Legacy of the Rural Systemic Initiatives: Innovation, Leadership, Teacher Development, and Lessons Learned

January 13, 2012

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Two companion documents, A Legacy of Leadership and Lessons Learned: Results from the Rural Systemic Initiatives for Improving Mathematics and Science Education (June 2007) and Proceedings of the Forum on Leveraging a Legacy of Leadership in Rural Mathematics and Science Education are available on the Edvantia website.

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Executive Summary

The Rural Systemic Initiative projects (RSIs), funded by the National Science Foundation (NSF), represent an investment of more than $140 million in the improvement of mathematics and science education in rural America. RSIs were launched in 1994 and came on the heels of the State Systemic Initiatives and the Urban Systemic Initiatives, which the NSF launched in 1990. From the mountains of Alaska to the Mississippi Delta, from the Indian reservations of the Great Plains to the hollows of Appalachia, RSIs have served economically disadvantaged and geographically isolated regions that face daunting challenges for educational reform.

This monograph pays tribute to the RSIs that created critical capacity in some of rural America's most impoverished communities to help ensure that students are prepared as citizens and workers with a quality education in mathematics and science. The monograph lays an important foundation for contextual understanding about improving public education in rural settings. Almost 8,000 or more than half (56%) of all public school districts in the U.S. are located in rural areas. These districts include approximately one third (31%) of the nation's public schools and more than one fifth (21%) of the total U.S. student population. More than 10 million students are served by rural schools.

Results of three separate research efforts by the authors are presented to document the legacy and impact of the RSIs. First, in 2007, reports of selected RSIs were synthesized to provide examples of the innovative leadership, intervention models, and lessons learned. Second, in 2008, a forum was held in the Rayburn Building, U.S. House of Representatives in Washington, DC, during which examples were presented of how school districts and selected federal agencies could leverage RSIs for improving mathematics and science education. Third, in 2009, we conducted focus group and conference call sessions with teachers who participated in selected RSIs that served five ethnically concentrated populations of students in rural America: African American, American Indian, Alaska Native, Appalachian White poor, and Hispanic American.

In this monograph, examples of the innovations, leadership, teacher development, and lessons learned that tell a story of success are provided. The final monograph chapter describes future directions for advancing the legacy of the RSIs: instructional leadership capacity, teacher recruitment and retention, and policy actions. One appendix lists the 30 RSIs funded by the NSF; a second appendix identifies science, technology, engineering, and mathematics (STEM) resources from numerous NSF research and development projects.

Innovation Highlights

The contexts for reform of mathematics and science education varied among the RSIs and influenced innovations pursued. For example, numerous factors defined the context in the Delta—an area of rural America that included 61 of the most underserved counties and parishes in the states of Arkansas, Louisiana, and Mississippi. The Delta RSI contextual factors included low population density, low expectations for student academic achievement, high percentage of students eligible for free or reduced-price meals, little economic diversification in the local economy, high teacher and administrator attrition rates, and limited educational attainment by parents.

The Delta RSI model of intervention sought to be a change agent by

- accelerating the pace of reform in science, mathematics, and technology education;
- implementing research-based strategies;
- identifying resources;
- replicating successful reform models;
- developing leadership abilities at all levels;
- delivering professional development based on identified needs; and
- using a team-based approach to improve teaching and administration.

The Appalachian RSI model, which evolved over 10 years, has been used to implement a standards-based curriculum and provide professional development and technical assistance for teachers and school leaders. The success of this model lies in its regional delivery system and its capacity-building strategies through the use of resource collaboratives and the development of "teacher partners."

Over a 10-year period, the Alaska RSI strategy sought to foster connectivity and complementarity between two functionally interdependent but historically alienated systems—the indigenous cultures of rural Alaska and the formal systems imported to serve the educational needs of Native communities. A key underpinning of the Alaska RSI is a body of scientific and mathematical knowledge that can strengthen the quality of education throughout rural Alaska.

A key Alaska RSI strategy was the regional Academies of Elders for Native Educators. Each time, the academy was held for a week or more at a camp or village site where teachers, elders in the native culture, and scientists in mathematics and science disciplines shared their knowledge. Teachers participating in the academy were then responsible for developing curricular applications of what they had learned, checking with the elders and scientists for accuracy, and then testing these outcomes in the classroom to determine how effective the curricular applications were. The refined curricular units were then compiled, placed on the Alaska RSI website, and published in paper form for distribution to other teachers and schools throughout Alaska.

The Coastal RSI model of change, focusing on the coastal regions of North Carolina, South Carolina, and Virginia, required the creation of a continuous improvement team at the district and school levels. The model sought to address the following common issues in rural school districts that traditionally limit sustainable improvements in mathematics and science:

- Small district staffs with too many job functions and responsibilities
- Lack of district personnel with math/science backgrounds
- Inadequate data for making program improvement decisions
- Limited teacher access to professional development opportunities
- Ineffective decision-making processes
- Inadequate use of existing school improvement resources
- Turnover in key leadership positions

The Ozarks RSI model in 10 Missouri school districts focused on systemic instructional change that required schools to adopt a standards-based curriculum. The need to implement the new curriculum served as a catalyst for all teachers to examine their teaching practices and identify their professional development needs.

The Wind River RSI served the Eastern Shoshone and Northern Arapaho nations and included five school districts on the reservation considered "site" schools. Two school districts off the reservation were considered "focal" schools. The Wind River RSI pursued a bottom-up and top-down approach that included numerous partners and listening to tribal leaders and also started the first virtual public school in Wyoming.

The Coalfield RSI strategy focused primarily on developing leadership capacity in 17 rural school districts of Virginia and West Virginia. The strategies used in this RSI were preparing "teacher leaders," emphasizing a data-driven approach to enhancing the support of district leadership, developing strong parent and community support, and partnering with local higher education institutions.

The Texas RSI pursued a Learn, Implement, Share model as the basis of an action plan. The Texas RSI supported members of a district leadership team to implement what they learned and to share with others. Supported by Texas RSI regional mathematics and science specialists, teacher partners were the primary catalysts for systemic reform in their districts.

Leadership Highlights

A common circumstance among the rural school districts participating in RSIs was a lack of specialists in mathematics or science. Consequently, most RSIs implemented a strategy to enhance the knowledge and skills of district and school administrators in order to improve mathematics and science education. Although this was a common strategy, major initiatives also focused on developing "teacher leaders," "teacher partners," or "team leaders" who could assist other teachers in their schools to implement inquiry-based, constructivist approaches aligned with curricular standards and assessment.

Examples of teacher leadership from the various RSIs include the following:

- Hawaii Networked Learning Community RSI (Hawaii RSI) defined teacher and student outcomes as parallel statements. For example, the teacher will "build inquiry around place-based issues and topics involving culture and environment" and "the student will investigate environmental issues and topics that are relevant to their neighborhoods and communities," respectively.
- Texas RSI provided leadership development opportunities at teacher partner academies, where presenters modeled learner-centered instructional strategies, such as problem solving and inquiry learning.
- Coalfield RSI teacher leader activities included modeling inquiry-based instruction, assisting in data analysis, helping with school and district planning, leading staff development, encouraging students to become mathematics and science teachers, serving as mentors, and helping to recruit new teachers.
- Appalachian RSI partners helped teachers implement standards-based instruction and provided support for curriculum development and selection of resources.

Some RSIs also focused on enabling school administrators (e.g., principals) to effectively lead improvements in mathematics and science education. Examples of leadership development activities among the RSIs include the following:

- Appalachian RSI principals were trained to recognize effective instruction in mathematics and science and were thus able to support data collection and analysis of classroom practices.
- Ozarks RSI provided principals and assistant principals with focused professional development on critical systemic reforms in mathematics and science, including how to conduct a walk-through observation of a classroom during the teaching of a mathematics or science concept.
- Texas RSI placed a priority on developing proactive principals who could support teachers by discussing changes in policies and school improvement plans consistent with a high-quality program of mathematics and science education (e.g., the TRSI Attributes).
- Navajo Nation RSI hosted its first school leadership conference, using indigenous knowledge of leadership and education as the centerpiece of training.

Teacher Development Highlights

Results of focus group sessions, conducted by the authors, with teachers who participated in the RSIs tell the story of how teachers prepare the next generation of engineers, mathematicians, and scientists. Teachers also provide insights into how involvement in the RSI helped change their teaching practices.

Teacher Development Needs

Most teachers in the focus group sessions described their RSI professional development opportunities as a "once-in-a-lifetime" experience. Teachers in their respective focus group sessions expressed examples of professional development needs. To illustrate,

- Alaska RSI teachers indicated a need for sessions on ideas for experiments and projects that are place-based or connected to Native Ways of Knowing.
- American Indian/Tribal RSI teachers expressed a need for networking opportunities to share ideas and best practices and to travel to see exemplary exhibits of mathematics and science instructional resources.

- Teachers in the Appalachian RSI expressed the need to be part of a group of mathematics and science teachers that consistently meets as a learning community, rather than district professional development meetings that focus on a general topic for all teachers.
- Delta RSI teachers expressed a need for workshops on how to do inexpensive lab activities with students, rather than using the expensive *Full Option Science System* (*FOSS)* kits.
- Teachers in the Texas RSI expressed a need for professional development opportunities that include instructional equipment and materials to take back to their classrooms so they could effectively implement the new practices.

Policymakers Need to Know

Teachers in the focus group sessions were asked what aspects of their professional growth resulting from participation in the RSIs should be shared with national, state, and/or local policymakers. Teachers pondered why high quality, content-specific professional development, like that offered by the RSIs, could not be provided more routinely to teachers of mathematics and science. The teachers said that making such opportunities available only seemed appropriate. After all, state leaders emphasized STEM education, and national policymakers consistently linked America's global competitiveness to excellence in teaching mathematics and science in public schools. Teachers perceived that policymakers may lack sufficient understanding of the positive impact of the RSIs on teachers and teaching.

Lessons Learned

Leaders of each RSI reported learning many valuable lessons from implementing their model of change for improving mathematics and science education in high-poverty rural areas. Lessons learned varied across the RSIs, though they are specific to the RSI model of change and/or circumstances encountered during implementation in rural contexts. Although a specific lesson learned may be applicable to more than one category, the lessons learned were grouped under four broad categories: (1) providing administrative understanding and support; (2) accessing ongoing external expertise, materials, and support; (3) developing and sustaining leaders for change; and (4) making decisions and maintaining communications. A detailed list of lessons learned is found in Chapter 5.

Concluding Thoughts and Future Directions

"Where do we go from here?," a question posed by Dr. James Rubillo, executive director of the National Council of Teachers of Mathematics, in his remarks at the *Forum on Leveraging a Legacy of Leadership in Mathematics and Science Education*. To answer this question, the authors draw upon their work in and research of the RSIs; research literature; and their experiences as former state department of education officials, project managers in a regional education laboratory, and as consultants and evaluators of numerous school improvement efforts.

In this monograph, the authors offer some insights and future direction for improving mathematics and science education in rural America. Three themes that build on the challenges addressed by the RSIs are discussed. These themes are instructional leadership capacity, teacher recruitment and retention, and policy actions, which is further divided into (1) planning improvements, (2) implementing improvements, and (3) providing incentives for improvements.

To address the challenges presented within each theme, tough decisions by policymakers, educators, and community leaders must be grounded in what has been learned from the RSIs. Clearly, one model of reform does not fit the diverse cultures, communities, and economies in rural America.

