellite Educational Resources Consortium, a multi-state collaborative comprised of state education agencies, local school districts, television stations, university educators and private industry, provides courses to students and inservices to teachers. Other delivery models which exist include publicly held corporate entities such as Wescott Communications (TI-IN Network) and others which are a combination of public and private partnerships such as Satellite Telecommunication Educational Programming (STEP).

Effective inservice programs designed to improve classroom teaching behaviors and practices include 1) clear and forceful conveyance of the rational for the practices to be shown, 2) modeling and demonstration of exemplary versions of techniques. 3) opportunities for teachers to practice the procedures demonstrated, and 4) provision for obtaining individual feedback and giving of guidance as needed (Fields, 1989). Successful and effective inservice can occur using distance learning technologies. Those designing distance learning inservice programs must consider ways of conveying information that are most efficient, innovative, and allow for the most flexibility. Perhaps one of the best uses of such approaches is to use distance delivery as a compliment to more traditional forms of inservice.

Types of Topics Appropriate to Meet Teacher Needs

The types of topics appropriate for use with distance learning are virtually the same as for more traditional forms of inservice. One key aspect, however, is to avoid producing what teachers have come to call the "talking heads" program, which is comprised of teachers sitting idly listening to one or more presenters on the television screen. Plans should be made to actively engage the viewers. In the initial airing of its *Science Alive!* series, Western Illinois University faculty produced background reading materials and activity handouts on selected science process skills in advance of program telecasts. These written materials were provided to teachers at multiple sites during the week prior to each program segment, allowing for materials to be collected for use during the telecast. In this case, care was taken to use simple, easily accessible materials and supplies commonly available in grocery or department stores. As teachers viewed each program, they were to work through the activities along with the faculty in the television studio. Other examples of topics suitable for distance learning inservice include exploring specific curricula, introducing new curricula or methods or strategies for science teaching, laboratory safety, special techniques, science related careers, resource identification and sharing, updates in science knowledge bases, learning from experts in the field, expansion on current research, new teaching standards, and so forth.

Need For Trained On-Site Facilitators

For courses or inservices involving significant laboratory components, logistics may become a problem through distance learning formats. First, the equipment, supplies and materials to be used at the source must be replicated and made available to each receiving site. These items must be at each site prior to program delivery. Second, most such approaches dictate that a facilitator be present at each site. The facilitator's role is multifaceted. Aside from being certain the distance learning hardware performs properly, site facilitators must be knowledgeable of the activities and laboratory exercises to be conducted. This necessitates advanced and separate training sessions between source faculty and site facilitators. Several such meetings throughout a single semester are necessary. Facilitators disseminate and retrieve materials, replace them as needed, and help coordinate the receiving and sending of materials to and from the source site. Additionally, site facilitators essentially serve as the eyes and hands of the source faculty when the programs are telecast. The need for duplicate equipment and materials, and for site facilitators, increases the costs involved in delivering laboratory-based science via distance learning technologies.

Teacher Certification Issues

University and college faculty are typically not concerned with teaching certification credentials when delivering courses or inservice programs via distance learning. For course credits, participants deal directly with universities and college registrars. However, if the courses or inservice programs are designed to help teachers become certified (or maintain certification) in specific subject areas within a state, those courses/programs must be acceptable to that state. Questions have arisen with respect to the acceptability of inservice originating in one state for another state's requirements (Hezel, 1991). Such concerns are usually alleviated on a case by case basis between the administrative state agency and the staff development/inservice originators.

A related concern of various states is whether site facilitators must be certified, not only in the subject being taught over the distance technology but also for the educational level (elementary, middle school, secondary, etc.). The states of Iowa and Washington require both of its distance learning facilitators, whereas Alaska and Oregon do not require facilitators to possess endorsement for specific subject matter (Schlosser & Anderson, 1993). "The necessity for current teaching certification for facilitators is directly affected by the way in which individual states interpret their policies governing the use of distance site facilitators. Training in effective distance practices may also be required depending upon the state" (Schlosser & Anderson, 1993, p. 39).

Being a Distance Learning Student

Does being a student who receives distance instruction require different skills than being a student in the traditional classroom? In many ways, the student skills needed in both situations are much the same. However, there are some particulars of which students must be aware if their distance learning experiences are to be successful. Some of these issues can be addressed directly by distance learning instructors, while students must take the initiative on others.

The student must learn and follow norms and rules for participation with distance learning. Typically, these norms are functions of past classroom experiences and the practices followed in specific types of classes (Baker, 1994). The students may be required to wait for the instructor to give some clues as to what is expected. For example, students will not speak unless spoken to, and rarely interrupt the instructor unless he/she actively encourages it. Very early into the first sessions of distance learning situations, it would be beneficial to all if instructor expectations are made explicit. Considering the limited time available for students to interact with instructors, plus the delays often entailed in interactions via distance learning technologies, students may need to be instructed to interrupt, ask questions, or add comments when not directly solicited by the instructor. Instructors cannot see every student at once at all remote sites. Hence, students must take the initiative to communicate with the instructor during class sessions rather than waiting for the instructor to call on them. Studies have indicated that student satisfaction with distance learning increases as their abilities and opportunities to interact increase (Beare, 1989; Jurasek, 1994; Ritchie & Newby, 1989). In the literature as a whole, conclusions are mixed as to the importance of interactivity to students, even though it has been demonstrated to be important for certain types of learning (Hackman & Walker, 1990; Keller, 1994; Palincsar & Brown, 1984; Webb, 1983).

Experiences related by distance learning instructors have also shown that some provision must be made to orient students regarding the distance learning experience (Moore, 1989). Besides the norms and rules mentioned earlier, students must understand how the technology operates so they can use it to interact with (or simply to receive the transmission from) the instructor. This may include some instruction in how to operate dedicated telephone lines, fax machines, and so forth. Accessibility to the distance learning instructor in other ways is important to students as well. Students need to know how to reach their instructors, even during nonclass times, through long distance telephone calls, electronic mail, etc. Some instructors are available on the interactive television for some period prior to and immediately following scheduled course times. Other instructors arrange for visits to each remote site throughout the course term, and sometimes rotate telecasting the course from each remote site. Overall, students must not feel isolated from the instructor.

Students must be made aware of methods for accessing materials out of class, such as through school media centers, print materials from computer network printers, local library resources, and so forth. In the same vein, instructors must plan for providing handouts and other pertinent materials for the students in a timely manner, preferably before class sessions begin. Similarly, students need to be informed as to what facilities are available to them and how they can be used. For example, some courses may require students to work in specific laboratory facilities. Such facilities may be in the same buildings as the receiving sites and others may be in different buildings. Times at which students may use these facilities, as well as identifying on-site personnel capable of providing help, should be arranged from the origination site and communicated to students (Schlosser & Anderson, 1993).

Baker (1994) offered a number of suggestions for students participating in distance learning. (1) Plan to arrive for class at least 15 minutes early to provide time to pick up handouts, returned tests, etc., and to be able to visit with the instructor. (2) Be assertive. Students having questions or other input during class must voice them and not remain passive and quiet. Students should tell the instructor if images on the monitor are too small, are blurry, or difficult to see. Print on monitors is particularly susceptible to such problems. (3) Sit near the microphone and the television monitor. This proximity aids in focusing on the instructor and course material, aids the instructor in hearing student questions and comments, and helps students hear better. (4) Be aware of any home-TV-viewing habits that may be interfering with the distance learning experience. While at home, many people do other things (eating, sewing, chatting with others, etc.) while the TV is on. Students must be fully attentive and focused. (5) Use the methods suggested in the syllabus for contacting the instructor outside of class. The instructor has probably considered what are the most likely avenues through which he/she can be contacted and what times those avenues can be employed. Attempting other routes and times may meet with little limited success due to the instructor's other commitments and schedule. (6) When turning in papers and assignments, the student should be sure his/her name, the instructor's name, site location, and class title appear on each page. In addition, the student should make a second copy to keep as a backup. (7) Students should be honest and open when asked to share experiences. (8) Students should learn how to operate the equipment (such as which button to push in order to speak to the instructor).

Support Staff for Delivery of Distance Learning Instruction

Successfully carrying out distance learning efforts requires the knowledge and talents of many individuals working cooperatively. In foregoing sections of this chapter, the roles of several such individuals were noted: teachers, students, and facilitators. In addition, clerical and technical personnel are essential to an effective, efficient enterprise. Clerical personnel deal with student enrollment, registration, and tuition (where appropriate); process requests for rooms and equipment; and assist in the production of course handouts/materials, to name a few. Technical personnel work with the hardware and software required to deliver instruction and receive student responses. Their tasks might include accessing satellite transponders; repairing, maintaining, and/or upgrading equipment; editing video segments; insuring remote sites are linked and on-line with the origination site; etc. The specific technical personnel required may vary with the mode of distance learning. For example, satellite courses may require an instructional designer, a producer and director, set designers and builders, a graphic artist, and a production crew (camera operators, floor directors, audio technician, remote-site coordinators, and engineers), whereas compressed video courses may only require an instructional designer, a producer, a production crew, and a graphics/video consultant.

The importance of having good support staff available is underscored by McGreal and Simand (1992) who noted that grouping three or more schools/sites together for distance learning courses increased the difficulties exponentially. When problems occur, students' feelings of separation/isolation may become heightened (Schlosser & Anderson, 1993).

Direct Instruction Courses

The number and variety of direct instruction courses offered over distance learning media have mushroomed over the past half decade. Keeping that in mind, one should be cautioned that there are no national guidelines or articulated standards for academic courses taught via distance learning technologies (Miller, 1991). Distance learning courses should focus primarily on the learning to take place, not on the technology used to deliver it (Miller, 1991). Technology should not be used to simply replicate what is already being done (new technology, same old lessons) rather than using it to do what cannot be done in a more traditional classroom or setting.

Some issues surrounding distance learning are more pertinent to certain sectors of the education community than are others. One such case is the teaching of precollege students. As noted elsewhere in this chapter, states have legitimate concerns as to whether the person teaching a course via television has met, or can meet, their particular certification requirements. Certain states have reciprocal agreements with regard to certification, and these can be used to alleviate such problems. For college level courses, intellectual property rights of faculty may become issues, as may royalties (Hezel, 1991; Miller, 1991).

Direct instruction courses offer a milieu of topics for students, many of which cannot be offered by the individual schools receiving the courses. Examples commonly cited are physics, calculus, and foreign languages. Individual schools may need to adjust students' schedules to match those of the courses, and may also need to provide for on-site facilitators (typically certified teachers).

Matching the Methodology With Available Technology

As has already been alluded to in this chapter, the primary focus of distance technologies should be on the course content (including methodology) rather than on the technology. Most teaching methods can be used with virtually any distance learning technology.

Student and Teacher Enrichment

The use of distance technology vastly expands the ways in which the curriculum can be enriched. Students and teachers can be taken to places never before possible. They can visit with experts and other students or teachers to learn more about science. They can explore careers and ways of thinking which were at one time difficult to access. Enrichment programs can be used interactively, such as the National Geographic Society's KIDS NET in which students investigate and share information (via computer network) about acid rain with other students and scientists across the nation. Other examples are Western Illinois University's *Career Vision* and *Science Alive!* series. Such programs can be videotaped by teachers and used for their own or their students' enrichment at a later time.

Adjustment of School Structure

Those who plan to develop and deliver courses via distance technologies will confront a variety of hurdles particular to the way schools are structured. For example, the bell schedule in one school may be poorly matched to that at the source site. Similarly, if several schools are each receiving the distance learning course, the likelihood of having matching bell schedules decreases dramatically. To compensate, schools participating in distance learning must be flexible in allowing students to attend distance courses without being penalized for missing portions of "regularly scheduled" classes. It is both unlikely and unreasonable to assume schools will be able to adjust their entire daily schedules to facilitate a few distance learning courses because their schedules are designed to accommodate many factors, such as bus route travel, state attendance requirements, etc. Such difficulties will present themselves regardless of whether the technology employed is satellite based or earth based. In our experiences with advanced placement courses via distance technologies, conflicting bell schedules have proven to be almost more problematic than have teacher certification issues. Other factors to consider include school calendars (teacher inservice days, holidays, assemblies, etc.), weather (snow days, etc.), and so forth.

Equipment Components in Distance Learning Education

Anyone who has dealt with video cassette recorders (VCRs), personal computers, or other technology can relate to the speed at which equipment and hardware undergoes change. Equipment capabilities and sophistication improve at rates making it difficult to have the technology operational before it is obsolete. The particular level of sophistication of the equipment required for a distance learning enterprise depends upon the chosen delivery method (eg. satellite TV, fiber optics, etc.) and perhaps on the type of system to which one subscribes (Schlosser and Anderson, 1993). However, one should first assess the needs, then select the technology based on those identified needs. Further, teachers should have opportunities to provide input about what technology is purchased, how it is implemented and how it is to be used. Typically, the teachers who must deal with technology during the teaching process are excluded from such fundamental decisions.

Educational readiness to begin using distance learning delivery systems is a question facing many educators at the building and district level. In looking at distance learning as an educational alternative, educators are faced with several key questions. These fall chiefly into three categories: (1) program need or purpose, (2) resource assessment at the school (human resources, facilities, and equipment); and (3) selecting a distance learning technology system. Listed below are a series of questions, that will help school educators assess their readiness for distance learning as a part of their instructional program and the direction they should take in implementing distance learning at their school.

Program Need or Purpose

- Why does the school need a distance learning program? Is the purpose to provide elementary school enhancement, expand secondary curriculum offerings, offer staff development, provide community programs, etc.? Educators should identify their specific distance learning programming needs. As an example, most national providers (satellite vendors, some cable vendors, etc.) focus chiefly on providing advanced placement or advance level high school courses for college students. Others provide extensive enrichment or enhancement programs for elementary school students. Others might have a large array of staff development programs. In any event, educators must first determine exactly why they want to invest in distance learning at their school.
- Should programming be locally controlled or purchased from a national provider? Compressed video, fiber optic, small cable networks, or computer-networked systems (audiographics) might be locally controlled by a small number of schools joined in a cooperative effort to share resources, control programming, and manage the cooperative network. National providers of distance education programs are chiefly satellite based. They typically provide a "turn-key" operation, offering an extensive array of program offerings and services to subscribing schools.

Resource Assessment at the School

- Staffing: What kind of staffing is available to work with the distance learning program adopted by the school? A turn-key program (eg. satellite, large cable network) will require limited if any additional staffing needs, whereas a locally controlled system (eg. audiographics, compressed video, or fiber optic network) will typically require extensive administrative effort to work with participating schools, hire distance learning teachers, maintain and troubleshoot technical problems associated with the system, maintain record keeping, etc.
- Room Space and Power: Where will the distance education room(s) be located; are there sufficient power outlets in the room? An adequate room is needed for those students who will be taking distance learning courses and for the equipment items which will be part of the technology delivery system. Sufficient electrical outlets are needed for equipment items associated with distance learning such as televisions, VCRs, computers, printers, facsimile machines, etc. Furthermore, room security should be considered. The distance learning room will usually house expensive computer and/or telecommunications equipment.
- Telecommunications Connections: Does the room include video, telephone inputs, or other telecommunications connections? Facsimile machines and computer modems operate on a direct telephone line which does not go through a switchboard. Satellite and cable programs require a video cable connection. Fiber optic and compressed video systems require specialized fiber, ISDN, T1, Switch 56, or DS3 lines.
- What technologies/facilities are currently available for distance learning? Besides power outlets and telecommunications connections for the distance learning room, administrators should assess availability of equipment items which could be dedicated to the distance learning room. Items might include a television, telephone, facsimile machine, computer, modem, VCR , etc.

Selecting a Distance Learning Technology System

What kind of program delivery is desired at the school? The technologies used in distance learning offer a variety of program formats. Satellite, cable, microwave and ITFS (Instructional Television Fixed Services) systems are typically one-way video, two-way audio. Fiber optics and compressed video are typically two-way video, two-way audio; and audiographic or computer-linked networks are usually two-way computer conferencing with audio interaction. Equipment and transmission costs vary widely depending on the system chosen. The cost of installation, equipment, and transmission of fiber optics, compressed video, microwave, or ITFS systems can be high. Without help from external funding sources (grants, foundations, etc.) or legislative initiative, such systems have remained cost prohibitive for a large number of rural schools. A satellite downlink dish and video equipment to receive the TV signal has proven affordable for many rural schools. The same has been true in regards to cable TV systems. The cost of installing and operating an audiographic system is typically limited to the cost of a standard computer, specialized program software, purchase of a facsimile machine, and access to a direct telephone line.

Once a distance learning delivery system has been selected, educators will need to determine what equipment items (not already owned by the school) should be acquired. In addition, electrical wiring, video and telecommunications connection needs, and room modifications should be considered. Deciding on the system that best meets local needs or falls within budgetary limits may not be as simple and as one might think. See Table 2 for brief explanations of the more common distance learning technologies currently being used in the United States. These are presented to help inform educators of the specific equipment, cabling, and connections requirements associated with each system; and to help educators assess which syste is best suited for their school's needs.

Interactive Satellite Systems

Interactive satellite systems currently utilize C Band and/or Ku Band frequencies. Although most current systems are analog based, providers are increasingly turning to digital compression technology as a means to improve signal quality and reduce delivery costs. This is occurring even though there are very few digital receivers available at present and the fact that digital reception does not lend itself to steerable multi-purpose receive dishes. Major satellite providers are Westcott Telecommunications TI-IN Network, Dallas, Texas; Satellite Telecommunications Educational Programming (STEP), Spokane, Washington; Arts and Sciences Teleconferencing Service (ASTS), Stillwater, Oklahoma; and Satellite Education Resources Consortium (SERC), Columbia, South Carolina.

- *Format:* (Half-Duplex) one-way video, two-way audio (return audio via telephone), two-way data (some providers).
- *Basic Equipment:* Satellite receiver (C and/or Ku Band), satellite receive dish (steerable), coaxial cabling, television monitor, telephone and circuit.
- *Enhanced System*: Digital receiver (if required by program provider), VCR, facsimile machine, computer and modem, large screen television.
- *Special Considerations*: Programming source and costs, scheduling, placement of receive dish, reception (based on geographic location), equipment security (receive dish), equipment and liability insurance. Most of the current satellite providers are large centralized systems which provide turn-key services to subscribing schools.
- *Site Considerations*: Does the school or community have an existing satellite receiver and dish; location? Does the local cable system have downlink capability and interconnections to schools? Do schools have internal cabling for delivery to individual rooms; television monitors and VCRs for multiple use?

Cable Television Systems

Cable television systems have been technologically available for some time. The recent scrutiny of the cable industry by both regulators and users has enhanced cable television's viability as a delivery mechanism. The most visible current example of a cable television system is Mind Extension University (MEU). The most viable current use of cable television systems may be to receive and redistribute interactive satellite programming (TI-IN, STEP, ASTS, SERC, etc.) via cable to schools in urban and/or rural areas served by a cable carrier. Another potential for many users is represented by the existence of local access channels and studios maintained by some community cable companies.

Table 2
Distance Learning Technologies

Technology	Format	Basic Equipment	Typical Applications	Special Considerations
Interactive Satellite	One way full-motion video, two-way audio	Downlink dish, coaxial cabling, TV monitor, telephone and circuit	High school credit courses, elementary enrichment, teacher inservice, college credit	Large systems; centrally controlled; telecasting to multiple states
Cable Television	One way full-motion video, two-way audio	Cable access, coaxial cabling, TV monitor, telephone and circuit	High school credit courses, elementary enrichment, teacher inservice, college credit	Typically regional or state networks, centrally controlled
Microwave television	Two-way full-motion video, two-way audio	Tower, transmitters, receivers, cameras, microphones, coaxial cabling, TV monitors	High school credit courses, elementary enrichment, teacher inservice, perhaps some college credit	Usually located in large cities; microwave signal beamed 20-40 mile range and is line-of-site; centrally controlled; FCC licensure required
Instructional Television Fixed Service	One-way full motion video, two-way audio	Tower, transmitter, receiver, antenna, coaxial cabling, TV monitor	High school credit courses, elementary enrichment, teacher inservice	Broadcast signal is line-of-sight and does not carry over long distances; FCC licensure required; typically regionally controlled
Compressed Television	Two-way compressed video, two-way audio	CODEC unit; cameras, microphones, TV monitor, fiber optic, T1 or DS-3 circuits	High school credit courses, elementary enrichment, teacher inservice, college credit, teleconferencing	Cost of monthly line charges can be high; systems are typically locally controlled; network members are usually small in number
Audiographics	Two-way computer conferencing; two way audio	MS-DOS or Macintosh computer, modem, printer, facsimile machine, speaker telephone; two telephone circuits	High school credit courses, limited elementary enrichment, limited teacher inservice	Low cost; typically small cooperatives of two or more schools; locally controlled

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These public access channels allow for local production and transmission to the school and community. Future trends include the movement by cable companies into both partnerships and competition with telephone companies which will eventually open more possibilities.

- *Format*: (Half-Duplex) one-way full-motion video, two-way audio (return audio via telephone), two-way data (some providers).
- *Basic Equipment*: Cable access (control box), coaxial cabling, television monitor,telephone and circuit. Local program origination would require a local access channel and broadcast equipment (cameras, etc.).
- *Enhanced System*: VCR, facsimile machine, computer and modem, large screen television.
- *Special Considerations*: Programming sources and costs; the only current truly cable-based service is Mind Extension University which is primarily for college level and is not live nor interactive. However, cable systems can and are carrying programming from K-12 interactive satellite providers. Most networks are centrally controlled, providing turn-key service to subscribing schools.
- *Site Considerations*: Does the commercial cable system and school district have a current or existing relationship (dedicated channel)? Does the local cable system have downlink capability and interconnections to schools? Do schools have internal cabling for delivery to individual rooms; television monitors and VCRs for multiple use?

Microwave Systems

Microwave systems have been in existence for some time and in many cases, particularly with recent digital enhancements, continue to be viable. It should be noted that microwave systems require substantial investments in engineering, equipment, licensing, and operation. However, there are many microwave delivery systems currently in operation and often the investment required to access an already functional system is minimal. Microwave signals have a range of 20- 40 miles with most systems centralized in large urban centers.

- *Format*: (Full-Duplex) two-way full-motion video, two-way audio, two-way data (some providers).
- *Basic Equipment*: Transmitter/receiver tower(s), transmitters, receivers, cameras, microphones, coaxial cabling, and television monitors. In addition to basic equipment, Federal Communications Commission (FCC)licensing is required.
- *Enhanced System*: Digital transmitter/receiver, VCR, facsimile machine, computer and modem, large screen television.
- *Special Considerations*: Cost is a prime concern. Microwave systems require towers for both transmission and reception as well as extensive equipment investments. The operation of these systems requires an FCC license and an FCC licensed operator. Systems are usually centrally controlled at a regional or large district level.
- *Site Considerations*: Are there any microwave-based systems in operation within 40 radius? These systems need not be video systems. Microwave systems might include telephone systems, gas and oil pumping companies, cable companies, government or military systems. Do schools have internal cabling for delivery to individual rooms; television monitors and VCRs for multiple use?

Instructional Television Fixed Service (ITFS) Systems

Instructional Television Fixed Service is actually a variation of commercial broadcast television that is specifically allocated and licensed by the Federal Communications Commission. Utilizing a fairly narrow broadcast frequency and low power transmission, ITFS has been utilized for many years and there are a number of systems in operation. ITFS has recently gained the attention of both potential educational users and regulators as a result of the efforts and activities of rural cable television entrepreneurs (Rural Vision, etc.).

Throughout rural America, cable companies have attempted to form partnerships with school districts utilizing their exclusive access to ITFS frequencies to deliver both commercial and educational programming. The FCC has considered these partnerships on a case by case basis and granted approval of a sizable number for operation.

- *Format*: (Half-Duplex) one-way full-motion video, two-way audio (return audio via telephone), two-way data (some providers).
- *Basic Equipment*: Transmitter and tower, receivers and antennas, satellite receive system (for rebroadcast) coaxial cabling, and television monitors. In addition, FCC licensing is required.
- *Enhanced System*: Cameras, microphones, VCR, facsimile machine, computer and modem, large screen television.
- *Special Considerations*: Cost is a prime concern. ITFS systems require towers for transmission and special receivers and antennas for reception as well as extensive equipment investments. The operation of these systems require an FCC license and an FCC licensed operator. Most systems are centrally controlled either by a large district or central region.
- *Site Considerations*: Are there any towers available locally? These towers need not be dedicated television broadcast towers. Educators must determine distance between potential sites and evaluate potential transmission range based on topography. Do participating schools have internal cabling for delivery to individual rooms; television monitors and VCRs for multiple use?

Compressed Television Systems

One of the most exciting and perhaps least understood developments in the field of distance education is compressed digital television. Generally these systems are digital transmission over terrestrial telephone circuits (either fiber optic or copper). It is a misconception that compressed digital video (television) can only be transmitted via fiber optic circuits or fiber optic lines. Compressed video systems require the transmission of a large amount of data and thus require a fairly large amount of circuit capacity (often referred to as bandwidth) whether fiber or copper. Recent advances in the technology have allowed video transmission over increasingly less circuit capacity or bandwidth. Increasing access to fiber optic circuits has also begun to drive down costs for operation. Most compressed TV systems are cooperative networks of anywhere from two to 10 or more schools linked together. An audio/video bridge is needed whenever three or more schools are linked together for simultaneous audio/video interaction.

- *Format*: (Full-Duplex) two-way compressed video, two-way audio, two-way data (some providers).
- Basic Equipment: CODEC (Compression/ Decompression Transmitter/ Receiver), cameras, microphones, television monitors, access to high capacity telephone circuits (384 kilobits per second minimum up to DS3 capability).
- *Enhanced System*: Remote controlled cameras, microphones, VCR, facsimile machine, computer, large screen television, and an audio/video bridge if more than two schools are linked to the network.
- *Special Considerations*: Cost is a prime concern. Currently CODEC prices are declining and many equipment vendors offer integrated systems containing cameras, microphones, monitors, and computer interfaces. However, classrooms must still be modified and have access to high capacity telephone circuits. Perhaps the most costly component is the recurring monthly expense of these telephone circuits. These costs vary according to the circuit capacity and distance covered. Ultimately circuit capacity determines the quality of transmission and thus it may be desirable to sacrifice a small degree of picture quality to lower operating costs. Most systems are

small cooperatives locally controlled by participating members.

- *Local Considerations*: Careful study of local telephone systems which includes availability and quality of switching and bandwidth (ISDN, T1, Switch 56, DS3, etc.). Also attention should be given to number of local service providers involved as well as long lines carriers and the location of their POP (Point of Presence). Because of FCC/ICC regulations it will be necessary to check LATA (Local Access and Transport Area) lines as well as tariff rates for service.

Internet Computer Network

Among the fastest growing distance education media is the Internet. The Internet is a network of computer networks that joins many government and university networks, as well as a growing number of private networks, together over telephone lines (mostly T-1s, but increasingly dial-up 56 Kbps). The network was initially set up in 1969 as part of the Department of Defense's data communications network, and has grown to encompass over 20 million users in 133 countries by conservative estimates (Estrada, 1993; Pawloski, 1994). The Internet Network now includes NSFnet (National Science Foundation) as well as other special interest networks, bulletin boards, and databases and is in part managed through subsidies from the National Science Foundation. However, no one individual or group manages or controls the Internet. It is a decentralized collection of computer networks managed by separate groups who have agreed to a common set of technical standards or protocols which connect and interconnect their individual networks to one another for information sharing. The Internet Society estimates that this "mother of all computer networks" links more than 30,000 computer networks into one global network, and that it is experiencing a 10 percent growth rate in number of users each month. Composition of the Internet is estimated at 55% commercial networks, 35% educational networks, and 10% government networks (The Internet Society, 1994).

Because of its global scope the Internet has emerged as a potential major force in distance education. However, the potential of the Internet as a distance education medium is still largely undefined as far as an organized or centralized effort. Still, because of its sheer size and reach combined with its educational resource and information base, it has immense potential.