Foreword

Legacy of the Rural Systemic Initiatives: Innovation, Leadership, Teacher Development, and Lessons Learned offers an in-depth look at key factors central to the National Science Foundation's (NSF's) efforts to reform rural K-12 public education and tribal programs in mathematics and science. The authors, Drs. Hobart L. Harmon and Keith C. Smith, provide a foundation of contextual understanding for improving public education in rural schools where more than 10 million students are educated. The accomplishments and lessons learned by the Rural Systemic Initiatives (RSIs) hold unparalleled value for policymakers, researchers, and reformers who seek to improve mathematics and science education in rural America.

The RSI evolved from two previous reform efforts. The initial effort to promote reform in mathematics and science education began with a Statewide Systemic Initiative (SSI) for 26 states. The SSI was followed by the Urban Systemic Initiative (USI), which targeted the largest urban school districts. The USI eventually expanded to serve 30 smaller urban school districts throughout the country.

The NSF Directorate for Education and Human Resources, under the visionary leadership of Dr. Luther S. Williams, provided an unprecedented opportunity to promote a holistic approach to the reform efforts of mathematics and science education that demanded the application of process drivers by local educational leadership in establishing standards-based curriculum and instruction. Equally important, the process allowed flexibility for cultural and regional differences to be factored into the process. Historically, many reform efforts have been limited to piecemeal funding approaches and local educational leadership, e.g., leadership training, curriculum development, and teacher training, without considering the interaction of such efforts in addressing comprehensive educational reform.

The investment of more than $140 million by the NSF in rural education from 1994 through 2008 represents perhaps the most significant effort by the federal government to ameliorate the inadequacies of K-12 mathematics and science programs in some of the most impoverished areas of rural America. The effort sought to raise the educational standards of rural schools in order to enhance the quality of life for rural residents and impact the long-term economic development of their communities. Rural leaders viewed the initiative as an effort to overcome the benign neglect that has been allowed to fester throughout the history of rural schools in America.

As with schools in urban areas, the challenge to reform schools in rural America is complex. Rural schools have issues and barriers that are endemic to their communities, with different regions of the U.S. having special circumstances to consider in the reform process. Commonalities include poverty, complacency, economic deprivation, geographic isolation, teacher turnover, lack of resources, and limited training programs for teachers and parents. More positively, rural communities share strong core values and cultural characteristics—e.g., languages, belief systems, local knowledge bases—that have contributed historically to their survival.

The NSF's RSI program provided a necessary venue and structure for rural educators to utilize the strengths of their communities in adopting or designing effective approaches to reform initiatives. The NSF's theoretical framework required that each RSI develop a strategic plan to address community participation, parental involvement, resource convergence, leadership, partnerships, teacher development, and establishment of educational standards at the district level, while also considering local or regional differences and cultural circumstances. In addition, the required strategic plans mandated outcome drivers, establishing targeted outcomes for levels of achievement over specific time frames. This was a paradigm shift in how most rural school systems planned educational improvements in mathematics and science education. For the first time, many leaders in public and tribal rural schools believed they had a license to think creatively in their efforts to improve mathematics and science education.

The following chapters provide examples of the success experienced by the RSIs, including the areas of innovation, leadership, teacher development, lessons learned, and issues for policymakers. Finally, the monograph provides concluding thoughts and future directions in the belief that what has been learned from the NSF experiment must be shared and considered by policymakers, educational reformers, and organizational leaders to meet future challenges in rural education.

Gerald E. Gipp, Ph.D.
Hunkpapa Lakota
Standing Rock Sioux Tribe
Former Program Director
NSF Division of Educational System Reform

Acknowledgments

Several individuals at the National Science Foundation (NSF) deserve acknowledgment for their contribution to the improvement of mathematics and science programs in rural America. NSF leadership was instrumental in recognizing that K-12 educational systems in high-poverty areas of rural America required special attention, and it created the Rural Systemic Initiatives (RSIs) to complement urban and state initiatives. In particular, Dr. Luther S. Williams' vision of systemically addressing improvement in mathematics and science education enabled the RSIs to be developed over an adequate period of time in order to produce important results. Dr. Williams served as the assistant director of Education and Human Resources (EHR) at the NSF when the initiatives were established and initially funded.

Two additional leaders at the NSF played major roles in the formulation of systemic initiatives: Dr. Pierce Hammond, senior advisor to the EHR director, and Dr. Jane Stutsman, deputy assistant director. Both were key players in designing and developing the RSIs. Equally important was the consistent, knowledgeable, and dedicated project officer, Dr. Jody Chase, who provided essential support, guidance, and advocacy for the duration of the RSI effort.

On the implementation side, Dr. Wimberly Royster, a mathematician and principal investigator of the Appalachian RSI, played a unique role and provided the initial leadership to organize a 1993 conference that led to the national RSI effort. Dr. Royster further helped to create interest in and support for the RSIs across the country, frequently serving as a spokesperson for the RSI community to the NSF and federal policymakers.

It has been our privilege to personally work in some of the RSIs, as well as serve in researcher roles to examine the NSF RSI effort. We know firsthand the highly dedicated leadership and commitment of their principal investigators and directors. We owe them and their staff members a great debt of gratitude for responding to our requests for information over the last three years that contributed to this monograph. Moreover, we extend a special thanks to the practitioners in rural school districts who served on the forum panel, in focus groups, or in other capacities to share their experiences as participants in an RSI. We also are grateful to the district superintendents, school board members, and rural students who shared their talents with us. Telling the RSI story would have been impossible without their voices.

Numerous other individuals deserve recognition here, including the representatives of selected federal agencies who participated in the Washington, DC forum: Dr. Jody Chase, NSF Program Officer; Dr. Brian O'Donnell, Program Manager, Office of Science, U.S. Department of Energy; Dr. Carl Person, Manager, Minority University and Education Program, National Aeronautics and Space Administration; and Miriam Lund, Program Officer for Mathematics and Science Partnerships, U.S. Department of Education. We extend a special thanks to Dr. James Rubillo, Executive Director, National Council of Teachers of Mathematics, for providing observations about the forum.

Appreciation is also extended to the House Standing Committee on Science and Technology's Subcommittee on Research and Science Education for assistance in conducting the forum in the Committee's conference room. We also thank Majority Staff Director, Dr. James Wilson, and staff for logistical arrangements that made the forum a huge success.

We are immensely grateful to Dr. Gerald Gipp for writing the foreword to this monograph. Funding by the NSF enabled us to discover how the RSIs produced a legacy of leadership, innovation, and lessons learned. Lastly, we offer a special thanks to Paul Harmon for figure-design assistance and selected personnel at Edvantia, Inc., who supported us in various ways over three years in collecting data, preparing reports, and producing this monograph. These persons include Dr. Doris Redfield, Dr. Sandra Angius, Dr. Kristine Chadwick, Nadine Goff, Carolyn Luzader, Penny Garnes, and Nathan Davis.

About the Authors

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Dr. Keith C. Smith is the Virginia State Liaison for the Appalachia Regional Comprehensive Center at Edvantia, which is funded by the U.S. Department of Education. Dr. Smith served as the director of the Coalfield Rural Systemic Initiative, a project funded by the National Science Foundation to address educational opportunities and student performance in mathematics and science education. Previously, Dr. Smith served as an assistant state superintendent for the West Virginia Department of Education and, for two years, served as the director of the Appalachian Rural Systemic Initiative (ARSI), which was operated by the Kentucky Science and Technology Council. Prior to joining the ARSI staff, Dr. Smith played an active role in planning the six-state ARSI project and was a member of the ARSI management team. Dr. Smith earned a Ph.D. degree from The Ohio State University, a Master's degree from the University of Toledo, and a Bachelor of Science degree from Glenville State College.

Chapter 1 - Introduction

Almost 8,000 or more than half (56%) of all public school districts in the U.S. are located in rural areas. These districts include approximately one third (31%) of the nation's public schools and more than one fifth (21%) of the total U.S. student population. More than 10 million students are served by rural schools (Provasnik et al., 2007).

The Rural Systemic Initiative (RSI) projects funded by the National Science Foundation (NSF) represented an investment of more than $140 million in the improvement of mathematics and science education in rural America (see Appendix A for a list of RSI projects awarded by the NSF). The RSIs were launched in 1994, succeeding the State Systemic Initiatives and the Urban Systemic Initiatives, which were launched by the NSF in 1990. From the mountains of Alaska to the Mississippi Delta, from the Indian reservations of the Great Plains to the hollows of Appalachia, the RSIs served economically disadvantaged and geographically isolated regions that faced daunting challenges to reform education.

While calls for the nation to reform mathematics and science education in public schools continue to accelerate, limited information has been available about the results of the RSIs. A few articles about the RSIs have been published in academic journals (e.g., Blanton & Harmon, 2005; Harmon, Gordanier, Henry, & George, 2007; Harmon, Henderson, & Royster, 2002; Harmon, Henderson, & Royster, 2003). Two somewhat recent books reveal how the RSIs pursued the reform of mathematics and science education: *Building Community: Reforming Math and Science Education in Rural Schools* by Paul Boyer (2006), and *Telling the Story: Tribal College Rural Systemic Initiative* edited by Loretta DeLong (2006). Annual project reports for the RSIs are also available (e.g., Good, 2004; Harmon, 2006; Heenan, St. John, Brown, Howard, & Becerra, 2001; Horn, 2004; Horn & Tressler,2002; Inverness Research Associates, 2006; McKinley, 2004; Russon, Paule, & Horn, 2001; Westat-McKenzie Consortium, 1999).

This monograph brings together key results of three different research efforts by the authors to document the legacy of the RSIs. First, in 2007, reports of a sample of RSIs were synthesized to provide examples of innovative leadership, intervention models, and lessons learned. For example, reports from all of the tribal RSIs funded by the NSF were not examined. Based on our familiarity with NSF projects and discussions with NSF personnel, the RSIs included were those that could offer geographic, rural, and cultural diversity within the total set of NSF RSI projects (e.g., Alaska, Appalachia, Delta, American Indian, and Hispanic). Second, in 2008, a forum was held in the U.S. House of Representatives' Rayburn Building during which former RSI leaders, practitioners, and federal agency representatives served on panels to provide examples of how rural school districts could leverage the RSIs to improve mathematics and science education. Third, in 2009 focus group and conference call sessions were conducted with teachers who participated in the RSIs that served five ethnically concentrated populations of students in rural America: African Americans, American Indians, Alaska Natives, Appalachian White poor, and Hispanic Americans.

Call for Action

Throughout the first decade of the 21st century, the need to improve mathematics and science education accelerated. Numerous reports and organizations called for significant action to increase U.S. competitiveness in the evolving global economy. For example, on December 6, 2005, a group of more than 55 leaders that included corporate CEOs, university presidents, and scientists participated in a daylong summit. These leaders pressed cabinet secretaries and members of Congress on key issues related to keeping the U.S. economy globally competitive (National Association of Manufacturers, 2005). Their report titled *National Summit on Competitiveness: Investing in U.S. Innovation* (2005) was a call to action:

> The National Summit on Competitiveness has one fundamental and urgent message: If trends in U.S. research and education continue, our nation will squander its economic leadership, and the result will be a lower standard of living for the American people.
>
> Global conditions are changing. The competition is getting better at creating and deploying new knowledge. Information technologies are enabling the rapid diffusion of knowledge, know-how, and advanced manufacturing capacity. Talent, technology, and capital are available globally. In this new economic landscape, past performance is no guarantee of future success.
>
> The good news is that America is able to meet these challenges from a position of economic strength. We have the resources in people, ideas, and financial strength to invest in a successful future. We will falter only if we are complacent (p. 2).