- *Format*: (Full-Duplex/Half-Duplex) two-way fixed image video exchange, two-way data exchange. Some use of compressed video packets.
- *Basic Equipment*: MS-DOS or Macintosh computer: telecommunications software, computer modem, printer, access to direct telephone lines for computers.
- *Enhanced System:* LCD panel and overhead projector for enlarged projection of computer screen.
- *Special Considerations*: The Internet lends itself to small group or individualized instruction. Inasmuch as the computer screen is the visual medium, class size at each site is typically limited to no more than four or five students. Control of the system/network can be maintained by the schools which partner together. However control can be a problem. Most systems require at least one outside phone line per user and dedicated phone lines for heavier use.
- *Local Considerations*: Careful study of local telephone system. It is essential to find the best vehicle into the Internet. For heavy users a dedicated T-1 line into the system might make economic sense. It is important to understand that even though there are many public and private networks offering varying degrees of access to the Internet, it is not free and indeed can be just as expensive as more conventional distance education technologies.

Audiographics Public Switched Telephone Network (PSTN)

Audiographics technology links microcomputers between school sites. The image on the computer screens whether text or graphics is seen on each machine simultaneously. Audio interaction is usually via speaker telephone thereby leaving the hands free to operate the computer. Neither students nor the teacher can see each other, but they do share a common visual reference on the computer screen and can speak freely in real-time. This technique has been a popular low-cost approach for working with very small groups. As compressed technologies become more advanced and economical, it is expected that telephonic applications with small cameras at each site will permit compressed video interaction in real-time between participating sites.

- *Format*: (Full-Duplex) two-way fixed image video exchange, two- way audio, two-way data exchange.
- *Basic Equipment*: MS-DOS or Macintosh computer; audiographics/telecommunications software, computer modem, printer, facsimile machine, access to direct telephone lines for computers, speaker telephones, and facsimile machines.
- *Enhanced System*: Video telephones, LCD panel and overhead projector for enlarged projection of computer screen, an audio bridge to link three or more sites together, video cameras and telephonic software.
- *Special Considerations*: Audiographics networks lend themselves to small cooperatives of two to four or five schools linked together to share courses. Inasmuch as the computer screen is the visual medium, class size at each site is typically limited to no more than four or five students. Control of the system/ network is maintained by the schools which partner together. Most systems require two direct telephone lines—one for the computers to "talk" to each other and one for the speaker telephones at each site.
- *Local Considerations*: Careful study of local telephone system. This study should include availability and quality of switching and bandwidth (ISDN, T1, Switch 56, DS3 etc.). Also attention should be given to the number of local service providers involved, as well as long lines carriers and the location of their local POP (Point of Presence).

Obtaining Additional Information

Distance learning, a relatively new concept for many rural schools only a few years ago, is now regarded as not only an acceptable, but indeed a desirable means to deliver instruction to students in remote or isolated locations. In rural schools, this approach to learning has helped broaden educational opportunities for students and increased staff development options for teachers. The information presented has been directed to school educators and administrators who are interested in adding distance learning as a part of their school's instructional program. The intent has been to pose questions and present options that might promote thinking and discussion among decision makers. Decisions on what kind of technology system to install or national provider to contract should be made only after gathering input from other key players who would be part of the network and after conducting a thorough investigation of what best meets local needs and budgetary guidelines. Educational technology specialists at the state level should be knowledgeable about specific technologies, their costs, and their potential for local use. Furthermore, specialists at the state level should have names and addresses of successful on-going projects that might be contacted or visited in order to gain added insights. They should also have the names of program providers at both the national and regional level who might be contacted for more information.

Rural School Science and Distance Learning: Implications

One of the more obvious implications of using distance learning technologies for teaching rural school science is that geographic isolation becomes less of a barrier to students' educational advancement. Science courses, once unavailable to rural students, can now be provided in helping to prepare them for future pursuits. Both science students and teachers can have access to a wealth of data, information, and ideas through databases and/or contacts with distant instructors and colleagues. Students (and their teachers) can become an interacting community of learners rather than each functioning as an isolated pocket. Using distance learning technologies to deliver science courses becomes cost effective when considered systemwide. What is prohibitive for single schools with three or four students in a class becomes possible for a handful of schools with a total of fifteen or more students taking the same course. Separate schools can each contribute a fraction of the cost for a teacher's expertise and yet derive full benefits of that teacher's time with respect to course delivery. In some cases, equipment and/or service costs can be shared as well. Rural schools, like almost any school, will have additional demands placed upon them as they delve into distance learning. They may find they must invest more in laboratory equipment and supplies to support courses which were not offered in the past. Site facilitators may need hiring and training, particularly for laboratory-based courses. Additional funds may be required for distance technology equipment, service, and maintenance. Temptations will arise to shift monies from science instructional lines to equipment lines. Such thinking should be carefully monitored, particularly in tough economic times. Flexibility in scheduling students' class days will be necessary, allowing students to attend distance learning courses in their entireties as well as meeting the demands of on-site classes. Access is the key. Through distance learning technologies, rural teachers and their students have access to the world of science beyond what were once isolated science curricula scattered among rural schools.

References

American Association for the Advancement of Science (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

Augenblick, J., & Nachtigal, P.M. (1985, August). *Equity in rural school finance*. Paper presented at the National Rural Education Forum, Kansas City, MO.

Baird, W.E., Prather, J.P., Finson, K.D, & Oliver, J.S. (1994). Comparison of perceptions among rural vs. non-rural secondary science teachers: A multi-state survey. In Press: *Science Education*.

Baker, M.H. (1994). *Distance teaching with interactive television: Strategies that promote interaction with remote-site students*. Unpublished doctoral dissertation, The University of Iowa, Iowa City, IA.

Barker, B. (1985). Curricular offerings in small and large high schools: How broad is the disparity? *Research in Rural Education*, *3* (1), 35-38.

Barker, B.O. (1993). *Issues and suggested strategies for working with faculty in distance education delivery systems*. Discussion paper for the Higher Education Technology Task Force, Springfield, IL: Illinois Board of Higher Education.

Barker, B.O., & Platten, M.R. (1988). Student perceptions on the effectiveness of college credit courses taught via satellite. *The American Journal of Distance Education*, *2* (2), 44-50.

Beare, P.L. (1989). The comparative effectiveness of videotape, audiotape, and telecture in delivering continuing teacher education. *The American Journal of Distance Education*, *3* (2), 57-66.

Buckland, M., & Dye, C. M. (1991). *The development of electronic distance education delivery systems in the United States. Recurring and emerging themes in history and philosophy of education.* (ERIC Document Reproduction Service No. 345 713)

Davis, J. (1987). Rurality and isolation in education. *The Rural Educator*, *9* (1), 1-13.

Estrada, S. (1994). *Connecting to the INTERNET*. Sebastopol, California: O'Reilly & Associates Inc.

Fields, B.A. (1989). Minimal intervention in-service teacher education: A strategy for training teachers at a distance. *Distance Education*, *10* (2), 184-195.

Finson, K.D., & Beaver, J.B. (1990). Rural science teacher preparation: A re-examination of an important component of the educational system. *Journal of Science Teacher Education*, *1* (3), 46-48.

Grinvalsky, D. (1990, August). *Echoes from the future: Challenges for new learning systems*. Proceedings of the 6th Annual Conference on Distance Teaching and Learning, Madison, WI.

Hackman, M.A., & Walker, K.B. (1990). Instructional communication in the televised classroom: The effects of system design and teacher immediacy on student learning and satisfaction. *Communication Education*, *39* (3), 196-206.

Hezel, R.T. (1991). Statewide planning for telecommunications in education: Some trends and issues. *Tech Trends*, *36* (5), 17-20.

Hixon, J. & Jones, B.F. (1991, May). Using technology to support professional development for teachers and administrators. In A. Sheekey (Ed.), *Education Policy and Telecommunications Technologies*.

Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement.

Holmberg, B. (1986). *Growth and structure of distance education.* London: Routledge.

Horn, J.G. (1985, August). *Recruitment and preparation of quality teachers for rural schools.* Paper presented at the National Rural Education Forum, Kansas City, MO.

Hoyt, M.A. (1981). *Preservice/inservice training options for rural school personnel. Rural Education Fact Sheet.* Las Cruces, NM: ERIC Clearinghouse on Rural Education and Small Schools. (ERIC Document Reproduction Service No. ED 232 797)

Internet Society, 1994. *About Internet.* An information sheet provided at the Mining "The Net" Conference held in Des Moines, Iowa, July 13, 1994. Also available via O'Reilly & Associates, Inc. (email: ibox@ora.com)

Jess, J.D. (1985, August). *Local leadership and quality rural education.* Paper presented at the National Rural Education Forum, Kansas City, MO.

Johnson, J.K. (1988). *Attitudes of high school students in small rural schools toward interactive satellite instruction.* Unpublished masters thesis, Iowa State University, Ames, IA.

Jurasek, K.A. (1994, February). *Distance education via compressed video: An evaluation of the attitudes and perceptions of students and instructors.* Paper presented at the meeting of the Association of Educational Communications and Technology, Nashville, TN.

Keller, B.H. (1994). *Instructional strategies for effective two-way video distance education: An exploratory study.* Paper presented at a meeting of the Association of Educational Communications and Technology, Nashville, TN.

Martin, W.H. (1983). Student achievement in rural schools: A view from the national assessment data. In J. Fletcher (Ed.). *Rural education: A national perspective.* International Dialogue Press.

McGreal, R., & Simand, B. (1992). Problems in introducing distance education into northern Ontario secondary schools. *The American Journal of Distance Education, 6* (1), 51-78.

Moore, M.G. (1989). *Effects of distance learning: A summary of the literature.* Report prepared for the Office of Technology Assessment, Congress of the United States.

Miller, I. (1991, March). MECT: Creating the infrastructure. *The Annals of the American Academy of Political and Social Science, 514,* 92-106.

National Science Teachers Association. (1992). *Scope, sequence and coordination of secondary school science.* Washington, D.C.: Author.

Palincsar, A., & Brown, A. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*, 117-175.

Ritchie, H., & Newby, T.J. (1989). Classroom lecture/discussion vs.. live televised instruction: A comparison of effects on student performance, attitude, and interaction. *The American Journal of Distance Education, 3,* 36-45.

Rose, S.N. (1991). Collegiate-based noncredit courses. In B.B. Watkins & S.J. Wright (eds.). *The foundations of American distance education* (pp 67-92). Dubuque, IA: Kendall/Hunt.

Schiller, S.S. (1993, November/December). Multimedia equipment for distance education. *Media & Methods,* 33-37.

Schlosser, C., & Anderson, M. (1993). *Distance education: Review of the literature.* Research Institute for Studies in Education, Iowa State University, Ames, IA.

Schmidt, B.J. & Faulkner, S.L. (1989). Staff development through distance education. *Journal of Staff Development, 10* (4), 2-7.

U.S. Congress, Office of Technology Assessment (1989). *Linking for learning: A new course for education.* (OTA-SET-430). Washington, D.C.: U.S. Government Printing Office.

Watkins, B.L. (1991). A quite radical idea: The invention and elaboration of collegiate correspondence study. In B.B. Watkins & S.J. Wright (eds.). *The foundations of American distance education* (pp 1-35). Dubuque, IA: Kendall/Hunt.

Webb, N.M. (1983). Predicting learning from student interaction: Defining the interaction variables. *Educational Psychologist, 18* (1), 33-41.

Weiss, I. (1987). *Report of the 1985-86 National survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute.

Welch, W. W., & Wagner, T.G. (1988). *Science education in rural America.* Elmhurst, IL: North Central Regional Educational Laboratory.

Chapter 9
Political Ramifications.for Rural Science Education in the Twenty-first Century

Paul M. Nachtigal

Predicting the political ramifications for rural science education in the 21st Century is certainly not a scientific process, particularly in these times of political volatility. The future is not predestined based on the continued trend-lines of the past. For politics and science education are human endeavors subject to an ongoing series of personal decisions. Thus there is room for speculation, some wishful thinking and, in fact, an obligation on the part of this writer and you the readers to help shape the nature of rural science in the next century and the political decisions related to this enterprise. To set the stage for one possible scenario we begin with four myths followed by a brief look at political action and its impact on science education in the recent past.

Myths

Myth #1. Once upon a time education was perceived to be above the fray of politics. The process of schooling was a 'sacred' endeavor, the domain and responsibility of educators who were apolitical, interested only in furthering the well-being and intellectual growth of their students. What was taught and how it was taught was simply a matter of keeping in tune with perceived needs and desires of the local community.

Myth #2. Science is science, objective knowledge based on scientific principles, not subject to the values of ideologies or responsive to the interests of political agenda.

Myth #3. Because the national constitution is silent on the issue of public education, it is a state responsibility, a responsibility which in turn has been delegated to local communities and local school boards. And, while there are school board elections and bond issues to be voted on, these are non-partisan issues decided only on merit of how to provide the best possible education for the community's young people. Politics at the national, state or local level has little, if any thing, to do with science education.

Myth #4. Good science education is good science education regardless of the context within which it is taught be it rural, urban, or suburban communities. There is, in America, one-best-system of education and it is a generic process equally appropriate for students regardless of their abilities, interests, or place of residence.

The Reality

Whether or not these myths were ever true, the reality is that politics permeates education, particularly math and science. It reached into every school in the country with the launching of Sputnik in 1957. The cold war was raging and America had been embarrassed by Russia's launching of the first satellite. We were behind in the space race, education had not prepared a sufficient number of engineers and scientists. Federal legislation followed that provided funds for staff training and new curriculum. In the late 50s, the nation's politicians enlisted public schools in the security interests of the country by passing the National Defense Education Act. It, too, pumped additional resources into the teaching of math and science, and through the development of the BSCS, ESS, and all the other 'alphabet' science curricula, began reshaping how science was taught across the country.

With the winding down of the cold war, competition on the military playing field no longer justified political involvement in education at the national level. The nation, however, was found to be at-risk for becoming unable to compete in the arena of international economic competition. Thus, we now have the latest call-to-arms for the reform of public education, the response to the politically inspired report, A Nation at Risk, in which improved math and science occupy center stage. This report served to place public education on the political agenda at both the national and state level. Governors participated in the first ever "summit meeting" on education called by the president and then returned to their states to push for reform legislation. This latest politicization of education is notable in that comparatively speaking, it is long on directions and short on funding. However, movement toward a national curriculum was now gaining momentum, shaped in large part by political expediency. The specifics of this national curriculum included the development of national guidelines of what should be taught and how, 2061, Science for All Americans and standards or benchmarks for levels of achievement. America is now "... to be first in the world in math and science by the year 2000". This national goal is to be achieved with the aid and direction of federally funded programs including State Systemic Initiatives, Urban Systemic Initiatives, Rural Systemic Initiatives and a network of Eisenhower Mathematics and Science Regional Consortia and Demonstration Sites.

While momentum has been building for this national agenda, not all has been harmonious in the political life of the country. A very well organized and vocal group of fundamentalists and proponents of the political far right have been actively pursuing their own agenda. "Creationism" should be offered as an alternative to evolution. "Out-comes based education", somehow related to, but not quite the same as, "standards" has become the rallying point around which school board members are elected or defeated and, school administrators hired or fired. Schooling, the nature of education, has increasingly become the arena for the struggle of conflicting political ideologies.

Politics and (Rural) Science Education, The 21st Century

Even the cursory look at politics and (science) education discussed above indicates (1) politics and education are clearly connected and (2) that education (science) has been used in the service of political agenda which, by the very nature of the political system, implies short-term, simple solutions. Unfortunately, the process of education is a complex set of human interactions. Educational reform does not lend itself to politically inspired simple solutions. To summarize the ramifications of recent political action on rural science education: rural schools are now required to meet ever higher expectations established by national and state interests with little real support for improved teacher preparation, additional instructional resources or concern for the relevancy of the science curriculum for the place within which the students and their parents live. Science education in rural schools, rural students, and rural communities have not been well served by the mass production, one-best-system of schooling. Neither have they been well served by a political system which has disempowered rural communities and resulted in decisions which increasingly benefit state and national interests.

We have been acculturated to believe that the decline of rural self-determination is an inevitable result of "progress" and, therefore, rural people have felt powerless to halt or reverse this trend. Another point of view is emerging, however. Embedded in the notion of sustainabiliity, this alternative suggests a changed relationship between politics and science education. First, we need to change the way we do politics. Second, we need to change the way we do science education.

The New Politics, The Politics of Place

> *Keeping citizens apart has become*
> *the first maxim of modern politics.*
> *Jean Jacques Rousseau*

We daily confront the extent to that citizens have been kept apart from each other. In fact, we are not only apart from each other but rapidly becoming alienated one from another. Gang violence, drug abuse, growing demand for more and more prisons, and, closer to home for most of us, the mean spirited ideological battles that are becoming ever more frequent around school reform all divide us from one another. What is the role of education in society? How should our children be educated? With the isolation of citizens, the disintegration of community, arriving at consensus around these very fundamental questions is increasingly difficult. Society has lost its center. It is each one for himself, we have lost any sense of the common good. And just as we are bumping up against the limits of deteriorating communities, we are also bumping up against the limits of what the natural environment can sustain. The basic ground rules must be shifted from those based on "industrial competitiveness" to those base on "ecological sustainability." The political trend line that has brought us to this place will need to change.

Ecosystem Level Societies

David Orr (1992) calls for replacing our industrial, competitive society with one grounded in, and in harmony with, the environment. He makes a persuasive argument for moving beyond "technological sustainability" — solving the problems that we have caused in our environment with another technical solution, to "ecological sustainability"— living in such a way that the problems do not arise. This suggests a fundamentally different understanding of "science." To move in this direction will mean reexamining and changing the way we live our lives socially and economically, how we educate our children, how we do politics, and how we go about collective problem solving. So, how might we begin? Orr (1992), Kemmis (1990) and Wilkinson (1992), along with others advocating an alternative world view to our ever escalating industrial global competition, suggest that a place to begin is to redefine operationally the arena within which we live our lives. We begin to move away from the abstract and distant to the particular, the specific, the near. They propose the notion of "bioregionalism" or creating ecosystem-level societies. Some of the defining features of bioregionalism include:

- Defining political social systems that are in harmony with the ecosystem, e.g. areas defined by mountain ranges, or watersheds. Organizing around natural features provides fundamental reasons for finding "common ground" around such issues as air quality, water usage, land development, and so forth.
- Re-inhabitating those areas in ways that are sustainable (Kemmis 1990). "Doing things right means living as though your grandchildren would also be alive, in this land, carrying on the work we're doing right now, with deepening delight" (p. 80).
- Reinventing politics at the ecosystem level. This requires clarity about what should be done locally and what can only be done at higher levels. Science has much to contribute here. Effective controls on carbon emissions, for example, can only be accomplished at an international level. Energy conservation, the means of reducing energy use and thereby the release of CO_2 is best done by individuals, institutions and individual communities (Orr 1992).
- Substantially disengaging from the global economy and the passivity and dependence it fosters. Practically, this means stopping some things, such as subsidies for agribusiness and preferred tax treatment for large corporate enterprises, utilities, and land speculators. On the other side, it means rebuilding the local communities, small towns, and neighborhoods that have suffered from decades of neglect (Orr, 1992). It means relinking education with the real lives of young people, as they are lived, in real places. It also means demystifying science, equipping people to understand macro and micro measures and to read and evaluate research and scientific findings in terms of what they really mean for real lives.

Conducting public affairs in bioregions, at the ecosystem level, would involve those residing in nonrural areas and those residing in the surrounding rural areas, acting together to will a common world. Cities, suburbs, and rural areas, recognizing their interdependency, would have the capacity to define working economies. The health and viability of each would depend upon the health and viability of the others. Politics would move beyond rural versus nonrural to rural and nonrural. Conducting public affairs at the ecosystem level provides both the opportunity and the responsibility to practice republicanism in the Jeffersonian sense, to rediscover and make a reality of civic virtue, informed by scientific understanding.

A Matter of Place

Kemmis (1990) talked about this refocusing of public problem-solving as "the politics of place." Understanding the notion of "place" is critical to creating a new politics and to engage science for the common good. Wallace Stegner, a regional writer of the West, through his elegant prose helps those of us living in the West to understand what it means to live in that place (Stegner, 1962). Regional writers in the South or the prairie states or the Northeast can do the same for those residing in those regions. Understanding the place that we inhabit is informed by and informs science education. It is important for four reasons.

First, it promotes the time-tested learning power of combining of intellect with experience. Second, the study of place is relevant to the problems of overspecialization, that has been called a terminal disease of contemporary civilization. Third, it has significance in reeducating people in the art of living well where they are. Finally, knowledge of place — where you are and where you come from — is intertwined with knowledge of who you are, landscapes shape mindscapes (Orr, 1992).

If the way we do politics and science is to change for not only rural Americans but for nonrural Americans as well, education will also need to be re-formed. While learning can take place in groups, it is an individual activity, changing and expanding one mind at a time. The minds that are expanded and changed exist in specific and unique places. If young people are to learn to be participants in our democracy, we must provide them opportunities to practice civic virtue, to interact and reflect with their communities and their circumstances, to define and address real problems in real ways. This means locally taking back responsibility for determining what will be taught, and how it will be taught. And it means greatly expanding the definitions of who is a teacher and who is a learner.

Is it possible to change the way politics takes place in a ship-of-state that has been on a course for more than two centuries? There is growing evidence that indeed it may be possible. There is growing evidence that, at least around some issues, people are wanting more say about their resolution. A case in point is the battle over future regulation of grazing on Bureau of Land Management (BLM) public lands.

Governor Roy Romer (Colorado) and Interior Secretary Bruce Babbit have conducted eight lengthy local meetings over the future regulation of cattle grazing on Bureau of Land Management lands. Key to the proposed reforms is the shift of grazing decisions from BLM land managers to local groups made up of ranchers, environmentalists, miners, recreationists, and other significant public land users. In announcing the preliminary results of these meetings, Secretary Babbit (1994) said, "Perhaps we can resolve this century-old conflict by bringing management back to the state and local level...it will take us together on the landscape, here in the West to make it work" (p. 1A).

The editorial in which this was reported, "Westerners will have to live with both cows and condos," (Babbit, 1994) continued with :

> The traditional Western rancher or miner, threatened in various ways by previous Washington-based methods of public land regulation, would welcome stronger local control, but also would fear the arrival of such "dudes" as the environmentalists and recreationists at the policy table. But policy made by a consensus of all public-land users is slowly replacing the older domination of agriculture, mining, and water development interests. (p. 1A)

Changing the way we make decisions for the public good, engaging in the politics of place, creates the social context for how we change the way rural science education might take place.

The Science of Place

One of the major criticisms of science education has been its abstract, theoretical, text-book orientation. Courses in Biology have too often looked like vocabulary classes rather than a study of living things. Efforts to improve science education have focused on "hands-on" learning. But even here, this is often little more than manipulating scientific apparatus to solve text-book or laboratory manual problems. Exciting exceptions are beginning to emerge across the country. In Alabama, students in rural schools are engaged in conducting community health surveys, collecting data which helps identify community health needs as well as information which will help identify ways to address those needs. Other students are engaged in identifying the source of lead poisoning which is thought to be contributing to a high incidence of learning disabilities. In Oregon, students are working in partnership with the Bureau of Fisheries to study the adequacy of food sources for the salmon which migrate up the Columbia River. Students also collect weather data at their seacoast outpost for television weather reports. While projects such as measuring for acid rain or taking water samples in local streams and rivers are on the increase, such experiences still play far too small a role in science education. Real hands-on/minds-on science education will be about investigating problems that are grounded in the local context, the place which real people inhabit, communities within which young people and adults live their lives. If, in fact, the environment around the school, the farms, the creeks, the canyons, the plants, the animals, are viewed as the laboratory for science education rural schools have a marked advantage over their suburban and urban counterparts. This laboratory is right outside the school house door.

In the broader context. David Orr (1994) in his book *Earth In Mind: On Education, the Environment and the Human Prospect* calls attention to a list of random facts from newspapers, journal articles, and recent books which had crossed his desk in the past month:

- Male sperm counts worldwide have fallen by 50s since 1938, and no one know exactly why.
- Human breast milk often contains more toxins than are permissible in milk sold by dairies.
- At death, human bodies often contain enough toxins and heavy metals to be classified as hazardous waste.
- Similarly toxic are the bodies of whales and dolphins washed up on the banks of the St. Lawrence River and the Atlantic shore.
- There has been a marked decline in fungi worldwide, and no one knows why.
- There has been a similar decline in populations of amphibians world-wide, even where the Ph of rainfall is normal.
- Roughly 80% of European forest have been damaged by acid rain.
- U.S. industry releases some 11.4 billion tons of hazardous wastes to the environment each year.
- Ultraviolet radiation reaching the ground in Toronto is now increasing at 5% per year (p. 1).

He suggests that whereas these appear to be random facts, they are, in fact threads of a whole cloth. And yet, we continue to educate our children as if there were no planetary emergency. Rather than continue to enlist education in the cause of industrial exploitation, Orr calls for helping students to develop an 'ecological design intelligence' which is the capacity to understand the ecological context in which humans live, to recognize limits, and to get the scale of things right.

Ecological limits are very much on the horizon as we look forward to the 21st Century. As we realize that this is indeed the bottom line and as we take seriously the recommendations that science education must be about involving students in "hands-on" real science, the relationship between politics and science education will take a very different turn. Rather than science being in the service of political ends, e.g. "...being first in the world...", science education, the scientific information and knowledge produced by students about the local context can help community leaders make more informed decisions around community issues. Rather than being in the service of the political agenda, science can and should help define that agenda. This is not say that science education might not become increasingly politicized. As students engage in scientific investigations around use of chemicals in agriculture, soil erosion, hazardous waste, air pollution, etc., someone's self interests will be at risk.

Rural science education and politics will continue to be tightly linked as we move into the 21st Century. Depending on how we answer the question of "What is education for?" those linkages will either continue to be science in the interest of political expediency, or science in the interest of ecological sustainability and stronger, healthier communities.

References

Babbit, B. (1994, January 23). Denver Post, Sunday 1A.

Kemmis, D. (1990). *Community and the politics of place*. Norman, University of Oklahoma Press.

Orr, D. (1992). *Ecological literacy: education and the transition to the postmodern world*. Albany, State University of New York Press.

Orr, D. (1994). *Earth in mind: On education, environment, and the human prospect.* Washington, D.C.: Island Press.

Stegner, W. (1962). *Wolf willow.* Lincoln, NE: University of Nebraska Press.

Wilkinson, C. (1992). *The eagle bird: mapping a new West.* New York, Pantheon Books

Chapter 10
Science Education for Rural Native Americans

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Demographics of Native Americans

There are approximately 1,959,000 Native American people presently living in the United States of America, including American Indians, Eskimos, and Aleuts (US Bureau of Census, 1990, cited in Reddy, 1993). Native Americans are found in every state in the union with the lowest population density of 0.1 percent in Pennsylvania in contrast to the highest density of 15.6 percent in Alaska (US Bureau of Census Press Release, cited in Reddy, 1993).

Although a sizable number of Native Americans live in this country, they represent only 0.8 percent of the total population. In contrast, African Americans constitute 12.1 percent, Hispancis, 8.5 percent, and Asians 2.9 percent(US Census Bureau, cited in Reddy, 1993). Native Americans, however, occupy a unique position among minority groups. Foremost, they represent the indigenous culture in the United States. They were living here prior to the advent of Europeans who took over the land and established a new government. To lose this group of people and their respective culture would be a loss of the very roots of our heritage as a country.

The philosophy of Native Americans, which places human kind in harmony and balance with nature and "Mother Earth," appears to have profound implications for survival of society in the present technological era which is dependent upon the depletion of natural resources and the disposal of industrial and human wastes. As the predominant society increasingly looks toward maintaining a quality of life for humans, and the wise use of natural resources, it appears that much can be gained from the traditional values of the Native Americans.