One of the key tasks highlighted at the national summit for action by policymakers was to expand the innovation talent pool in the U.S. by seeking to double, by 2015, "the number of bachelor's degrees awarded annually to U.S. students in science, math, and engineering, and increase the number of those students who become K-12 science and math teachers" (National Association of Manufacturers, p. 5).

Congress took action to improve mathematics and science education. In June of 2006, the House Science Committee unanimously passed a legislative package that included H.R. 5358, The Science and Mathematics Education for Competitiveness Act. On March 5, 2007, majority and minority leaders and more than 50 cosponsors in the U.S. Senate introduced S. 761, The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act. On August 9, 2007, President George W. Bush signed into law H.R. 2272, a redaction of the latter, and noted:

> This legislation shares many of the goals of my American Competitiveness Initiative (ACI). ACI is one of my most important domestic priorities because it provides a comprehensive strategy to help keep America the most innovative nation in the world by strengthening our scientific education and research, improving our technological enterprise, and providing 21st century job training (quoted in Woolley & Peters, 2010).

Against the backdrop of the nation's worst economic downturn since the Great Depression, President Barack Obama then launched the "Educate to Innovate" campaign on November 23, 2009, making science, technology, engineering, and mathematics (STEM) education a national priority. President Obama announced a series of high-powered partnerships involving leading companies, foundations, non-profits, and science and engineering societies dedicated to motivating young people across America to excel in science and mathematics. The partnerships represented a "call to action," initiating reforms to "help prepare America's students to graduate ready for college and career, and enable them to out-compete any worker, anywhere in the world" (White House Press Office, 2009).

Brown and Swanson (2003) offer several reasons why all Americans should care about the educational needs of rural America. As we entered the new millennium, more than 80% of the U.S. population resided in non-rural areas, and slightly more than 50% lived in places with more than a million residents. David Brown and Louis Swanson (2003, pp. 1-2), editors of *Challenges for Rural America in the Twenty-First Century*, offer three reasons:

1. Although rural people make up a minority of the U.S. population, the number of rural residents exceeds the total population of all but 22 of the world's 200 nation-states.

2. Almost three-fourths of the counties in the U.S. are classified as non-metropolitan (i.e., rural), and they house most of the nation's natural resources: energy, metals, water, soil, timber, and wildlife habitats. Thus, America depends on the wise use, preservation, and conservation of these valuable resources in ways that mutually benefit urban and rural locales.

3. Most Americans tend to see rural populations as repositories of almost sacred values, traditions, and a sense of stability during times of rapid change. This view fosters a complex mix of pro-rural and anti-urban attitudes. However, most Americans form their opinions about rural people and their communities from a distance (through literature, art, and music) rather than through direct experience with the conditions of rural communities and their people.

Whitener and Parker (2007) point out that research sponsored by the U.S. Department of Agriculture's Economic Research Service has documented a direct link between workforce quality and economic development outcomes. Increases in the number of adults with some college education results in higher per capita income and employment growth rates in rural areas, although less so in non-metro (i.e., rural) than metro (i.e., urban) counties. Researchers also report that efforts to reduce school dropout rates, increase high school graduation rates, enhance student preparation for college, and increase college attendance are critical to improving the quality of the local workforce. They recommend strengthening the quality of education by assuring that best practice models of distance learning are available to remote rural schools. As is also found in hard-to-staff urban schools, the researchers note that instructional quality could be improved by promoting effective teacher recruitment and retention efforts in remote and impoverished rural areas.

This monograph explores how the RSIs funded by the NSF planned and implemented improvements that could help students, in some of the most impoverished areas of rural America, be prepared for the 21st century. RSIs provide a valuable legacy of innovation, leadership, and teacher development in reforming mathematics and science education. They also laid the foundation for rural schools to be vital partners in developing their human resources for competing in a global economy. The increasing achievement of rural students in STEM education is critical for increasing their quality of life while also strengthening America's competitiveness in the world. Brown and Swanson (2003) remind us, however, of the following caveat:

> Rural development is about the interrelationships among the various aspects of rural life: about how population, employment, environment, politics, institutions, and national and international policies affect and are affected by each other. . . . In reality, there is no one rural America. Rural Americans and rural communities are extremely diverse—demographically, economically, environmentally, and culturally (p. 15).

Chapters 2-4 of this monograph present, accordingly, examples of how the RSIs addressed the issue of diversity by molding innovative interventions and inspiring teachers. Such examples offer valuable insights to policymakers who seek to improve education in rural America, particularly in schools with ethnically concentrated populations of African American, American Indian, Alaska Native, Appalachian White poor, and Hispanic American students. Chapter 5 describes examples of success and lessons learned in the RSIs. In the final chapter, Chapter 6, the authors offer some concluding thoughts about promising practices and future directions for leveraging the RSI legacy to address three themes of critical importance in rural education: instructional leadership capacity, teacher recruitment and retention, and policy actions.

Chapter 2 - Innovations and Intervention Strategies

RSIs operated across the geographically and culturally diverse regions of rural America. Led by educators and key partners, each RSI planned a project consistent with the drivers for systemic reform of mathematics and science advocated by the NSF and, then, implemented the project within the context of local schools and communities. A set of six NSF systemic reform drivers guided the implementation of each RSI project: (1) standards-based curriculum and instructional practices, (2) supportive policies, (3) convergence of resources, (4) partnerships, (5) project and student performance data, and (6) elimination of student achievement gaps. Although focused intensely on the drivers, each RSI had to develop its own unique strategy for implementing a systemic approach of change in the high-poverty, rural school districts participating in the initiative.

Models of Change

What models of change or intervention guided the various RSIs funded by the NSF? RSIs were breaking new ground in the approach to rural school reform. Key staff and stakeholders of a RSI reviewed the literature and strived to create a model of intervention that would succeed in its respective rural context. These research-informed designs might be considered "home-grown" to the extent that no previous systemic intervention models existed for reforming mathematics and science education in high-poverty, rural areas.

Highlighted below are examples of the model of change used by various RSIs. The intent in selecting these examples is to help readers understand how an individual RSI customized and/or evolved a model for improving mathematics and science education in high-poverty, rural school districts. Specific traits of the rural context were important in the change model of each RSI.

Delta RSI

Table 1 profiles a rural American context, i.e., the Delta, which differs from other rural areas in a few ways. The Delta RSI included 61 of the most underserved counties and parishes in the states of Arkansas, Louisiana, and Mississippi. In the Delta RSI's final report (Alexander, 2003), *Building Educational Bridges Across the Delta*, the contextual circumstances affecting the reform of mathematics and science education are specified.

Table 1. Context of the Delta RSI

Contexture Feature	Current Circumstance
High poverty rate	• 74% of Delta students qualify for free or reduced-price meals
Agrarian society	• Little economic diversification • Few employment opportunities • School system is often the largest employer
Cultural and geographic barriers	• Low population density • Migration to/from rural communities is limited • Closed systems, somewhat resistant to reform
High teacher and administrator attrition rate	• Annual employee turnover is as high as 60% in some schools • Inadequate pay and lack of amenities • Critical shortage of family housing
Few external resources	• Limited capacity to access resources • Community partnerships minimal
Lack of human resources	• Multiple course responsibilities for math and science teachers • Multiple job responsibilities for district personnel • Few opportunities for professional engagement and growth
Distrust of educational systems	• Higher educational attainment often results in people leaving the Delta
Dual (segregated) educational systems	• Some districts have a total student population that is 50% African American, yet the African American student population in some schools is as high as 95% • Little interest in and tax support for public schools
Lack of parental involvement	• Limited educational attainment by parents • Low expectations • Single-parent families: 36% in Arkansas, 33% in Louisiana, and 43% in Mississippi

Located strategically within the Delta region, mathematics and science field coordinators collaborated with universities, state departments of education, community representatives, governmental agencies, and school districts to implement programmatic strands of the Delta RSI. The six strands were (1) data-driven decision making, (2) curriculum analysis, (3) professional development, (4) convergence of resources, (5) analysis of state and district policies, and (6) community engagement.

Delta RSI coordinators brokered services as needed and provided job-embedded professional development for teachers within their school districts. Regional Advisory Councils (RACs) comprised of school-district leaders served to ensure that Delta RSI activities addressed the needs of students. As each RAC developed a sense of ownership in the Delta RSI vision, it assumed a leadership role in implementing reform strategies.

The Delta RSI model sought to be a change agent by pursuing the following courses of action:

- Accelerating the pace of reform in science, mathematics, and technology education
- Implementing research-based strategies
- Identifying resources
- Replicating successful reform models
- Developing leadership abilities at all levels
- Delivering professional development based on identified needs
- Using a team-based approach to improve teaching and administration

Alaska RSI

The Alaska RSI evolved operationally over a 10-year period and strived to implement a set of initiatives in five cultural regions of the state (20 rural school districts) to document the indigenous knowledge systems of Alaska Native people and to develop pedagogical practices and school curricula that incorporated indigenous ways of knowing in formal education. The overall ethnic makeup of the 20 districts included more than 90% Alaska Native students, with the remaining 10% being primarily White, Asian, and African American students associated with the larger regional centers of Alaska (i.e., Kodiak, Bethel, Nome, Kotzebue, Barrow).

These 20 school districts continued as the focus of Alaska RSI activities over the project’s 10-year duration, involving a total of 185 rural schools serving 19,855 predominantly Alaska Native students, along with 30 associated Native organizations, state agencies, rural campuses, and professional organizations. Although non-equivalent in some important ways (e.g., schools serving native versus non-native communities), the remaining 28 rural school districts, with 103 rural schools serving mostly non-Native communities, served as a comparison group for assessing the impact of Alaska RSI initiatives. Five rural districts served as Alaska RSI "focal districts," representing 61 schools with 711 certificated staff that served a total of 9,342 students.

The systemic reform focus of the Alaska RSI model was to foster connectivity and complementarity between two functionally interdependent but historically alienated systems—the indigenous knowledge systems rooted in the Native cultures of rural Alaska, and the formal systems of education imported to serve the needs of rural Native communities. A key premise of the Alaska RSI was that within each of these evolving systems existed a rich body of complementary mathematical and scientific knowledge that, if properly explicated and leveraged, could strengthen the quality of educational experience and improve the academic performance of students throughout rural Alaska. The Alaska RSI thus sought to demonstrate the applicability of locally driven, culturally responsive strategies in shaping the reform of the state's educational system.

The Alaska RSI sponsored numerous professional development opportunities for teachers in partnership with the Alaska Science and Math Consortia and the Alaska Native Science Education Coalition. These included workshops, science camps, and leadership institutes. The model also sought to change state policies and encourage the use of culturally aligned curriculum resources generated by the Alaska RSI and made available through the Alaska Native Knowledge Network. Among the activities to advance the desired change were statewide conferences for math/science educators, curriculum workshops, a regional Scientist-in-Residence program, the Alaska Native Science Education Coalition, Native science camps for teachers, regional Academies of Elders for Native Educators, cultural orientation programs for new teachers, and various district-level workshops on specific initiatives.

A key strategy was the formation of the Regional Academies of Elders for Native Educators. Each region where the Alaska RSI worked established an Academy that was comprised of Native elders, professional scientists, and science teachers, all of whom gathered for a week or more at a camp or village site where the elders and scientists passed on their knowledge of the local environment to the teachers. The teachers then were responsible for developing curricular applications of what they had learned, checking with the elders and scientists for its accuracy, before pilot testing it in the classroom. Refined curriculum units were posted on the Alaska RSI website and published in paper form for distribution to other teachers and schools.