In 1980, eighty-seven percent of all Native American Indians were classified as "rural" (Reddy, 1993). However, only four percent of this rural population was engaged in farming. The high percentage of Native Americans being classified as rural is due in part to their traditional affinity to the earth and close relationship to nature. Their love and respect for the land was so intimately entwined with their spiritual beliefs that they could not readily accept assimilation into a culture which alienated them from their roots. Rather than give up what was sacred to them and lose their identity, they accepted a life on reservations where they anticipated maintaining some semblance of their former existence. Also, during the periods of treaty signing, a number of Native Americans felt that the superior knowledge and technology of the white people, gave them the right to do as they saw fit (Deloria, 1978; McNickle, 1975).

Historical Influences on Native American Education - Religion

It appears that the inculcation of religion has been one of the prime goals in American education dating back as far as colonial times. One finds in the Laws of Virginia, February 12, 1631-2, chapter 8 (Calhoun, 1969):

> That upon every Sunday the minister shall half an hour or more before evening prayer examine, catechize, and instruct the youth and ignorant persons of his parish, in the ten commandments, the articles of the belief and in the Lord's prayer;...And all fathers, mothers, masters and mistresses shall cause their children, servants or apprentices which have not learned the catechism to come to the church at the time appointed, obediently to hear, and to be ordered by the minister until they have learned the same. (p.17)

The Records of the Governor and Company of Massachusetts Bay mandate the familiar "Old Deluder Clause" (Calhoun, et al., 1969):

> It being one chief project of that old deluder, Satan, to keep men from the knowledge of the Scriptures,...that learning may not be buried in the grave of our fathers in the church and commonwealth,...It is therefore ordered, that every township in this jurisdiction,...shall then forthwith appoint one within their town to teach all such children as shall resort to him to write and read. (p. 23)

The emphasis on religion was the major goal for the education of Native Americans. In 1611, the French Society of Jesus was the first organization to bring education and the Christian religion to Native Americans. Its sphere of influence was along the St. Lawrence and Mississippi rivers and the Great Lakes region. In 1617, King James I ordered the Anglican Church to solicit funds for "the erecting of some churches and schools for ye education of ye children of these [Virginia] Barbarians" (Wright & Tierney, 1991, p. 12). The 1693 charter of the College of William and Mary had the stated purpose "that the Christian faith may be propagated amongst the Western Indians" Wright & Tierney, et al., p. 12). William W. Kemp (1913, as cited in Calhoun, 1969) described the policy of the Society for the Propagation of the Gospel in Foreign Parts toward the education of the Iroquois in Colonial New York during 1771:

> That two Missionaries, men of good character, abilities, and prudence, and in the orders of the established Church of England, be sent to the Iroquois, one to reside at Conajohare, the other at the old Oneida Town. Most of the Indians at both these villages have been baptised [sic], and even profess Christianity; all are willing to be further instructed....Their business will be to teach the Indians, to read and write....the Society have with great fidelity discharged the important trust reposed in them, and have already done much towards Converting and Civilising [*sic*] the Iroquois. (pp. 65-67)

The rationalization was not only the "saving of souls" but had the added component of "civilizing" the Indians.

In Arizona, California, New Mexico, and Texas, the Spanish Franciscans followed the Conquistadors, converting the natives to Christianity and establishing missions and Indian schools. During the latter part of the eighteenth century, the Catholic and Protestant groups focused their efforts on educating, Christianizing, and civilizing the "unsaved savages."

During the nineteenth century, religious materials were translated into the Indian dialects. The Federal government began supporting religious endeavors with the Indians in 1819 through appropriations for "Christianization." The policy was terminated in 1873 due to outcries of violation of separation of church and state (Thompson, 1978).

Assimilation Policy

The goals of the predominant society historically have not been relevant to the indigenous culture As far back as June 17, 1774, the Commissioners from Maryland and Virginia petitioned the elders of the Six Nations at Lancaster, Pennsylvania to send their boys to William and Mary College. In their refusal, the elders stated (McDonald, 1978):

> We are convinced that you mean to do us good by your proposal; and we thank you heartily, but you who are wise, must know that different Nations have different conceptions of things; and you will therefore not take it amiss, if our ideas of this kind of education happen not to be the same with yours. We have had some experience of it. Several of our young people were formerly brought up at the College of the Northern Provinces; they were instructed in all your sciences but when they came back to us, they were bad Runners, ignorant of every means of living in the Woods—Neither fit for Hunters, Warriors, nor Counsellors, they were totally good for nothing. We are, however, not the less oblig'd by your kind offer, tho' [sic] we decline accepting it; and, to show our grateful sense of it; if the gentlemen of Virginia will send us a dozen of their sons, we will take care of their education, instruct them in all we know, and make men of them. (p. 84).

By the end of the nineteenth century, the Federal government followed the policy of assimilation to involve Native American youth into the mainstream of the dominant society. Government boarding schools were created with the first established in 1879 as the Carlisle Indian School at Dickenson, Pennsylvania. These boarding schools made it possible to isolate the students from their homes and the influence of their parents and the tribe. Although intended as institutions of higher education, their curriculum was directed at occupational training at the high school level in mechanics, agriculture and domestic training. The protestant work ethic and strict military discipline were designed to reconstitute the Native Americans into productive citizens modeled after the dominant society (Wright & Tierney, 1991). The curriculum in such schools was deliberately devoid of native languages and cultural programs.

Assimilation was accomplished through the imposition of hair styles, dress, housing, customs, and the Christian religion. Little effort was made to understand the lifestyle, customs, and especially, the religion of the indigenous people. In fact these were to be suppressed and finally eliminated—and once they were, the people would become worthy citizens functioning in the white society.

Social and Environmental Factors

The cultural values and the religious foundations of the indigenous people were, and still are, in stark contrast to that of the predominant society. The result has been alienation between the two cultures. The lack of education for competing and survival in the present technological society as well as the paucity of job and employment opportunities in remote reservations has tended to place native Americans in a state of poverty and depression. Alcoholism and other drug abuse too often serve as convenient outlets (Green, 1978). Depression and hopelessness lead to family breakup, crime, and the detriment of future generations through such maladies as fetal alcohol syndrome.

The situation among the youth of the indigenous culture can be particularly frustrating. Faced with living at or below the poverty level (Hillabrant, et al., 1991) and coming from a homelife of depression and hopelessness, they find themselves caught between the traditional and the dominant culture. On one hand they are faced with the materialistic dominant society and its allure and excitement as well as its crime-ridden paradox, replete with officials involved in criminal acts at the highest levels of government. On the other hand, they do not particularly find relevance in the traditional tribal values which emphasize such qualities of sharing with others, respecting the elders and those in authority, respecting the earth, and displaying individual modesty. As a result, a number of youth find themselves subscribing to neither culture, taking a path somewhere in between.

Present-day Native American students tend to either buy into the cultural values of the indigenous culture, the dominant society, both the indigenous culture and the dominant culture, or neither. It appears that increasing numbers during the past decade have fallen into the latter category. Having little, if any, cultural roots from which to realize stability, these young people exist in a state of flux. As a result, individuals are prone to involve themselves in alcohol, drugs, sexual promiscuity, gang membership, and criminal activities, with little desire to achieve educationally. They have a high probability of not realizing their potential, and at worst, of dropping out of school and society.

Young Native Americans are not being taught the cultural values of the indigenous culture. Because they lack knowledge, they lack understanding and feel out of touch with reality in their societies. They feel adrift and perhaps even ashamed to be "Indian."

A Native American Adolescent Health Survey, administered during the spring of 1993 in a reservation tribal school in northeastern South Dakota, indicated that 53% of the Grades 6-12 students were emotionally insecure or unsure of self and found daily life uninteresting. Sixty-one percent felt their family cared little about feelings.

The situation is especially acute in view of the fact that Native Americans tend to be younger than the overall population of the United States. The median age for Native Americans is 22.6 years of age compared to a median of 30 for the general population (US Department of Health and Human Services, Public Health Service, Indian Health Service, cited in Reddy, 1993).

Implications For Rural Science Education

A considerable amount of literature has extolled the wisdom of making science education relevant to the personal lives of students (Anderson, 1983; Bybee, 1986; Bybee, 1987a; Bybee, 1987 Harms and Yager, 1981; Hurd, 1972, 1975; NSTA, 1992; Rubba, 1987; Rutherford & Ahlgren, 1989; Yager, 1984, 1985, 1988). Does this mean that science should be taught only to prepare people to survive on the reservation, or in a hunter-gatherer society? The answer can be affirmative in some respects because reservation survival skills can be useful for life on the reservation. McDonald (1978) stated that "Education should incorporate teaching students to learn how to survive in a particular environment" p. 74. In fact, he believed that the present college preparation curriculum is inappropriate for non-Native American students as well. The major educational goal of educational institutions should be survival in each student's respective environment. If that environment is the reservation, the educational processes and materials should be meaningful to the reservation way of life (Indian education, 1969a). However, Platero (1978) and Cheek (1984) argued that with the existence of over 400 Native American tribes, each with a degree of cultural variance, no composite of Native American cultural values exist. Platero urges recognition of the existence of cultural diversity and the allowance of each respective group to exploit their culture as they desire.

Conversely, realistic indigenous people recognize their position in a global society. They live in conventional houses, drive automobiles, view television, and own computers. All of these modern conveniences are even available on the reservations. As a result, heavy emphasis is placed on the individual to come to terms with what it means to be "Indian" in the generic sense, rather than Lakota, Dakota, or Navaho, etc. The essence is on developing a strong self-concept (Gilliland, 1986), allowing the individual to feel good about his or her personal being even in the face of extreme adversity. A Native American, even in the latter part of the Twentieth Century, needs to be keenly aware of the probability of being confronted with bias and prejudice. The individual needs the appropriate sense of self worth and adequate people skills to deal with confrontations in a calm, intelligent manner. The school science curriculum should equip Native Americans with the appropriate scientific literacy to deal appropriately with environmental problems. It should also enhance their ability to make an adequate and satisfying living through appropriate skills for "hunting the buffalo" in the twenty-first century.

The Tiospa Zina Tribal School in Agency Village, South Dakota has developed the following Mission Statement in an attempt to meet the needs of its students to successfully function in the twenty-first century:

> *To provide students of tiospa zina tribal school with educational opportunities which will prepare them to function in a multi-cultural and increasingly technological society while retaining their unique cultural heritage and identity*

Upon graduation from high school, the Tiospa Zina Tribal School students are expected to demonstrate six Exit Outcomes:

1. **Effective Communicators** who demonstrate the ability to express themselves clearly in all aspects of life.
2. **Enlightened Representatives** who incorporate principles of Dakota culture, modern and traditional values, and tribal affairs into their daily lives.
3. **Self-Directed Achievers** who formulate goals and priorities, and continuously evaluate their progress.
4. **Balanced Individuals** exhibiting sensitivity, self confidence, and respect, who model holistic lifestyles and are able to live in harmony with self, others, and Mother Earth.
5. **Creative Thinkers** who use a variety of problem-solving techniques and resources to resolve challenges facing them.
6. **Global Citizens** who demonstrate respect for and acceptance of cultural diversity.

It seems reasonable to educate Native American students in their heritage and the basic culture while developing survival skills necessary for functioning in the non-Native American society. Both the Jewish and Asian cultures have successfully maintained their strong cultural heritages while successfully integrating into the dominant society. Testimony from representatives from a variety of American Indian and Alaska Native persons (Preston, 1991) had the common thread of::

> The need for American Indian and Alaska Native students to have their culture acknowledged and to be taught in the ways they learn. The type of school, the type of class (language arts, social studies, science, mathematics), the area of the country does not change the need to be respected as a human being and to be taught in a manner that allows the individual to understand and internalize the material to be learned. (p. 1)

The Use of Stories and Legends

The infusion of Native American culture in science classes can readily be accomplished through the use of indigenous stories and legends. Excellent sources are elders within the local communities as well as established Native American writers. Such stories and legends can serve as the basis for studying science and promoting its relevancy. N. Scott Momaday (1989, cited in Caduto & Bruchac, 1989) stresses the importance of stories in the indigenous culture:

> In his traditional world the Native American lives in the presence of stories. The storyteller is one whose spirit is indispensable to the people....His object is most often the establishment of meaning....Stories tend to support and confirm our perceptions of the world and of the creatures within it....In the Native American world this relationship is so crucial as to be definitive on the way in which man formulates his own best idea of himself. In the presence of these stories we have an affirmation of the human spirit. (p. xvii).

Examples of excellent sources of Native American stories, and associated teaching suggestions, are *Native American Stories* (Caduto & Bruchac, 1991), *Keepers of the* Animals (Caduto & Bruchac, 1991), *Keepers of the Earth* (Caduto & Bruchac, 1989), and *Earth's Caretakers, Native American Lessons* (Nyberg, 1993). Careful analysis of the traditional stories indicates a correspondence between them and the current theories of science and mathematics. Ecologists routinely warn us that the future health of our planet and ourselves depends on the interrelationship between ourselves and the plants and animals in our environment (Johnson, 1992).

The indigenous peoples viewed the natural world in balance with all things, including themselves, as part of a great circle. Humans were not more important than the rocks, the plants or the animals. In fact, it is not uncommon for them to be described as "ancestors" and for stories to include people becoming animals and animals becoming people. Therefore what was done to nature was done to a brother or sister. They emphasized a harmony with nature rather than control of nature. The people believed they were living with rather than on the place they called Turtle Island. If people became sick, it was viewed as an imbalance which must be restored. The Creator was ubiquitous requiring ceremonies and prayers which involved the sick person's entire community. Chief Standing Bear, Oglala Sioux stated (Project Learning Tree, 1993) that "The old Lakota was wise. He knew that man's heart away from nature becomes hard. He knew that lack of respect for growing living things soon led to lack of respect for humans too" (p. 348).

The view of the "old ones" is as apropos today as it was for centuries in the past. Michael J. Caduto (1985, cited in Caduto & Bruchac, 1989) cautioned that even today "We are in relationship with the Earth and other people. Doing good supports this relationship. Love and moral goodness are inseparable, they are the elemental components of a life ethic" (p. 11).