Appalachian RSI

The Appalachian RSI model of change (presented in Figure 1) evolved over 10 years. The model embraced a regional delivery system and several capacity-building strategies. The Appalachian RSI model overcame many of the challenges it faced initially when working with rural Appalachian school districts in six states through implementation of key capacity-building strategies, such as:

- Local "teacher partners" who build district capacity for improving education in mathematics and science
- Resource collaboratives located at universities and comprised of external support personnel to facilitate local school planning and decision-making
- Leadership teams consisting of teacher partners, an Appalachian RSI liaison, a school superintendent, and a principal that develop a district-wide plan to support program improvement
- Improvement reviews that help schools assess their current mathematics and science programs and create a plan for improvement
- Resource convergence for student learning through partnerships with state departments of education and other agencies, including the Appalachian Technology and Education Consortium; Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics; and the Appalachian Mathematics and Science Partnership

The Appalachian RSI's five resource collaboratives, strategically located at area universities, spearheaded the RSI's reform efforts and proved to be the primary catalyst for program improvement initiatives across the Appalachian region. A coordinator at each collaborative served as a "field agent" to facilitate local planning and decision-making while coordinating training for teacher partners and directing services to schools in the region. Each coordinator's leadership efforts focused on professional development, technical assistance to schools and districts, and program assessment. Such endeavors were the cornerstone of the Appalachian RSI's strategy for accomplishing project goals. A mathematics consultant in the Kentucky Department of Education noted:

> *I have seen the teacher partners grow in their content knowledge in mathematics and have seen them grow as teacher leaders. I think this aspect of the ARSI [Appalachian RSI] project may pay the greatest dividends in the long run, as these teachers have developed the skills and knowledge necessary to continue to drive improvement in mathematics education in their districts.*

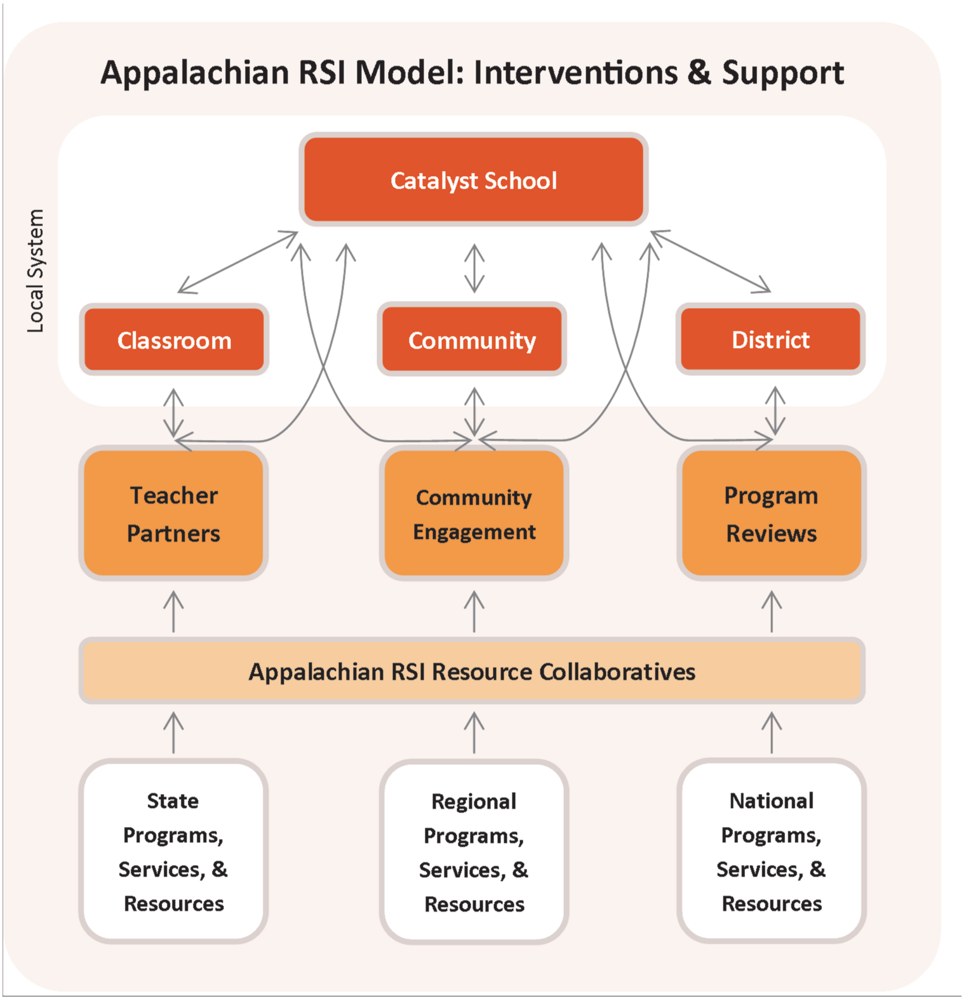

Figure 1. The Appalachian RSI Model of Change

Ozarks RSI

Figure 2 shows the Ozarks RSI model of systemic instructional change. In its inaugural year (2002), schools were assisted in adopting a standards-based curriculum, an action that became the most critical decision to ensure an intense focus on content knowledge and instructional coherence. The need to implement the new curriculum served as a catalyst for all teachers to examine their teaching practices. It also allowed for professional development opportunities and assessment strategies, which emphasized inquiry-based instruction and notebooking, to focus on teaching all students to achieve higher levels of content and conceptual understanding that are critical elements of the new curriculum.

Ozarks RSI/Carver Partnership

Curricula and Focused Professional Development Model (workshops, summer institutes, follow-up with distance learning, online short courses, and level coaching and mentoring)

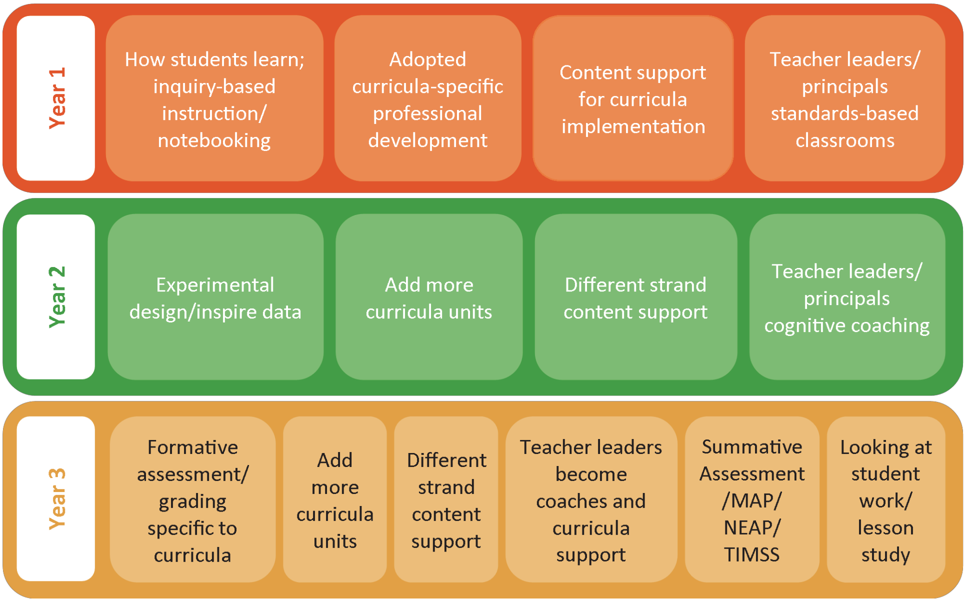

Figure 2. The Ozarks RSI Model of Change

In year two (2003), the decision to adopt the curriculum continued to serve as a catalyst for ensuring coherence and relevance in elements that support teacher change, such as content-specific professional development, curriculum materials, and learning assessments. Ozarks RSI staff selected and trained teachers and school administrators to assist teachers as coaches, with the primary role of supporting teachers in learning and applying instructional techniques that are highly effective in implementing the new curriculum.

In year three (2004), teachers learned to use formative assessment strategies. Teachers learned how to implement additional units in the curriculum and increase their content knowledge. Teacher leaders and coaches also provided assistance to those needing additional support in their classrooms. Teachers in some schools chose to participate in the Ozarks RSI-guided study groups that enabled networking among teachers in the region. The group activities and networking provided a unique opportunity for teachers to reflect, learn, and share how best to implement their adopted curriculum, instructional strategies, and assessment practices.

Coalfield RSI

The Coalfield RSI model of change focused primarily on developing additional leadership capacity to improve the teaching of mathematics and science in participating school systems in seven Virginia districts and 10 West Virginia districts. The Coalfield RSI strived to build synergy for positive change by emphasizing a data-driven approach to improvement, enhancing the support of district and school leadership (including teacher leaders), developing strong parental and community support, and partnering with local universities and other systemic reform initiatives.

The role of teacher leaders included modeling inquiry-based instruction, assisting in data analysis, participating in school improvement planning sessions, leading staff development, and encouraging students to become mathematics and science teachers. They also served as mentors in district efforts to recruit new mathematics and science teachers. Before the Coalfield RSI was initiated, the one-year planning effort funded by the NSF revealed that districts lacked adequate staff with either content knowledge in mathematics and science or adequate time to fill the role of district leaders in those academic fields. The Coalfield RSI strived to fill this need by preparing 34 teachers as teacher leaders, two teacher leaders in each of the 17 school districts.

Texas RSI

The Texas RSI model of change is based on the belief that sustainable change is best accomplished through committed and knowledgeable local stakeholders working together across an entire school district. In order to participate in the Texas RSI, each district's school board had to sign a partnership agreement. The decision to participate followed a district and community forum conducted by Texas RSI staff. During the forum, administrators, teachers, parents, and community members indicated interest in working with the RSI. Districts had to agree to focus on systemic reform guided by the state standards-based curriculum framework, known as Texas Essential Knowledge and Skills (TEKS), and the Texas RSI Attributes. The Texas RSI Attributes are:

1. Successful implementation of the mathematics and science TEKS through
    - vertical alignment of the K-12 curriculum
    - teachers prepared in TEKS implementation, assessment, inquiry-based activities, technology, and the use of available resources
    - inquiry-based learning for all students
    - technology tools and training
    - alignment of professional development

2. District policies supporting math and science TEKS implementation and systemic reform through
    - proactive principals supporting teachers in systemic mathematics and science reform efforts
    - alignment of school improvement plans with Texas RSI Attributes
3. Alignment of resources to support systemic reform efforts and mathematics and science TEKS implementation through coordination of funding
4. Stakeholders' commitment to systemic reform of mathematics and science education through
    - district-wide involvement
    - parental involvement
    - collaboration with other partners
5. All students reaching high standards through
    - high quality mathematics and science programs
    - high expectations for all students

Figure 3 shows the model of change for the Texas RSI. Each participating district identified a district leadership team (DLT) consisting of central office administrators, mathematics and science teacher leaders from each campus, counselors, parents, and community members to guide the district's work with the Texas RSI.

The Texas RSI strived to build sustainable leadership capacities in a DLT by providing opportunities for team members to *learn* about the Texas RSI Attributes and high quality mathematics and science for all students. The Texas RSI then supported DLT members as they *implemented* what they learned and *shared* their new knowledge and skills with others. This Learn, Implement, Share professional development design formed the basis of the Texas RSI change model.

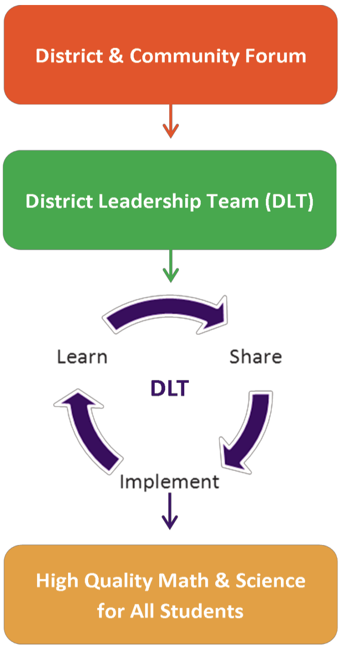

Figure 3. The Texas RSI Model of Change

Mathematics and science teachers on the DLTs were called "teacher partners." In the Texas RSI model, teacher partners were supported as the primary catalysts for systemic reform in their districts. Texas RSI staff and other experts provided leadership development opportunities for teacher partners at academies, where presenters modeled learner-centered instructional strategies, such as problem solving and inquiry learning.

Mathematics and science education specialists were located in regional offices to facilitate work with teacher partners in their districts on a regular basis, usually meeting with each teacher partner at least once every six weeks. These Texas RSI regional specialists provided more than 16,600 support sessions. They served as mentors and coaches, provided follow-up to Texas RSI summer academies, taught lessons, and demonstrated technology uses. They also made a wide range of standards-based curricular materials and resources available for checkout by teacher partners. This arrangement resulted in the districts being able to purchase materials that could be used by all teachers.

Coastal RSI

The Coastal RSI change model depicted in Figure 4 was designed to address common issues that traditionally limit the capacity for creating sustainable improvements in mathematics and science programs in rural school districts:

- Small number of staff with too many job functions and responsibilities
- Lack of district personnel with math or science backgrounds
- Inadequate data for making program improvement decisions
- Limited access for teachers to professional development opportunities
- Ineffective process of decision making
- Inadequate use of existing school improvement resources
- Turnover in key leadership positions

Few rural school districts in the coastal regions of North Carolina, South Carolina, and Virginia had mathematics and science specialists in the central office. More often than not, curricular and instructional reform was led by a person who was a "generalist" with many job functions to perform. While central office staff could usually provide each school with data revealing how students performed on standardized tests and state assessments, little human and fiscal capacity was available to help schools identify program needs or address the teaching and learning needs of students in mathematics and science. Decisions about all aspects of such programs were traditionally made in isolation by a few teachers, with little or no data to support decisions about long -term improvement plans.

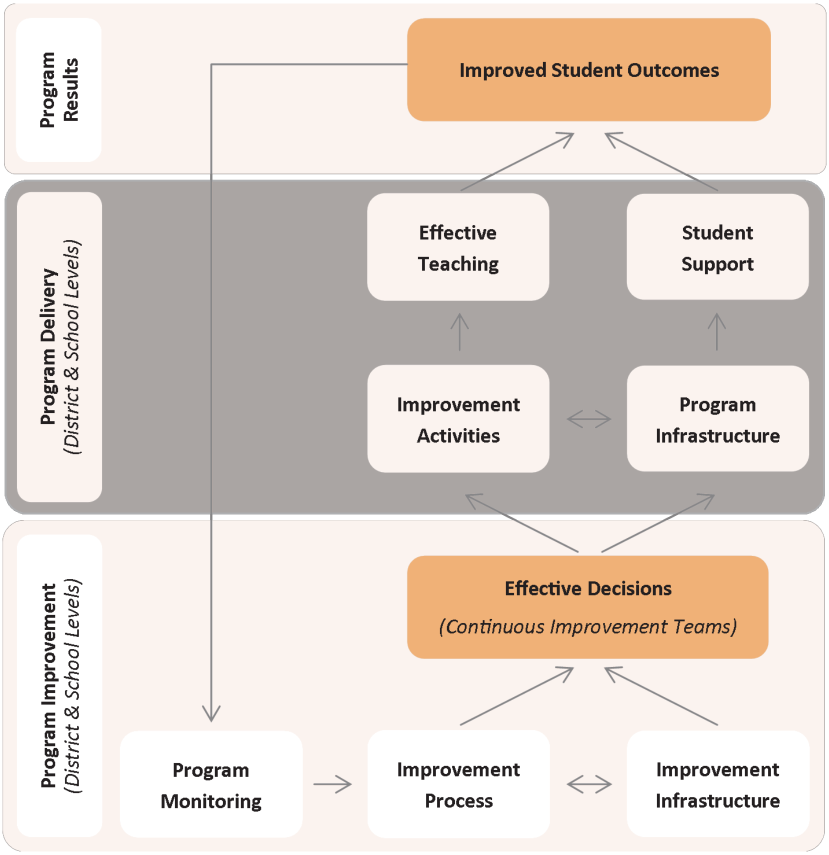

Figure 4. The Coastal RSI Model of Change

Figure 4 shows that improving student outcomes was the long-term intended result of the Coastal RSI model. Delivering research-based interventions, with appropriate improvement activities, and building appropriate infrastructure at the district and school levels were designed to increase the probability of improved student achievement in mathematics and science. That focus guided the monitoring of program-improvement activities.

A critical step in the decision-making element of the Coastal RSI change model was that each school district signed a cooperative agreement to establish continuous improvement teams (CITs) at the district and school levels. The CITs could be integrated into an existing committee with a continuous improvement purpose. Teachers signed the cooperative agreement to be members of school and/or district CITs. These teachers, consequently, committed to participate in activities and professional development designed and implemented by their teams. Every teacher who signed the agreement had an opportunity to participate in team decisions and to assume leadership roles.

These CITs represented a fundamental change in how decisions were made at the school and district levels—an essential element in the Coastal RSI model of change for creating lasting improvements in mathematics and science education.

A school CIT became the sustainable leadership that continued to design and implement improvement efforts if teacher and/or administrator turnover occurred. This capacity included the skills to use program standards, assessments, and other data to prioritize needs and determine use of resources.

The Coastal RSI's regional facilitators provided assistance to the districts and schools in developing their CITs, defining the CITs' work, and guiding overall Coastal RSI assistance (e.g., professional development, data collection, and analysis). Facilitators also worked with each school's CIT to ensure teacher input, foster leadership opportunities, and connect the teams to external resource partners and programs. An important role of a Coastal RSI regional facilitator was to assist the schools' CITs in following the Coastal RSI's continuous improvement process, which, by design, the success or failure of the Coastal RSI change model relied upon greatly.

Hawaii RSI

The Hawaii Networked Learning Communities RSI (Hawaii RSI) followed a model of change based on a logic model framework. Project evaluation assessed outcomes against inputs and interventions. Figure 5 depicts this framework.

Project goals were influenced by those of the Hawaii Department of Education and No Child Left Behind legislation. These goals took into consideration what knowledge and skills a high school graduate should possess, standards for teaching and learning, and the needs of students and teachers. Project goals were measured by implementation and outcome indicators.

The logic of the framework was that, successfully implemented, all interventions and changes would result in the Hawaii RSI model of systemic change. Evaluation results were to inform changes needed in implementation activities to achieve the desired outcomes. Evaluation activities were guided by the logic model framework and were expected to contribute evidence of project success required by the NSF and Hawaii Department of Education.

Hawaii Networked Learning Communities Implementation and Evaluation Framework

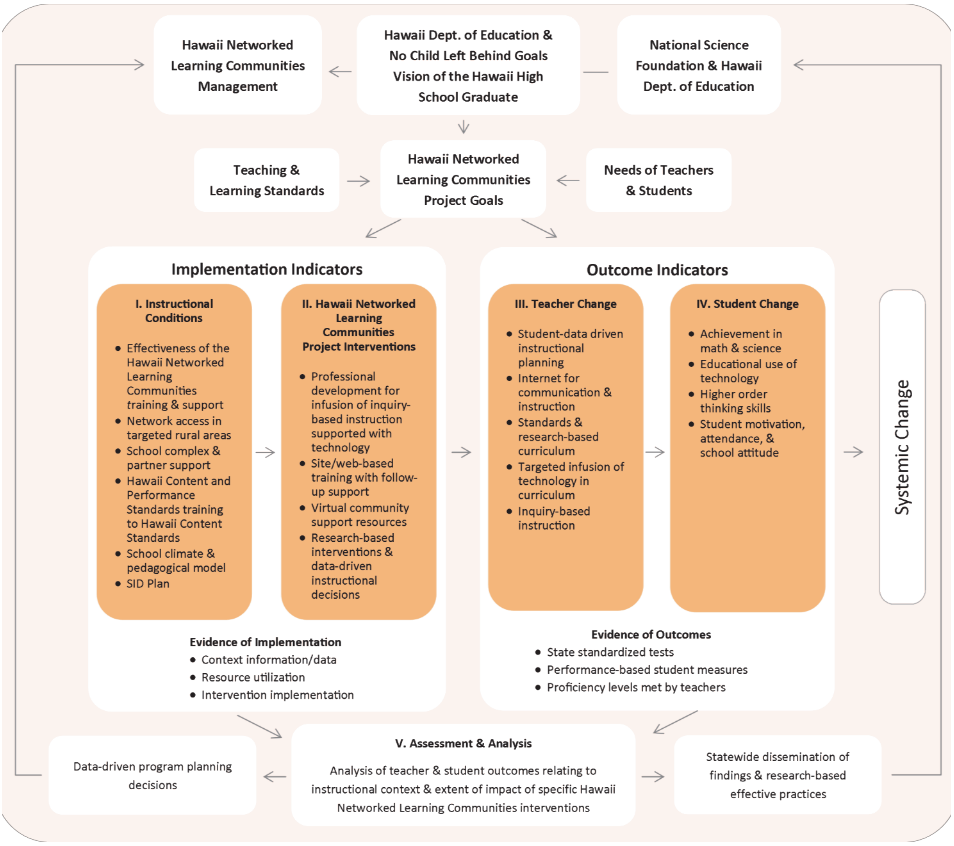

Figure 5. The Hawaii Networked Learning Communities RSI Model of Change

Wind River RSI

The Wind River RSI served the Eastern Shoshone and Northern Arapaho nations. Five districts on the reservation were considered “site” schools, while two districts off the reservation were considered “focal” schools. Each site school provided representatives to make up the Advisory Council that proposed activities to promote STEM education within their districts.

A bottom-up and top-down approach was used in the Wind River RSI. One of the important elements involved listening to the community, elders, tribal leaders, and tribal government. A Council of Superintendents was formed that met quarterly to discuss STEM issues within schools, address policy issues, and reaffirm the importance of professional development. Talking Circles were used to discuss common issues.

The Wind River RSI embraced a strong partnership approach to offer high quality professional development to help teachers implement a culturally responsive, standards-based curriculum (see Figure 6). Of particular importance was the Native Ways of Knowing (NWOK) document, which was adopted from the Alaska RSI and integrated into the standards-based curriculum. Approximately 25 teachers and administrators attended a camp meeting with elders for a week to learn how to incorporate culture into contemporary mathematics and science. The Wind River RSI devoted almost two years to curriculum development and offered summer institutes for teachers on the NWOK approach.