Examples of Cultural Infusion

During the 1994-95 school year, the University of South Dakota was a National Science Foundation Statewide Initiative (NSF-SSI) project partner with a Lakota reservation school in the western part of South Dakota. Involvement was a direct spinoff of an Eisenhower grant activity science inservice project for teachers.

The involvement of university personnel with the NSF-SSI project began with a half-day inservice session. Initially, the K-12 teacher participants were provided background in the infusion of Native American stories and legends into science teaching. Actual science lessons were modeled by a university science educator and a professor of Native American Studies, who is a Lakota speaker. The teachers participated as students in short science lessons which integrated Native

American stories and legends.

Following the model lesson activities, the teachers spent time in planning lessons based on native stories, legends, and artifacts or events. The university personnel served as facilitators and advisors in pedagogical techniques. Because not all of the teachers were Lakota, they were cautioned to respect spiritually sensitive areas such as the circle, the drum and the sweat lodge. In fact, they were encouraged to work closely with the local elders and spiritual leaders in developing their lessons and curricular objectives.

During the interim between the initial and second planned meeting, the teachers were asked to plan their lessons in detail, teach the lessons in their classes, and to assess the success of each lesson. They were also asked to demonstrate their lessons to the group during the next meeting.

The second teacher inservice session consisted of teacher presentations of their lessons and sharing their assessments. Presentations ranged from a high school science lesson which incorporated animal skins and a lesson based on the mathematics of a sweat lodge, to elementary school lessons based on activity science which the students videotaped for the group. The teachers enthusiastically endorsed the infusion of the Native American culture. A teacher aide publicly supported the use of traditional stories and customs as a superior way to teach science to Native American youth and a means to bring them to the traditional values of showing respect for fellow human beings and Mother Earth. Another teacher testified that her fifth-grade son would rather work on his science project than visit with his friend via the telephone.

Three months after the second session, the teachers mailed teaching units to the project director. Activity topics included an eighth grade unit based on the Virginia Driving Hawk Sneve book, *Medicine Bag*. Activities included the brain tanning of an Elk hide as well as the cutting, sewing, and beadwork processes in producing a medicine bag. The students sliced 60 pounds of beef which was hung on a clothesline and dried in the classroom. A second grade recycling unit was developed along the theme of "Integrating Native American Culture with Math and Science." A kindergarten unit on the drum-making, in which the students made their own drums, involved the study of sounds, rhythms, and beats. The first grade teachers developed a buffalo unit based on the book *Buffalo Women* in which the students studied the weight of a buffalo by using arithmetic subtractior nroblems and the relationship of the human five senses to the senses of the buffalo. The resources which c :n be utilized from the buffalo were also studied. One third grade unit was based on the spider. Another third grade unit focused on the sacred pipe as the basis for the mathematical activities of estimating, sorting, and measuring as well as the science activities of observing, classifying, estimating and gathering and recording data.

One secondary school unit was entitled Technology Transfer During the Fur Trade 1793-1847. Another secondary school unit integrated science and mathematics in a study of the sweat lodge. The science component involved studying the types of woods utilized, the types of rocks used, along with their respective characteristics, and the seasons of the year. The mathematics component involved measurement, counting, geometry, graphing and problem solving.

The teachers' assessment packages reflected considerable success and satisfaction with their Lakota-oriented science and mathematics units. They especially felt successful with the increased involvement of students who had been discipline problems and who were unmotivated with previous science teaching methods. An encouraging aspect was the inclusion of the community parents, relatives, elders, and spiritual leaders as resource persons.

A second Eisenhower project is in progress in the Tiospa Zina Tribal School (TZTS) at this writing. The administration had previously established the groundwork for a complete curriculum revision with an established mission statement, specific exit outcomes, subject area/grade-level outcomes, and a school wide curriculum plan. A common thread running through the documents is the infusion of the traditional native culture to develop productive global citizens with a strong sense of self-worth to be able to function in a multi-cultural and increasingly technological society while retaining their unique cultural heritage and identity. The infusion of Native American cultural heritage into the teaching of science is also one of the main goals of the TZTS Eisenhower project. This goal directly supports the TZTS science outcome number six, "the learner will demonstrate a healthy lifestyle applying scientific knowledge in an ethical/cultural manner."

Background in infusing Native American stories, legends, and folklore as well as the utilization of local resources, was provided for the project teachers during a four-day summer inservice session. Lessons were modeled and critiqued by the project staff. The participants were encouraged to develop lessons and present them to the group for feedback.

Follow-up sessions are being held monthly during the academic year. For each monthly meeting, the participants are asked to plan three science or mathematics lessons, utiize them in their classes, critique them, and present them to the group. An inventory of lesson plans are being accumulated and categorized in electronic database form, for easy dissimilation and coordination with the master curriculum plan. An electronic data base of Native American cultural resources available to the teachers is also being developed. Resources include those from the local community, the school, faculty personal professional libraries, and those from a local community college.

As with the first project discussed, evidence is being accumulated from TZTS project which demonstrates teacher satisfaction as well as student acceptance in infusing Native American culture into the teaching of science, as well as mathematics. An extension of the project is being planned which will concentrate heavily on the integration of mathematics and science along with other disciplines. Native American cultural infusion can be a natural theme upon which to base interdisciplinary curriculum plans.

Native American Learning Styles

A popular perception of Native Americans is that their "learning styles" are different than those of the dominant society. They are said to be spatially and visually oriented and therefore at a disadvantage in the typically verbal classroom. If classes would become more spatially and visually oriented, Native Americans would somehow find science appealing and easy to learn. The premise seems so logical and satisfying to one's intuition.

A careful scrutiny of the research literature yields little evidence that Native Americans possess a unique learning style. Kleinfeld and Nelson (1988) could find no compelling evidence in the research literature to uphold the hypothesis that Native American students have a unique learning style, nor that attempting to match teaching styles leads to increased learning. More (1989) found that differences between the Learning Styles of Native American and non-Native American students are "often observed" but lack the consistency necessary to lend credence to the hypothesis. He does suggest however, that the frequency of occurrence of such observations does warrant careful consideration. Given the lack of empirical evidence, however, one is hard pressed to place much stock in a unique Native American Learning Style theory. In fact, More (1989) cautioned, that "over-emphasis on learning style differences may lead to a new form of inaccurate labeling and stereotyping of Native Indian students, or, even worse, diagnoses of brain differences or genetic differences" p. 25.

Why then do educators continue to espouse a unique learning style theory and the matching of teaching styles to learning styles? Klinefeld and Nelson (1988) suggest a threefold explanation:

> First, educators and researchers use the term "learning style" to avoid "deficit" language in discussing Native American students' education problems. The term "learning style" suggests that differences in school achievement are not due to "deficiencies" but merely to variations in the way students learn.
> Second, proposal writers tell us that the "learning style" concept gives them a way to argue that special funding for academic instruction for Native Americans is justified. Major funding sources in Native American education, such as the Indian Education Act or Johnson O'Malley program, require proposals showing how instruction will be explicitly targeted to Native American groups.
> Third, teachers use the term "learning style" as an umbrella concept referring to a wide variety of adaptations they make in teaching certain Native American groups—adaptations in vocabulary, pacing of the classroom, frame-of-reference, displays of emotion, use of hands-on instruction, etc. Each of these instructional adaptations is justifiable in terms of the cultural contest. These types of adaptations, however, have little, if any, relationship to "learning style" as conceptualized in the psychological literature on cognitive ability patterns. (p. 16-17)

Constructivism and Teaching Science to Native Americans

Given the paucity of support for a unique Native American "learning style," it seems reasonable to assume that which is espoused in the literature for students of science, is equally applicable to Native American students. The present focus on the teaching of science is directed to the learner rather than the teacher. There can be no knowledge other than that which has been cognitively assembled by the learner. Learning cannot be verbally transmitted to another individual. According to Yager (1991), "Learning is the product of self-organization and reorganization" (p. 55). The individual must "construct" that which is learned. One can only "know" something if that individual can explain it to someone else.

According to the four-step Constructivist Learning Model (CLM) of the National Center for Improving Science Education (NCISE), students will be enabled to construct their own knowledge by 1) invitations to learn, 2) exploration, 3) proposing explanations and solutions, and 4) taking an active role. Trowbridge and Bybee (1990) stipulated that learning takes place when the conceptual level of the student is identified, problem confrontation or challenges are provided, and the student experiences personal resolution of the problem. All learners bring a certain level of knowledge to school and a state of cognitive equilibrium with such knowledge. According to Piaget (1977), in order for the student to learn, he/she must be placed in a state of disequilibration through confrontation with an unfamiliar encounter. Resolution of the "discrepancy" leads to equilibrium, but at a higher cognitive level.

The three sequential phases, of 1) Exploration, 2) Concept Introduction, and 3) Concept Application, of the Robert Karplus Learning Cycle (Karplus, et al, 1977), fits the constructivist model quite well. Disequilibration is caused by the Exploration phase. Concept Introduction and internalization through Concept Application lead to equilibrium at a higher cognitive level. The Karplus Learning Cycle model has been utilized with positive results with Native American students in the two projects previously cited.

The constructivist model demands that students interact with their environment in order to question, hypothesize, probe, and draw inferences. Both the American Association for the Advancement of Science (AAAS) (Rutherford & Ahlgren, 1989) and the National Science Teachers Association (NSTA, 1992), advocate students learning science by doing science. Evidence over the past three decades consistently verifies the efficacy of the activity/inquiry approach to teaching science. Meta-analyses of hundreds of experimental studies involving thousands of students indicate the hands-on inquiry curricula as superior to traditional curricula in achievement, reading readiness and skills of analysis, mathematics, social studies, communication, and positive science attitude development (Bredderman, 1983; Shymansky, et.al., 1983).

Summary

While Native Americans currently represent only 0.8 percent of the total population, they also represent the indigenous culture of the United States. Native American philosophy places mankind in harmony and balance with nature. To preserve a quality of life for humans and wisely use natural resources, much can be gained from the Native American philosophy.

Historically, an emphasis on religion was the major goal in educating Native Americans. Europeans used religion to save uls, civilize, and educate the indigenous population. Education was used to assimilate Native Americans through the building of government boarding schools. These schools isolated native children from the influence of their culture.

Native American populations are predominantly young and rural, although there is evidence of migration to urban areas. A number of Native Americans live on isolated reservations which negate socioeconomic self-improvement and offer little in the way of economic opportunity. In general Native Americans are of low income with 30.9 percent reported below the poverty level (Reddy, 1993), and are underepresented in the science occupations (Digest of Educational Statistics, 1991).

There is evidence of the wisdom in relating science to the personal lives of students. An excellent vehicle for infusing the Native American culture is a focus on the indigenous stories and legends which can be gleaned from the local community as well as Native American writers, and use them as the basis for studying science.

Little evidence exists to support the hypothesis that Native American students have a unique learning style. Given the paucity of evidence that Native Americans exhibit learning styles different from the dominant society, it is reasonable to assume that they too will respond to activity-oriented hands-on science using the constructivist model. The Karplus Learning Cycle Model is an appropriate model for implementing the constructivist approach to the teaching of science.

More Native Americans need to be recruited into the science, engineering, and medical professions, not only to personally and collectively move into the higher economic strata of society, but to be able to effectively utilize, by culturally appropriate means, the resources of the tribal lands. Science appropriately taught can be a powerful vehicle for improving the personal and environmental facets of everyday life both on and off of the reservation. It is the premise of this article that infusion of the Native American culture into the teaching of science based upon traditional stories and legends through the utilization of local human resources can be a powerful tool for developing individual self-concept and worth as well as making science relevant to Native American youth. The Karplus Learning Cycle Model is one method of combining Native American culture with the teaching of science.

Students view teachers as the single most important influence on their science attitudes (Westerback, 1982). The teacher who teaches science as a dynamic endeavor intimately related to personal needs, also presents a positive model for living. A positive teacher attitude toward science, as well as Native American cultural values, can do much toward fostering a positive student attitude toward science and enhancing self-concept. In the words of Hap Gilliland (1986), "The teacher who can earn the respect of Indian students and who can show them that they are respected for what they are is well on the road to giving those children success in school. A teacher's attitude is more contagious than chicken pox or measles" (p. 62).

References

Anderson, R. D. (1983). Are yesterday's goals adequate for tomorrow? *Science Education, 67*(2), 171.

Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A quantitative analysis. *Review of Educational Research, 53*(4), 499-518.

Bybee, R. W. (1986). The Sisyphean question in science education: What should the scientifically and technologically literate person know, value, and do—as a citizen? In Roger W. Bybee (Ed.), *1985 Yearbook of The National Science Teachers Association*. Washington, D.C.: National Science Teachers Association.

Bybee, R. W. (1987). Teaching about science-technology-society (STS): Views of science educators in the United States. *School Science and mathematics, 87*(4), 274.

Bybee, R. W.(1987a). Science education and the science-technology-society (STS) theme. *Science Education, 71*(5): 677.

Caduto, M. J. & Bruchac, J. (1989). *Keepers of the earth Native American stories and environmental activities for children*. Golden, CO: Fulcrum, Inc.

Calhoun, D. (1969). *The educating of Americans: a documentary history*. Boston: Houghton Mifflin Company.

Cheek, H. N. (1984). A suggested research map for American mathematics education. *Journal of American Indian Education, 23*(92), January, 1-9.

Digest of Educational Statistics, (1991). Bachelor's degrees conferred by institutions of Higher Education, by racial, ethnic group, major field of study and sex of student, 1988-89, 256-266.

Deloria, V. Jr. (1978). The Indian student amid American inconsistencies. In *The schooling of Native merica*, Thomas Thompson, editor. Washington, D.C.: American Association of Colleges for Teacher Education in collaboration with The Teacher Corps, United States Office of Education.

Gilliland, H. (1986). Self concept and the Indian student. In J. Reyhner (Ed.), *Teaching the Indian Child: A bilingual multicultural approach*. ERIC Documents 283 628, 57-68.

Green, R. (1978). Math called key to Indian self-determination. *Science, 201*, 435, 433.

Harms, N. C. & Yager, R. E. (1981). *What research says to the science teacher, Volume 3*. Washington, D. C. National Science Teachers Association, NSTA Stock Number 471-14776.

Hillabrant, W., Romano, M., Stang, D. & Charleston, M. (1991). *Native American education at a turning point: current Demographics and trends*. ERIC Document Reproduction Service No. ED 343 756.

Hurd, P. D. (1972). Energizing perspectives in science teaching for the 1970s. *School Science and Mathematics, 72*(8), 765.

Hurd, P. D. (1975). Science, technology and society: New goals for interdisciplinary science teaching. *The Science Teacher, 42*(2), 27.

Indian education: A national tragedy—a national challenge. (1969a, November 3). Washington, D.C.: U.S. Government Printing Office.(Report of the Committee on Labor and Public Welfare, United States Senate, made by its special subcommittee on Indian education, Report No. 1, No. 91-501).

Johnson, T. (1992). What whites want. *Winds of Change, Autumn*, 137-140.

Karplus, R.; Lawson, A. E.; Wollman, W.; Appel, M; Bernoff, R; Howe, A.; Rusch, J. J.; Sullivan, F. (1977). *Science teaching and the development of reasoning*. Berkeley: Lawrence Hall of Science University of California.

Kleinfeld, J. & Nelson, P. (1988). Adapting instruction to Native Americans' "learning styles": and iconoclastic view. ED 321952.

McDonald, A. (1978). Why Indian students drop out of college. In Thomas Thompson (Ed.), *The schooling of Native Americans*. Washington, D.C.: American Association of Colleges for Teacher Education in collaboration with The Teacher Corps United States Office of Education.

McNickle, D. (1975) rev. ed. *They came here first: The epic of the American Indian*. New York: Octagon Books.

More, A. J. (1989). Native Indian learning styles: A review for researchers and teachers. *Journal of American Indian Education*, Special Issue, August,15-28.

NSTA (1992). *Scope, Sequence, and Coordination of Secondary School Science Volume 1 The Content Core A Guide for Curriculum Designers*. Oxford: Oxford University Press.

Nyberg, L. M., editor (1993). *Earth's caretakers Native American Lessons*. Lawrence, Kansas: MASTERS Project, Project Director, Walter S. Smith, 207 Bailey Hall.

Piaget, J. (1977). *The development of thought: equilibration of cognitive structures*. New York: Viking Press.

Platero, D. (1978). Multicultural teacher education center at Rough Rock. In Thomas Thompson (Ed.), *The schooling of Native Americans*. Washington, D.C.: American Association of Colleges for Teacher Education in collaboration with The Teacher Corps United States Office of Education.

Preston, V. P. (1991). Mathematics and science curricula in elementary and secondary education for American Indian and Alaska Native students, ERIC Document Reproduction Service Number ED 343767.

Project Learning Tree, (1993). *Environmental education pre K-8 activity guide*. Washington DC: American forest Foundation.

Reddy, M. A. (1993), Editor. *Statistical record of Native North Americans*. Detroit: Gale Research, Inc.

Rubba, P. A. (1987). Perspectives on science-technology-society instruction. *School Science and Mathematics, 87*(3), 181.

Rutherford, F. F. & Ahlgren, A. (1989). *Science for All Americans*. New York: Oxford University Press.

Shymansky, J. A.; Kyle, W.C.; & Alport, J.M. (1983). The effects of new science curricula on student performance. *Journal of Research in Science Teaching, 20*(5), 3878-404.

Thompson, T. (1978). Preface. In Thomas Thompson (Ed.), *The schooling of Native Americans*. Washington, DC: American Association of Colleges for Teacher Education in collaboration with The Teacher Corps, United States Office of Education.

Trowbridge, L.W. & Bybee, R.W. (1990). *Becoming a Secondary School Science Teacher*. Columbus, Ohio: Merrill Publishing Co.

Yager, R. E. (1984). The major crisis in science education. *School Science and Mathematics, 84*(3), 189.

Yager, R. E. (1985). Preparing students for a technological world. *Curriculum Review, 24*(3), 21-22.

Yager, R. E. (1988). A new focus for school science: S/T/S. *School Science and Mathematics, 88*(3): 181.

Yager, R. E. (1991). The constructivist learning model. *The Science Teacher*, 59 (6) (September), 52.

Westerback, M.E. (1982). Studies on attitude toward teaching science and anxiety about teaching science in preservice elementary teachers. *Journal of Research in Science Teaching, 19*(7), 603-616.

Wright, B. & Tierney, W. G. (1991). American Indians in higher education a history of cultural conflict. *Change*, March/April.

Chapter 11
Serving the Needs of Minority Students in Rural Settings

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Whatever one's definition of rural education, one has to be impressed with the utter diversity (Nachtigal, 1982) that abounds both in the literature and in observed rural settings. Rios (1987) summarizes, "Rural New England is quite different from rural Iowa, and both are quite different from rural Alaska or rural Texas" (p.1). Also even though North Dakota, South Dakota, Alaska, and Nebraska head the list in percentages of public schools in rural areas, the largest rural populations live in Ohio, Illinois, Michigan, Pennsylvania, Texas, N. Carolina, Georgia, Kentucky, Mississippi and Indiana (Sherman, 1992). There is not one concrete definition,.but several, in shades of gray.There is the general impression that the term is understood even if a definition cannot be agreed upon.

Definitions of rural science education are also diverse according to a study by Baird, Prather, Finson, and Oliver (1994) in which they reported that teacher participants were allowed to decide for themselves whether or not they believed their setting was rural. Apparently none of these teachers had any difficulty reaching a decision although no criteria were provided to guide them.

The National Center for Educational Statistics (1994) provides more specifics about minority populations and defines them in the following manner: "A person is considered a member of a racial-ethnic minority if they are American Indian or Alaskan Native; Asian or Pacific Islander; Hispanic, regardless of race (Mexican, Puerto Rican, Cuban, Central or South American, or other culture or origin); or Black (not of Hispanic origin)" (p.132). Minorities comprise 31% of public school students by race/ethnicity with 16% being Black, 11% Hispanic, 3% Asian, and 1% American Indian. Over half of the minority population, i.e. 18%, are located in areas designated as Rural/Small Town. These minorities represent a large portion of children in rural schools whom DeYoung (1991) describes as, "not just statistics but individuals with their own aspirations for the future who can become either an asset or a liability for this society ... They represent a huge resource for the nation that simply must not be squandered through neglect" (p.137).

The general air of pessimism that appears to surround the terms "rural education" and "minorities" is not one that the authors ascribe to. There is cause for genuine optimism about the future and, when one reads that Arizona alone has 48 successful partnership programs underway as of September 1992 to improve minority access and achievement, there seems reason to be optimistic. Admittedly, these are not all science-related, but many are, such as Project PRIME, which is a project to improve minority education (Arizona State University, 1992). Project PRIME is not limited to rural minorities but has the goals of doubling the number of minority students attending college and tripling the number majoring in science, engineering, and mathematics through an accelerated academic program.

Abel, Easton, Edwards, Herbster, and Sparapani (1994), in a paper presented at the Annual Meeting of the Association of Teacher Educators, described how five medium-sized state institutions with teacher education programs have begun to meet the needs of underrepresented, diverse populations. One of these, Central Washington University in Ellensburg, Washington, is establishing a professional development center to cater to its large Hispanic and Yakima Indian populations. Another, Jacksonville State University, Alabama, is operating the Center for Individualized Instruction; an academic support center serving an urban and rural Black population. Montana State University has created the Systemic Teacher Excellence Preparation Project which is aimed, in particular, at helping mathematics and science teachers from the Crow and Northern Cheyenne Nations, while the State University of New York at Plattsburgh, has an outreach program attempting to increase the diversity of the student body which includes Blacks, Hispanics, Asians, and French-speaking Canadian Americans.

Problems to Overcome: Possible Solutions

David Tyack (cited in Nachtigal, 1982) points to the heart of the problems in our educational system with his description of the "One-Best-System" model of education which, "not only fails to recognize urban/suburban/rural differences, but ignores the needs of unique populations as well" (p. 5). It should also be noted that there has been a failure to realize that "the function of a rural school goes far beyond that of educating children; it is not only a piece of the local social structure, it is often the hub that holds the community together" (Nachtigal, 1982, p.11). Further, Galbraith (1992) claimed that small, locally run schools have a better chance of responding to the needs of a minority community than schools embedded in a large bureaucracy.

In the case of rural minorities, the major problems to surface, above and beyond those of rural poverty, isolation, and inadequate health services, are those associated with:

1. The need for validation and inclusion (Tikunoff, 1984; Cummins,1989; Grant & Gillespie, 1993; Dooley, 1994; Barba, 1995).
2. Limited English Proficiency (LEP) (Tikunoff, 1984; Cummins,1989; Grant & Gillespie, 1993; Sosa, 1993; Barba, 1995).
3. The need to include parents and community (Tikunoff, 1984; Cummins, 1989; Grant and Gillespie, 1993; Barba,1995).

H. L. Mencken once said (as cited in U. S. Department of Education, 1989), "There is a solution to every problem: simple, quick, and wrong" (p.60). We shall now look at three of the greatest problems facing underrepresented, minority students that we consider solvable but the solutions are neither simple nor quick. However they may just be appropriate.

Validation and Inclusion of Minority Cultures

Henry Giroux, in his book *Theory and Resistance in Education* (as cited in Grant and Gillespie,1993) posits that "minorities do not succeed in the public school system because they resist the dominant culture and reject institutions that render them invisible or devalue their heritage" (p.5). Surely, an obvious solution would be to incorporate minority students' own culture in their education and to work from there so that they feel validated and included.

Marinez and Ortiz de Montellano (1988) state that there is a need to teach using a wider diversity of examples from different cultures. "This will send a message to the minority child that my ancestors or people like me did engage in scientific endeavors, and thus I can do it too" (p. 7).

This idea is being put into action through a joint project between The Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) and The Project for Renewed Incentives in Science Education in Los Angeles (Project RISE-LA) at UCLA (Marinez and Ortiz de Montellano, 1988). Los Angeles is not a rural setting but a model is being developed using workshops which introduce teachers to culturally relevant materials and provide them with activities that are currently being developed, such as a unit on the different uses and sources of plants. This particular unit focused on how Indian civilizations have contributed to food resources. A similar unit worked well for one of the authors while teaching in Botswana, Africa. As a way to engage the students' interest in a unit on plants they were asked to bring in examples of traditional plant remedies for common illnesses. The students produced a wealth of information and ideas, and allowed the teacher to become the learner, hence empowering the students. This was an example of validation and inclusion in action. Grant and Gillespie (1993) made a valuable contribution when discussing sound teaching practices: "Though good teachers from any background will do all these things, the value of a teacher from the child's own culture cannot be overestimated" (p. 26). To illustrate the point that however well intentioned a teacher may be, a lack of knowledge about a particular culture can sometimes have unfortunate results, the following example from Szasz (as cited in Grant and Gillispie, 1993) is used. A Hupa Indian parent who was testifying before an Indian Nations at

Risk Task Force hearing in 1990 related how a teacher had said that "only pigs and deer eat acorns." Taking this literally the parent reasoned that, "Since I have only two children, this means that one must be a pig and the other one must be a deer..." (p.31).

Another example of validation and inclusion is taken from Joining the Circle (Grant and Gillespie, 1993). The teachers from Eastwood Elementary School, a mining town in Northern Manitoba, Canada decided to forsake the teaching of science through the traditional chalk, talk, and textbook. Instead they invited local community experts into the classroom to teach from experience such practical activities as gutting and preparing fresh fish. "While non-Native colleagues squirmed uncomfortably, Native American students contributed vigorously with instructions and anecdotal remarks, which they later included in excellent writings and retellings" (p. 37). Apparently student self-esteem was enhanced and the program was retained as a part of the regular curriculum before also being adopted at the Junior High level. It is interesting to note that "retellings" is an integral part of the program as it is an aspect of learning that is often ignored as teachers tend to focus on what students can put down on paper rather than what they can verbalize.

Grant and Gillespie (1993) claimed that, by allowing Native American students to see that their culture was valued and respected, enabled them to develop the skills necessary to fit into the mainstream curriculum. Batey and Hart-Landsberg (1993) noted that well-intentioned teachers who "fail to learn about local customs, culture, history, and ways of being can unwittingly sabotage the chances that they have to succeed" (p. 11). Students from different cultures may learn in different ways that must be respected and incorporated into the pedagogy.

Limited English Proficiency (LEP)

Garcia (1988) found that "Instruction in the native language of LEP students allows them to participate in school and to acquire the skills and knowledge covered in the curriculum while also learning English" (p. 6). This strikes us as not only reasonable but essential. Batey and Hart-Landsbery (1993) provided the example of a native Yup'ik Eskimo teacher who helped her students to grasp certain math concepts that were causing them problems because, in their culture, they do not use exact numbers. She did this by translating from English into Yup'ik and by showing pictures, words, and ideas as the students are highly visual.

One attempt to find a solution to the problem of Limited English Proficiency is being tried in Botswana, Africa. The first three years of elementary school instruction are in Setswana (the native language). Year Four is a transition period when both Setswana and English are used, and the focus of years five, six, and seven is on increasingly adopting English as the predominant language. Obviously a major stumbling block in this process occurs if the teacher is not bilingual and, in the United States, the recruitment of bilingual teachers is abysmally low. Oklahoma is one state which is attempting to improve its record in this area where recently a school reform act called for the establishment of a center for minority teacher recruitment.

Newly graduated teachers in Botswana were unwilling to move from the more densely populated eastern edge of the country to teach in the more remote areas around the Kalahari Desert. The government solution was to actively recruit potential teachers from these remote areas, with their different tribes and dialects, with the not unreasonable expectation and understanding that they would want to return to their home areas to teach. It is a solution that appears to be working for the benefit of remote, rural minorities and could, presumably, work in the United States.

Cardenas, Robledo, and Supik (1986) pointed out that Hispanic students are twice as likely to drop out of school as their White counterparts in Texas, mainly due to a lack of academic achievement. A recent study by the American Council on Education (Carter and Wilson, 1991) reported a decline in high school completion rates for Hispanics which, in 1990 was 54.5% compared to 77.0% for Blacks and 82.5% for Whites. In addition, according to Cardenas et al. (1986), LEP students are over-represented in special education classes; are less likely to be identified for programs serving the gifted and talented; and are penalized by low teacher expectations for language minority groups. One way to redress these imbalances is to allow students to continue to learn in their native language or dialect.