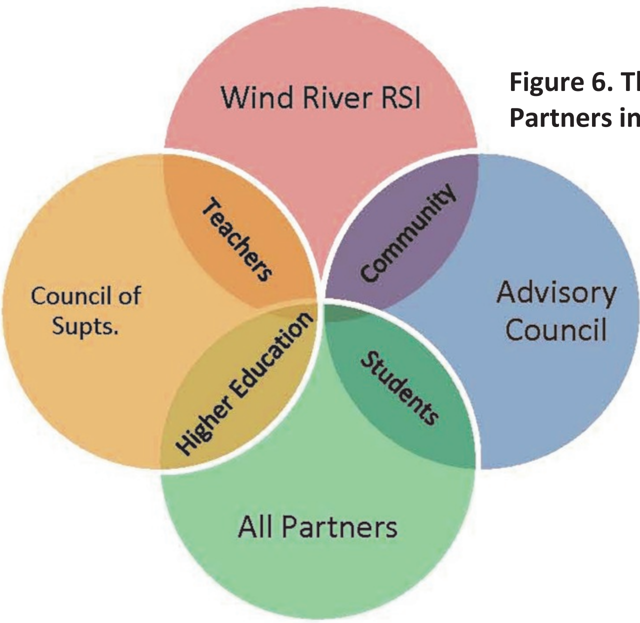

Figure 6. The Wind River RSI's Partners in Education

Advisory Councils were formed, superintendents came and went, and the Wind River RSI struggled to get culturally attuned leaders and teachers in school districts. No previous superintendent had been Native American, and only about 35% of the teachers were Native American. The Advisory Councils were formed, in part, to represent the importance of culture, and they included 12 members with responsibilities such as disseminating materials and information to districts, meeting weekly with superintendents and principals, and proposing to the Wind River RSI activities that promoted STEM within their districts.

The Wind River RSI's goals addressed the following areas of concern:

- Professional development
- Summer school activities
- Afterschool activities
- Summer teacher institutes
- Cultural curriculum development
- Inclusion of *all* stakeholders
- National conferences and presentations
- Career-related activities for students

Wind River RSI leadership learned from experience that the way many schools traditionally operated was not meeting the needs of Native American students. Consequently, the Wind River RSI started a virtual high school, the only one of its kind in Wyoming. As a result, students have Advanced Placement courses available and online training is available for teachers in mathematics and science programs. The Wind River RSI also partners with more than 20 school districts in the state to provide online assistance for at-risk students.

Summary

In summary, each RSI worked with various partners to formulate a model of change unique to its rural context. Most RSIs brought content specialists and networking opportunities as direct support for teachers to learn and implement inquiry-based instructional strategies. In the rural school systems, with inadequate time or expertise to guide improvements in mathematics and science education, each RSI model of change was designed to build sustainable leadership capacity. A long-term expectation was that efforts of each RSI would support changes that ultimately would prepare students educationally for living and working in the 21st century. Teacher development was a critical part of how each RSI planned to change mathematics and science programs for students in the rural schools.

Chapter 3 - Leadership Development

A common circumstance among school districts participating in the RSIs funded by the NSF was a lack of specialists in mathematics or science. Consequently, most of the RSIs implemented a strategy to address the lack of leadership capacity for improving education in those content areas. While employing regional field agents with mathematics and science expertise was a common strategy, major initiatives also focused on developing "teacher leaders" or "teacher partners" who could assist colleagues in implementing inquiry-based, constructivist teaching approaches aligned with curricular standards.

RSI project directors anticipated that these new teacher leaders would eventually become school and/or district administrators who would be prepared to sustain continuous improvement in mathematics and science education. Some RSIs also focused on enabling principals to lead effective improvements in their respective schools.

Teacher Leadership Emphasis

In addition to developing a six-credit online course that targeted teacher-leadership skills in standards-based curricular development and inquiry-based learning practices, the Hawaii RSI operationally defined the desired teacher and student outcomes as parallel statements (see Table 2 for the Hawaii RSI teacher and student expectations).

Table 2. Hawaii RSI Teacher and Student Expectations

Teachers will:	Students will:
Transform science and mathematics content standards into measurable learning objectives for their classrooms	Articulate what they are learning and why they are learning it
Devise criteria to assess achievement of these learning objectives and create tools to conduct assessment	Participate in self-assessment and peer-assessment of how well they are learning
Incorporate an inquiry process in classroom projects and units	Engage in a rigorous process of observing/inquiring, questioning, predicting/hypothesizing, planning and conducting investigations/research, interpreting evidence, and communicating findings
Build inquiry around place-based issues and topics involving culture and environment	Investigate environmental issues and topics that are relevant to their neighborhoods and communities
Integrate the use of technology tools for learning	Use technology tools to access and organize data and compose/create products that reflect their new knowledge

The Texas RSI built sustainable capacities of DLTs by providing opportunities for members to *learn* about Texas RSI Attributes and about high quality mathematics and science for all students. Texas RSI then supported DLT members as they *implemented* what they learned and *shared* their new knowledge and skills with others. This Learn, Implement, Share model formed the basis of the Texas RSI action plan.

Through the work of its regional specialists, the Texas RSI supported teacher partners on site in their districts as they implemented the best practices, strategies, techniques, and models learned at teacher partner academies. Specialists in regional offices worked with teacher partners on a regular basis, usually meeting with each at least once every six weeks. Specialists served as mentors and coaches but also made standards-based curricular materials available for checkout by teacher partners. This arrangement resulted in the districts being able to purchase materials that could be used by all teachers.

Teacher leaders in the Coalfield RSI modeled inquiry-based instruction, assisted in data analysis, participated in school improvement planning, led staff development, and encouraged students to become mathematics and science teachers. Their role was to increase the capacity and effectiveness of school leadership and decision making for mathematics and science programs.

Seven Coalfield RSI teacher leaders and a former mathematics specialist have subsequently become principals or assistant principals. Another eight Coalfield RSI teacher leaders were employed by their school districts as mathematics or science coaches. Consequently, these 15 former teacher leaders are now in positions that will allow them to continue using the valuable experiences and leadership skills gained through the Coalfield RSI to improve teaching and learning.

The Appalachian RSI developed a strong network of committed and competent teacher partners in participating districts. The teacher partners, who were provided released time to assist district colleagues, became the primary change agents for reform.

Strengthening Administrator Support

In addition to working with teacher partners to develop their leadership skills, the Appalachian RSI worked with principals, who can play a critical role in the professional growth of teachers. A major Appalachian RSI project was Leadership by Design (LBD): Patterns of Excellence. LBD is a system for monitoring and improving a school's instructional program. Principals were trained to recognize effective instruction in mathematics and science and thus were able to support data collection and analysis of classroom practices.

Several other RSIs also sought to increase the skills of school administrators to support systemic changes in mathematics and science. For example, principals and assistant principals in the Ozarks RSI schools received focused professional development on systemic reform in mathematics and science, including how to conduct classroom observations during the teaching of a concept. The goal was to increase the administrators' ability to communicate with teachers about key curriculum, instruction, and assessment elements inherent in a standards-based and inquiry-oriented classroom environment.

As with the Ozarks RSI, the Texas RSI also placed a priority on developing proactive principals who could support teachers in their implementation of high quality mathematics and science education for all students. This support included the ability to discuss changes in policies and improvement plans (e.g., Texas RSI Attributes). Building appropriate administrator skills was a capacity-building strategy for supporting teachers in improving student achievement in mathematics and science.

In the Coastal RSI, teacher leadership was addressed through the establishment of CITs. Teachers learned how to participate in team decision making and to assume leadership roles as a member of the school or district CIT. Regional facilitators worked with each school's CIT to ensure teacher input, foster leadership opportunities, and connect the teams to external resource programs.

The RSIs also encouraged teacher involvement on numerous district, regional, and state committees or initiatives formed to improve mathematics and science education. The Alaska RSI provides an example of how the RSIs influenced curricula and related teaching practices. Supported by the Alaska RSI, Native educators produced the Alaska Standards for Culturally Responsive Schools. These standards, which embodied the reform strategy of the Alaska RSI, were adopted by the state board of education and were distributed in urban as well as rural schools. Native educators subsequently developed Guidelines for the Preparation of Culturally Responsive Teachers used in teacher education programs around the state. They also developed Guidelines for Culturally Responsive School Boards, which have been adopted by the Alaska Association of School Boards.

Administrators and teachers in American Indian/Tribal RSIs also received important leadership training. In December 2005, the Navajo Nation RSI hosted its first school leadership conferences, using indigenous knowledge as the centerpiece of training. Leaders and teachers in the Navajo Nation RSI also advocated for important policy changes. For example, they introduced amendments to the tribal code of education regarding academic achievement, accountability, technology, and cultural infusion. The amendments were adopted and helped the Navajo Nation to exercise sovereignty in education.

Personal Examples of Leadership

Funded by the NSF, Edvantia held a forum on "Leveraging a Legacy of Leadership in Mathematics and Science Education" on July 16, 2008 in the conference room of the U.S. House of Representatives Standing Committee on Science and Technology in Washington, DC One of the purposes of the forum was to learn how practitioners in local school districts could leverage the RSIs' legacy of leadership to continue improvements in mathematics and science education. Representing hundreds of their peers who participated in one of the 28 RSIs, six individuals were selected as a panel to share experiences in implementing and leveraging their respective RSIs to improve mathematics and science education. The panelists were from Alaska, Kentucky, Mississippi, Texas, West Virginia, and Wyoming. During their presentation, the practitioners shared stories of what their respective RSI did for them and how they have continued to improve programs for students. What follows are excerpts of comments from the six practitioners that illustrate how their RSIs helped them to build leadership skills.

Jonathan Escue, Science Teacher, Lincoln County High School, Hamlin, West Virginia (Coalfield RSI):

Another change initiated by the Coalfield RSI was the development of leadership teams in both science and mathematics. As a result, we now have direction and purpose in our mathematics and science programs. On the teams, we have teachers, a principal, a central office designee, and the superintendent. As you know, superintendents come and go, but the leadership team sustains itself. We are better able now to talk about what we need in the middle school or in the high school. We are able to talk about higher expectations for students. None of that was being done before the Coalfield RSI came along.

It is exciting to get together with colleagues. We have done wonderful things in Lincoln County. We talked about a learning community through virtual hands-on labs, book studies, and common goal setting. I know book study is not the newest thing in the world, but it was for us. Four or five of us got together. We had book studies on research by Marzano, on leadership, and other topics. There were specific book studies for elementary schools, middle schools, and high schools. It has made us better instructors, and that has resulted in better student achievement.

The reality now is that our teachers are making decisions and we are being facilitated and supported by the central office, and that changed the culture. And once you have been shown how to do it, it is going to grow. It is sustainable. With our science and mathematics leadership teams, we were better able to direct what happened to our mathematics and science teachers.

The Coalfield RSI contributed to my personal growth. My participation gave me a renewed passion for teaching. One of the lessons that we learned was that you need to start small and it will grow. That has been affirmed in Lincoln County. It was difficult to deal with the name "teacher leader" because we are all in this together. But at some point in time, some of us had to step up and say this is where we have to go. It took us two and one-half to three years to understand what this means. We wear the badge of a teacher leader with humility. It changed the conversation. There is very little conversation now among teachers about what your administrator is doing. The conversation is about the neat thing I did in class today, or this program is going well, or I heard about this, or did you get a chance to read Chapter 8 yet for the book study.

The leadership growth is sustainable. As a teacher leader, I am now involved in a lot of things. Now I am going to be a mentor for general science teachers who want to teach chemistry. Last year in West Virginia, about 54% of our chemistry classes were taught by non-certified personnel. We now have an initiative to take those teachers through a three-year program at the university to get them certified in teaching—and I will be mentoring them.

Also, I learned it can be pretty neat to go to school board meetings. We presented what we were doing and what needed to be sustained or supported to best serve the students. And board members listened.

Angela Winters, Principal, James Rosser Elementary School, Sunflower County School District, Moorhead, Mississippi (Delta RSI):

The Delta RSI had a vast impact on me professionally as an administrator. As a principal, I became involved in the mathematics and science trainings. I observed Delta RSI field directors teaching lessons in our classrooms. I participated in Math and Science Fun Nights, where the field coordinator trained teachers, parents, and students at the same time. What an exciting event!

Because of the Delta RSI, I became aware that as the instructional leader at Rosser Elementary, I needed to help teachers sustain the momentum of innovative teaching practices. Teachers also implemented the new strategies in our afterschool and summer programs. When additional funds became available, I purchased math manipulatives, digital microscopes, and science kits for class instruction. I began to encourage teachers to do classroom observations to view new teaching practices in mathematics and science.

Intensely focused on providing high quality professional development in mathematics and science for teachers, I took action to hire an intervention teacher, previously trained by the Delta RSI, to help new teachers implement effective mathematics and science strategies. I scheduled meetings for teachers to share mathematics and science strategies with each other. I shared more data about student performance with teachers and discussed improvements needed. As the instructional leader, my role was essential to creating a science lab for teachers to use hands-on strategies that helped motivate students and improve achievement.

**Teresa Schneider, Teacher and Program Coordinator,
Kodiak Island Borough School District, Kodiak, Alaska (Alaska RSI):**

I served as the Alaska RSI Alvtiiq/Aleut Regional Coordinator from within my school district. This meant that I worked with schools and organizations from the Aleutian Chain, the Alaska Peninsula, Kodiak Island, Lower Kenai Peninsula, and Prince William Sound. I became a coordinator and liaison between the project, school districts, and Alaska Native organizations that crossed cultural regions of the Unangan, Alutiiq/Sugpiaq, Yupik, and Athabascan peoples.

The Alaska RSI role led to my current position in the school district as program coordinator for the Native and Rural Education Program. The sole purpose of the program and "department" (that is, a department of one person) is to bring curricula, programs, funds, and educational opportunities to the district that are specifically focused on the unique needs of our indigenous and rural students who live in Kodiak's city center and outlying communities. New capacity created by establishing the Native and Rural Education Program enabled the school district to

- *increase locally relevant staff development opportunities*
- *create teacher leaders and program development in collaboration with administrators and community leaders*
- *have a liaison for the district with community organizations, particularly with the Native community*
- *improve support for transitioning transient students, increasing standards of curriculum delivery, and retaining teachers*
- *increase opportunities for professional collaboration*
- *align district curriculum with cultural standards*

Gene Meier, Superintendent, Fort Washakie Charter High School, Fort Washakie, Wyoming (Wind River RSI):

The Wind River RSI program created an understanding of how change occurs and how to effect change in rural reservation communities. This has been one of the most truly dynamic, sustainable impacts that we have seen. Walking around in our communities are true change agents who, after working with the RSI program for 10 years, are now using the same philosophies and ideologies of systemic reform in their own professions.

We now have a contingent of experts in curriculum, assessment, standards, technology, institutional dynamics, and policymaking. This is because the RSI did not focus only on one group or one area. It was truly a program that allowed systemic change to happen. With the guidance of the NSF and the experts from around the country who also ran RSI programs, we were able to bring a national dialogue on STEM reform to our communities. It brought our small school districts to the apex of best practices from around the nation.

Today, the school district has become a mathematics and science partner with the University of Wyoming. We work with local businesses and industries that have a vested interest in seeing students succeed in mathematics and science. We participate in national panels, present at national forums, and disseminate best practices to teachers across the reservation.

Kim Zeidler, Director, University of Kentucky Resource Collaborative, PK-12 Math and Science Outreach Unit, Partnership Institute for Math and Science Education Reform, Lexington, Kentucky (Appalachian RSI):

Local leadership that was developed through the work of the Appalachian RSI resource collaboratives continues to reside in the rural districts. Many of the teacher partners have been assigned additional leadership responsibilities. The districts are more aware of high-quality resources, including curriculum resources (e.g., Connected Math, Investigations, Math Trailblazers) and how to locate them to support their continued improvement efforts. Many of the schools and districts now adopt these research-based materials to help teachers provide high quality mathematics and science instruction. In addition, schools and districts in the region have continued to build their capacity for improvement by being good consumers of opportunities (such as the Appalachian Math and Science Partnership, a comprehensive math and science partnership funded by the NSF) that will continue to move mathematics and science programs forward.

Irma Mondragon, Administrator for Curriculum and Instruction, Lyford Consolidated Independent School District, Lyford, Texas (Texas RSI):

My role in the Texas RSI was as a contact or go-between for the RSI and the Lyford Consolidated Independent School District. Attendance at training sessions, conferences, and special meetings provided an opportunity for me to keep abreast of changes, gain new knowledge about teaching the mathematics and science TEKS (Texas Essential Knowledge and Skills), learn how to align the curriculum with the state assessments, and gain other valuable insights. Teachers wanted to do a good job; however, teachers and administrators needed training. As a result, I continued to search for ways to assist teachers and assumed the role of facilitator for campus administrators and teachers. I have become a proponent of providing in-district training and using technology for staff development.

The partnership with the RSI helped me as an administrator to see our parents in a different light. The partnership renewed my belief in the necessity of cross-planning and cross-training for the parents of special population students. Parents can learn. One needs to expect it and provide training; parents will respond. And I have become more service-oriented.

Chapter 4 - Teachers' Professional Development

Leaders of the RSIs consistently report that their projects provided public school teachers and administrators with unparalleled access to professional development opportunities while advancing a vision that all students can and must achieve a rigorous, standards-based curriculum. This chapter reveals results of focus group sessions conducted by the authors to examine how the professional development legacy of the RSIs had an impact on those persons most responsible for the quality of mathematics and science education—teachers. The approach to tell this story will be largely through teachers' own reflections on their experiences.

This chapter highlights examples of teacher perceptions about how the RSIs changed the teaching practices and lives of teachers in ethnically diverse regions of rural America. Teachers were selected who participated in the RSIs that served five ethnically concentrated populations of students: African American, American Indian/Tribal, Alaska Native, Appalachian White poor, and Hispanic American. Results should be generalized only to participants in the focus groups or conference call sessions.

Focus groups were held with teachers who participated in the RSIs that served Appalachian, the Mississippi Delta, and Texas. Conference calls were held with those who participated in the Alaska RSI and American Indian/Tribal RSIs. The latter arrangement, rather than face-to-face meetings, accommodated issues of travel distances for teachers located in remote rural areas, time away from classrooms, and travel expenses. Teachers in the focus groups and conference call sessions were nominated by directors or other leadership personnel in their respective RSIs.

Table 3 charts the dates and number of teachers who participated in the respective focus groups and conference call sessions. Face-to-face focus group sessions were held for a period of four hours (10 a.m. to 2 p.m.) on a weekday with teachers who were served by the Appalachian, Delta, and Texas RSIs. These sessions included an hour lunch and introductory and concluding discussions that resulted in approximately two to two and one-half hours being devoted to the focus group questions. Conference call sessions lasted approximately two hours on a Saturday. All sessions were recorded to provide transcripts and check the accuracy of notes taken during the session. The names of participants, districts, and schools are omitted from this monograph in order to protect respondents' confidentiality.

Table 3. RSI Focus Group or Conference Call Session Dates and Participation

RSI Represented	Date Held	No. of Participants
Alaska RSI	September 26, 2009	4
American Indian/Tribal RSIs	October 24, 2009	4
Appalachian RSI	June 10, 2009	7
Delta RSI	July 14, 2009	8
Texas RSI	June 29, 2009	6

RSI Professional Development

Teachers experienced a variety of professional development opportunities in their respective RSIs. Inquiry-based instruction consistent with constructivist philosophies and hands-on, project-based methods were common topics in the workshops. Teachers also participated in training sessions designed to help them learn how to incorporate the methods in a standards-based curriculum and how to develop best practices for assessing student achievement based on the standards. Special issues related to rural context guided teachers in implementing the new curriculum and assessing instructional outcomes (e.g., teaching multiple grades of students in same classroom; providing relevant project-based learning activities linked to student cultural interests; development of authentic assessments).

Teaching a culturally responsive curriculum, for example, was a major theme in the professional development opportunities for participants in the Alaska RSI. Teachers may have participated in academies with Alaska Native elders as instructors or in special classes on creating indigenous units related to place-based education. Science fairs, summer camps, and student projects reinforced the NWOK approach to learning. One session participant acknowledged having an RSI-trained mentor who was exceptionally skilled in connecting the Western view of learning with the more culturally responsive NWOK model. Place-based mathematics and science emphasized the relevance of subjects for students in the Alaskan culture.

Like the Alaska RSI teachers, those serving American Indian/Tribal student populations tended to place considerable emphasis on addressing cultural issues and participated in professional development on the NWOK approach to teaching. One instructor indicated that his district had adopted the Alaska cultural standards model and implemented it for eight years following his RSI training. Professional development opportunities for this cohort included college classes to enhance the teaching of mathematics and/or science topics such as astronomy, environmental studies, physics, geology, and chemistry. Some teachers used the classes to receive another teaching endorsement area. Teachers found the special classes to be much more valuable and "less threatening" than the formal courses they remembered from their initial teacher preparation programs.

American Indian/Tribal RSI teachers also learned how to use the Full-Option Science System (FOSS) kits, the first time that many had access to such resources for conducting lab activities or hands-on student projects. Usually a textbook had been the only teaching resource available previously to most of these participants. They highly valued the RSIs' practice of conducting the classes and providing special training in their own school districts. Teachers in the American Indian/Tribal RSIs relied heavily on the regional assistance person who provided follow-up to the classes. This person frequently came to individual classrooms to demonstrate how to teach a mathematics or science lesson. One teacher noted:

> *I took a lot of mathematics courses, and the guy was out of Black Hills State College. That's like on the other side of our state, but he came over for us. I remember him. He wasn't pushing anything, but it was a lot of Everyday Math, as far as type of curriculum. Help with the FOSS kits was a really good thing for me because at the time I was teaching third-grade and sixth-grade science. I was a new teacher, and so it really helped me.* (American Indian/Tribal RSI Teacher)

RSIs serving impoverished areas of Appalachia (i.e., Appalachian RSI, Coalfield RSI) focused less on place-based context and more on implementing a standards-based curriculum, with its attendant grading practices, and deconstructing the standards to facilitate instructional planning. Data analysis was a critical element of the training provided to teachers for incorporating inquiry-based instructional strategies into curricular units. Book studies were a key professional development experience for some teachers, as was how to use graphic organizers and counteract common misconceptions about students' mastering all levels of content in mathematics and science. Teachers also gained valuable preparation to be effective "teacher leaders."

Delta RSI teachers experienced professional development opportunities such as how to teach by using an inquiry-based approach linked to state and national standards. Cooperative learning practices were emphasized. Teachers attended summer academies or workshops where content experts discussed best practices. In-state and out-of-state conferences were held, usually during summer, in which Delta RSI teachers learned how to conduct science experiments in classrooms and how to use mathematics manipulatives.

For many, this was the first time they had an opportunity to attend out-of-state professional development venues, usually because their school districts did not have sufficient funds to cover registration and travel expenses.

Summer workshops, special sessions, and customized assistance were common features of professional development opportunities for teachers in the two Texas RSIs (i.e., Texas RSI, South Texas RSI). Topics included "Math Their Way," "Elementary Glow," "Rocks in Your Head," and the "5E Teaching Model." Inquiry-based methods, questioning techniques, and student assessment were emphasized in the sessions. Some teachers also participated in field trips to enhance their knowledge, for example, at the McDonald Observatory in West Texas and the science museum in Fort Worth. Others praised the opportunity to attend a nanotechnology conference in Albuquerque, New Mexico, where they networked with mathematics and science teachers from other RSIs around the country.