Perhaps, one way to lessen the dependency on language is to reduce the use of written language, and make the learning more practical and hands-on. Nachtigal (1980) noted that "easy accessibility to the rural setting provides a living laboratory for the study of biology... Urban schools are forced to simulate such experience through textbooks and other learning aids; rural schools need not do this" (p. 37). Of course they often do because of the all pervasive influence of the ubiquitous textbook and a golden opportunity is being missed.

Inclusion of Minority Parents and Community

If parents are not involved in their children's education, academic achievement can be lessened. This is not a new idea but parental exclusion still continues and schools fail to involve the local community in school activities and decision making (Cummins, 1989). The problem is compounded by the fact that many minority parents have had little schooling or have poor academic backgrounds which, according to Sosa (1989), means that their children enter the educational system with no "educational legacy." A more appropriate statement might be that they enter with little or no "traditional educational legacy" because they assuredly come with some "culturally based education." Often a lack of traditional educational background is interpreted by teachers as a lack of ability when allowances should be made for building on the strengths that are present.

Parents can and should play a vital part in all classrooms, not just those of rural minority students. Moll (as cited in Sosa, 1993) calls attention to the many resources that are available to Hispanic children in Arizona. Their families have knowledge, information, and skills based on essential cultural practices that have allowed them to thrive despite their minority status which should be tapped by educators.

In Arizona, Robert L. Swift, Project Director of Community Science Programs (Nations, Swift, and Thomas, 1994) at Northern Arizona University has fostered just such cooperation with Native American schools in that region. Parents have been invited into the science classrooms so that they can experience "Western Science" with their children and work alongside them to solve problems. Children and their parents go on field trips together and produce a product after the event; something that allows sharing of skills, knowledge, and expertise. Despite the cessation of funding, many schools are continuing these joint parent-child-teacher programs through evening classes.

Two Rural Minority Population Staff Development Projects

In this section, two examples of science staff development projects are included, both with significant rural minority populations and were considered to be "successful" (defined in terms of teacher outcomes). In their design, some attempt was made to address aspects of the three major problems facing rural minorities just outlined, but it is the authors' contention that the level of "success" might have been higher had the problems of validation and inclusion, LEP, and inclusion of minority parents and community been addressed more completely.

1. *Rural Elementary Improvement Project (RESIP) 1989-1990.*

RESIP came about because it was recognized that Texas A &M University was underserving rural populations which lay between it and the more populated areas of the state. The needs of many rural students, some of whom might eventually seek access to the university to pursue science related courses, were being ignored.

With the help of a small group of rural administrators the science education needs of their rural districts were investigated. Subsequently, feedback from the teachers in these districts revealed the following science education needs:

- Improvement of teacher's science content,
- Assistance in helping students meet the state standards.
- Skills in implementing science processes.
- Training principals to support teachers in implementation of hands-on science.
- Identification of community resources to support elementary science.
- Development of a resource for hands-on science activities.
- Provision of science equipment and materials.

A total of seven small rural communities were served by the project. Their school populations varied from 10 to 1000 in grades K-6. Fifty-seven percent of the students were Caucasian, 22% were reported to be Black and 20% were reported to be Hispanic. In four of the districts, Black and Hispanic students made up more than half of the population.

Ten principals and 32 teachers participated in training activities. Unfortunately, only a few minority teachers were recruited, although minorities were actively encouraged to apply. This highlights the need for a more aggressive approach to increase minority student enrollment in Education Departments.

The teachers' 3-week training focused on content background and was enhanced by lectures provided by biology, chemistry, physics, geology and meteorology professors. A master teacher led the hands-on science activities portion of the training, and collaborated with the professors in selecting activities that supported their lectures. The emphasis on practical activities was seen as a way to improve both interest and performance in science for all of the students but was particularly beneficial to LEP students.

Teachers adapted hands-on science activities to fit their particular classroom environments and shared them with colleagues. Significant increases in the use of hands-on science were made from 20% at the pre-institute level to 85% during the first year following RESIP. In addition, gains in teacher scores on a science process skills test, and the implementation checklist demonstrated the positive impact of the program.

In order to involve local communities in RESIP a resource directory was developed by conducting a telephone survey. More than 150 local organizations, businesses and individuals committed to providing resources to support local elementary school science instruction. Copies of the directory were disseminated to the school principals and participating teachers.

2. *Agricultural Research Service Science Education Collaborative (ARSC) project 1994-1995.*

Recent reforms in science education have recognized the important role that scientists can play. Their understanding of scientific knowledge, participation in research, and access to the resources of the scientific community make them potentially invaluable to the success of a reform process.

The US Department of Agriculture's Agricultural Research Service (ARS) includes over 120 lab sites across the nation. Each lab site consists of agri-science research projects, scientists, technicians and facilities. Science teachers typically find familiar science concepts and processes being used in agri-science research laboratories. It is important to understand these laboratories are most often located in rural areas and are a wonderful potential resource for rural minorities.

While designing ARSC, it was decided that a collaborative activity including the schools, teachers, scientists, laboratories and county extension agents, would provide a project that would initiate and sustain change after the initial funded project was over. Thus, the project was named the Agricultural Research Service Science Education Collaborative (ARSC).

The specific objectives of the project were to: (a) familiarize middle level science teachers with agri-research; (b) guide them in the design and implementation of experience-based, thematic materials; (c) support teacher implementation through the establishment of a resource center that would remain at the lab site after the formal portion of the project was completed; (d) disseminate the project through staff development activities conducted by the participants for their peers; and (e) establish an on-going support mechanism of two teachers and a county extension agent. The components of the program included:

- Orientation to agri-scientists involved in the project.
- Collaboration between teachers and scientists in their labs.
- Development of hands-on agri-science activities.
- Leadership development through peer staff development.
- Maintaining a Science Learning Resource Center to sustain the project within the community.
- Establishing collaborative teams of sci-

ence teachers and an Agricultural Extension Service agent.

- Maintaining followup activities through inservice, classroom visits and networking through TENET (Texas Education Network).

Twenty-one science teachers were recruited of whom 85% were Hispanic and bilingual, a much more satisfactory percentage than that achieved for RESIP. The summer institute and follow-up activities were conducted in Agricultural Research Service or Research and Extension Center facilities, encouraging an interchange between the participants and researchers within the community.

By coincidence, as in RESIP, a total of seven school districts participated in ARSC. School District Administrators assisted in the selection and encouragement of the participants, provided release time for inservice sessions, and supported teachers in implementing the project in their classrooms.

As the project proceeded, it was discovered that these teachers had little sense of the potential of the science in their immediate environment. For example, apparently not since childhood had they paid any attention to antlions (Neuroptera) in the area. None had ever used the citrus flowers that are so abundant in the South Texas environment for the study of flower parts. Neither had they emphasized the study of the local soils. The project coordinator focused on the science of their immediate surroundings to stimulate teachers to use this resource in working with children.

Once the teachers were weaned from a strict adherence to the textbook, it was encouraging that they could find material, such as familiar indigenous flora and fauna, to use in their classrooms. It is an indictment of our current teacher education programs that the ability and confidence to move away from the text is lacking or suppressed. In this case validation and inclusion proved beneficial in helping to achieve the aims of the project.

Currently a Science Resource Directory similar to the one developed for RESIP is being put together for the ARSC area. Again, this is an attempt to involve the local community in the science that is being taught in their schools and to make it more relevant to minority students.

Current Thinking on the Design of Staff Development Projects

It is likely that most staff development designs are based on what the designer(s) believe will be successful. Recently, a more systematic approach has been developed. The booklet *Profiling teacher development programs: an approach to formative evaluation* (1993), contains a list of "best practice" for staff development programs based on a review of the literature. The list includes:

- Program administration (collegial atmosphere; serve underrepresented).
- Vision for the classroom (deep understanding; hands-on/minds-on approach; depth rather than breadth of content; balance between content and process; authentic assessment; and learning outcomes).
- Teacher development program activities (adult learners; construct knowledge; immerse (do science); "real world" science; learn cooperatively).
- Follow-up.
- Teacher leadership development.
- Program evaluation

ARSC was designed along the following lines:

Also guiding thinking on effective staff development is the concept of "systemic change." As detailed in *Systemic Reform Perspectives on personalizing education* (U. S. Department of Education, 1994), systemic change reflects the need to make provision for:

- Achieving national standards
- Implementing research based approaches to teaching and learning
- Implementing statewide programs
- Integrating technology into the curriculum
- Involving parents, business, and industry
- Ensuring equity and access
- Involving institutions of higher education

It is interesting to note that neither "best practice," nor "systemic change" directly address the problem of LEP among students but, that both inclusion and validation, and involvement of parents and community are covered to some extent.

In conclusion it is suggested that any future staff development programs should attempt to incorporate the elements of "best practice" and "systemic change" in their design. The design should also respond appropriately to the three major problems confronting rural minority students and the following strategies are offered as ways of achieving success in those areas:

Validation and Inclusion

- Identification and use of role models with whom students can identify
- Staff development for teachers on gender and ethnic equity in their classrooms
- Recruitment of minority teachers
- Immersion of project staff in the local culture before project design is attempted
- Inclusion of "cultural science" e.g. a local herbalist might incorporate indigenous plants and their medicinal properties

Limited English Proficiency

- Focus attention on minority language written materials and bilingual teachers.
- Continue the emphasis on hands-on science since it isless language based.
- Make use of minority language science terms.
- Engage the bilingual teachers in designing ways to help LEP students.

Inclusion of Minority Parents and Community

- Focus on community resources
- Seek more involvement from minority parents
- Attend to local science related issues and contexts
- Expand the project to include "family science"

Summary

The authors conclude that helping science teachers provide minority students with a sense of inclusion and validation, attending to the language needs of minority students, and involving parents and community in science instruction of minorities, could add to increased science learning. Teachers have not been taught to do these things and need to develop these skills.

Galbraithe (1992) observed that "Policies for one minority group, community, or region may or may not be appropriate for another" (p. 257). It is essential that an honest attempt be made to design each staff development project so that it is sensitive to the needs of the minority students in their respective rural setting.

References

Abel, F. J., Easton, S. E., Edwards, P., Herbster, D. L., & Sparapani, E. F. (1994). *Serving under-represented diverse populations.* Atlanta, GA: Association of Teacher Educators.(ERIC Document Reproduction Service No. ED 367 604).

Arizona State University. (1992). *Minority student achievement partnerships: what's working in Arizona.* Volume One. Phoenix, AZ: Arizona Minority Education and Achievement Cooperative. (ERIC Document Reproduction Service No. ED 360 118).

Baird, W. E., Prather, J. P., Finson, K.D., & Oliver, J. S. (1994). Comparisons of perceptions among Rural versus Nonrural Secondary Science teachers: a multistate survey. *Science Education, 78*(6), pp. 555-576.

Barba, R. H. (1995). *Science in the multicultural classroom. A guide to teaching and learning.* Needham Heights, MA: Allyn and Bacon.

Batey, A., & Hart-Landsberg, S. (1993). *Riding the wind. Rural leadership in science and mathematics education.* Portland, OR: Northwest Regional Educational Laboratory.

Cardenas, J., Robledo, C., & Supik, J. (1986). *Texas school dropout survey project: a summary of findings.* San Antonio, TX: Intercultural Development Research Association.

Carter, D.J., & Wilson, R. (1992). *Minorities in higher education: 1991 tenth annual status report.* Washington, DC: American Council on Education.

Cummins, J. (1989). *Empowering minority students.* Sacramento, CA: California Association for Bilingual Education.

DeYoung, A. J. (Ed.). (1991). *Rural education. Issues and practice.* New York, NY: Garland Publishing.

Galbraith, M. W. (Ed.). (1992). *Education in the rural American community. A lifelong process.* Malabor, FL: Krieger.

Grant, A., & Gillespie, L. (1993). *Joining the circle: a practitioner's guide to responsive education for Native students*. (Report No. ISBN-1-880785-08-0). Charleston, WV: Eric Clearinghouse on Rural Education and Small Schools. (ERIC Document Reproduction Service No. ED 360 117).

Marinez, D. I., & Ortiz de Montellano, B. R. (1988). *Improving the science and mathematics achievement of Mexican American students through culturally relevant science*. Las Cruces, NM: Eric Clearinghouse on Rural Education and Small Schools. (ERIC Document Reproduction Service No. ED 296 819).

Nachtigal, P. M. (1980). *Improving rural schools*. Washington, DC: National Institute of Education.

Nachtigal, P. M. (Ed.). (1982). *Rural education: in search of a better way*. Boulder, CO: Westview Press.

National Center for Educational Statistics (1994). *1990-1991 Schools and staffing survey: selected state results* (NCES Publication No. 94-343). Washington, DC: Government Printing Office.

Nations, D., Swift, R .L., Thomas, R. (Producers), & Swift, R. L. (Director). (1994). *Community Science Programs* [videotape]. Flagstaff, AZ: Northern Arizona University.

Profiling teacher development programs: an approach to formative evaluation. (1993). Andover, MA: The National Center for Improving Science Education of the NETWORK, Inc.

Rios, B. R. D. (1987). Selected trends and issues in rural education in small schools. Las Cruces, NM: Eric Clearinghouse on Rural Education and Small Schools. (ERIC Document Reproduction Service No. ED 289 669).

Sherman, A. (1992). *Falling by the wayside: children in rural America*. Washington, DC: Children's Defense Fund.

Sosa, A. (1993). *Thorough and fair: creating routes to success for Mexican American students*. Charleston, WV: Eric Clearinghouse on Rural and Small Schools. (ERIC Document reproduction Service No.ED 360 116).

Tikunoff, W. J. (1984). *Applying significant bilingual features in the classroom*. Rosslyn, VI: InterAmerican Research Associates Inc.

U.S. Department of Education. (1989). *Rural education. a changing landscape*. Washington, DC: United States Government Printing Office.

U.S. Department of Education. (1994). *Systemic Reform. Perspectives on personalizing education*. Washington. DC: United States Government Printing Office.

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