Teachers representing the two Texas RSIs learned at Texas A&M University how to use graphing calculators and reported high-quality experiences at conferences on water quality, environmental studies, and physical science. Hands-on activities were key elements, including how to use FOSS kits, for which the Texas RSIs maintained a lending library. Moreover, mathematics and science specialists in the Texas RSIs visited teachers in their classrooms, modeled how to teach lessons, and customized assistance to teachers' immediate needs.

RSIs' Impact on Teachers' Attitudes

Teachers in the focus group sessions indicated that the RSI professional development also influenced their attitudes. For example, selected participants representing the Texas RSIs acknowledged that the 5E instructional model bolstered their understanding of how to follow a constructivist approach in teaching mathematics and science. The 5Es represent five stages of a sequence for teaching and learning: (1) engagement, (2) exploration, (3) explanation, (4) elaboration, and (5) evaluation. The sequence represents a constructivist cycle for helping students to learn from hands-on experiences and new ideas. The teachers also stated that their attitudes were changed by a two-day conference in Austin that demonstrated how to get students to derive mathematical information and perform equations.

Teachers representing the Alaska RSI in the conference call focus group session often mentioned professional development on the NWOK philosophy, related summer camps, and experiences with elders as having an enormous impact on their attitudes toward teaching mathematics and science.

Such exposure changed their view of how to make mathematics and science more culturally relevant and interesting to students. One participant remarked:

> *I attended the "traditional" camps with the elders. Because the camps were done in remote locations, we had to fly in and live the traditional way. The teachers were the elders, overseen by the University staff. We learned from the elders. The elders were there to explain how mathematics and science were related to the whole focus, when the natives depended on the caribou in times of famine, all the way to today. It influenced my attitude because it helped me bring the lesson to students in a way that represented an understanding of the culture. Because as a student in Alaska I grew up with teachers who came from outside Alaska and didn't understand the culture or show respect for the native ways of doing things. . . . I looked at the standards and the content, and they fit perfectly. I was no longer afraid to include the cultural items that I was developing in my instruction. I started developing those units, and they gave me a more positive attitude about my culture and including them . . . in teaching mathematics and science.* (Alaska RSI Teacher)

Another Alaska RSI teacher explained how experiences in herbal medicine enabled her to integrate the indigenous worldview into science lessons. She noted, "What the Alaska RSI did for me was to give me confidence that what I was doing was right. You get confidence being around people that can help you, whereas before it was kind of scary, out on a limb to be teaching the Native Ways of Knowing in the curriculum. . . . At first, even putting names of local places in my navigation unit was controversial."

Teachers representing the American Indian/Tribal RSIs explained how attitudes toward teaching mathematics and science were affected by support personnel. Professional development sessions followed a more relaxed atmosphere that helped teachers feel more comfortable with science in general. No one felt "stupid" asking questions. One such teacher experienced a major attitudinal change upon realizing how students seemed to learn more and enjoy learning mathematics and science from a native's perspective, as opposed to the "chalk and talk" approach. Switching from the conventional textbook's approach of "here it is, review it, and move on" to a more native way of knowing made the pedagogy relevant.

The attitude of another American Indian/Tribal teacher changed when he realized that students should be allowed to use class notes and texts during tests: "That really changed my attitude because . . . testing should be a tool for teaching, not a means to destroy a student's grade. . . . I now let my students use their notes and their textbooks during any testing that I give." This teacher witnessed how students began to recognize the utility of taking notes for doing well on tests and, consequently, the connection between doing well in school and doing well in life.

Teachers in the focus group and telephone conference sessions indicated that their attitudes also changed regarding the importance of reflecting on one's teaching practices and doing what works. A participant in one of the Appalachian RSIs commented that networking with other mathematics and science teachers was a valuable professional development opportunity about how to "reach" students.

> *We talked a lot about reflection in the RSI professional development, how to reflect on what and how you were teaching. It was about how to examine your teaching to decide what you did and whether it worked. Were you reaching the students you needed to be reaching? That was a pretty important piece, especially learning how to let go of something that didn't work and saying forget about that. I must move on to what works.* (Appalachian RSI Teacher)

Learning new practices in professional development sessions conducted by the RSI enabled teachers to examine how attitudinal barriers prohibited implementation of more effective instruction. For example, teachers' attitudes were challenged as they learned why and how to organize differentiated instruction, how to use graphic organizers, and how to recognize the difference between basic "hands-on science" and "inquiry." The inquiry approach helped students to "discover" a solution instead of the teacher's telling them an answer.

The attitudes of some Delta RSI teachers changed when they learned how to pair students in cooperative groups to solve fraction problems. One teacher reported that the RSI "helped me do a better job with group work in the classroom by reinforcing the attitude that cooperative learning works if the kids are given a task to do, something that focuses their attention." Another remarked that the Delta RSI professional development "changed my attitude about how to improve critical thinking skills of students. I needed to use manipulatives, but not only in teaching steps where students keep practicing how to do the mathematics."

Attitudes of teachers toward shared responsibility for what students learned changed when RSI professional development helped teachers to reflect on what students at various grade levels in a school district were being taught. For example, a high school teacher found that prerequisite mathematics content was not in the middle school curriculum. Addressing the issue required her to work collaboratively with the middle school teacher(s).

Practical Practices

In the focus groups and telephone conference sessions, teachers were asked to reflect on the first change they made in instruction as a result of participating in professional development of their respective RSI. Table 4 presents examples of their responses.

Table 4. Most Practical Practices to Implement by RSI Teachers

Focus Group/Conference Call Sessions	Examples of Professional Development Practices Implemented
Alaska RSI	• Assessment activities (e.g., student portfolios and presentations) • Parents' and community members' integration into instructional practices (e.g., village elders) • Native Ways of Knowing cross-curricular approach • Science fairs • Hands-on experiments • Culturally responsive standards
American Indian/Tribal RSIs	• Ways to teach the metric system • Mathematics manipulatives • Full Option Science System (FOSS) kits • Physical representation of advanced concepts in mathematics with algorithms and numerical formulas assisted by elders in community
Appalachian RSIs	• Graphic organizers • Formative assessment rubrics • Sequenced and coherent units of instruction • Graphing calculators • Mathematics activities for special education students • Activities with parents of elementary students
Delta RSI	• Student groupings and independent assignments • Assessment rubrics (e.g., individual and group assessments) and variation (e.g., written/oral projects) • Peer-tutoring practices in mathematics instruction
Texas RSIs	• Inquiry activities • SMART Board technology • Benchmark tests for each grade level • Data analysis to identify students with deficiencies • Focused hands-on activities • Student assessment (e.g., more than paper tests)

Practices Impacting Student Achievement

Teachers in their respective RSI focus group or conference call sessions also were asked: "What new practices that you learned in the RSI professional development and implemented had the most positive impact on student achievement in mathematics and/or science?" Of particular interest were new instructional practices that increased student performance on state assessments, classroom tests, or lab work. Teachers in the Alaska RSI highlighted numerous practices. One respondent noted the following:

> *I believe that student engagement in the projects helped to develop skills in thinking more like a scientist. They helped draw the kids into science a little more, made the kids want to do more science back in the classroom, particularly when they realized their ancestors had been doing science back in their culture for centuries. Even though it might not have been titled science, they were doing experiments and tests to live off the land and survive.* (Alaska RSI Teacher)

According to one Alaska RSI teacher, a hands-on unit with geometric patterns helped students in second grade to learn the square, the triangle, and the parallelogram. Students explored what else they could make with the "pretend window" pattern of three rows on top and three rows on bottom. This pedagogical stratagem resulted in students' acquiring meaningful knowledge.

Teachers in the Appalachian RSI reported that designing new assessments of learning reduced students' guessing about what teachers wanted them to learn and placed more responsibility on the students.

> *This is the third year that I used the Stiggins' Assessment for Learning program that allows me to let the students know upfront what they have to learn, what they have to know and be able to do. Every lesson is tied to one of those knowledge targets or skill targets or performance targets. Instead of making students aware of what they were to learn as you go along, or maybe not until the end of a lesson, they get a list of the learning targets at the beginning. What is to be learned is upfront, transparent, and very clear to the student. And it is in language the student can understand. Students don't have to guess what the teacher wants them to learn. It also helps put the responsibility for learning back on the students. The other two teachers in the RSI and I shared the program with the principal, and now the whole school is using the program.* (Appalachian RSI Teacher)

New questioning techniques and brain research learned in Appalachian RSI professional development activities aided teachers in accelerating student achievement.

Teachers in the Texas RSIs also shared examples of how what they learned in professional development and implemented in classrooms had a positive impact on student achievement. A teacher of fourth- and fifth-grade students incorporated pictures into lessons to help students learn important science words as part of their everyday vocabulary. Another teacher witnessed an increase in student achievement after conducting a learning-styles inventory at the beginning of the school year to guide the selection of meaningful projects and assignments. Student achievement improved for another teacher when she implemented RSI curriculum training that emphasized teaching a math/science theory after first providing students with practical examples (activity before content).

Another participant representing a Texas RSI reported that fifth-grade students retained more information when they used journaling practices for recording information. A teacher of ninth-grade students found that students mastered science concepts when they had to teach them to younger students.

> *The ninth-grade students would pick a science topic, and then they would master the content so they could teach it to the fifth- and sixth-grade students. This also helped the students on the lower campus know what they would need to learn on our high school campus. I think the experiences also caused the teachers of the fifth- and sixth-grade students to get excited when they saw the ninth-grade students teach and saw our science labs.* (Teacher representing a RSI in Texas)

New practices used by teachers of American Indian/Tribal students included greater incorporation of visual modeling in lessons. One teacher noted, "If I could teach them so they could visualize it, when the test came, the students could better remember what we did with the blocks, remember what we did with the fractions. If they had the pictures in their minds, they could use the information better on their assessment tests." In teaching the concept of surface tension, another teacher in the focus group described how students used a penny and dish detergent to determine how many drops of water were required for the bubble on the penny to burst. The teacher commented on how implementing the activity, learned from a demonstration by the trainer provided by the RSI, produced astonishing success:

> *The kids remembered the activity and the content. I can remember them writing like crazy when it came to that question on the test. They all got it. They all remembered the surface-tension activity. I thought how great it was that something that simple could be used to help get ideas and concepts across for students to understand surface tension that well. That was wonderful.* (American Indian/Tribal RSI Teacher)

Using a boat-floating-in-water activity was equally popular among the Tribal teachers for helping students to learn density/mass concepts and solve equations with unknown variables.

During their RSI professional development activities, teachers of American Indian/Tribal students also embraced culturally responsive activities for making content more relevant to students. According to one participant, “FOSS kits were fabulous teaching tools, because the students were physical learners.” This teacher witnessed achievement gains in mathematics by taking students outside and building a teepee. Determining the diameter of a circle or the area of a cone became more organic and easier for students to understand through the hands-on activity.

Barriers to Successful Practice

Teachers in the various RSIs had to overcome many barriers to implement practices that were successful in improving student achievement in mathematics and science. “Time to do it all” in a teacher’s school day was a major obstacle in the Tribal RSIs. One respondent said, “Personal time to fit it all into the curriculum is a barrier. Of course, we get our preparation time to plan, but usually that is what my whole weekend consists of.”

While RSI teachers of American Indian/Tribal students generally proclaimed great success in using activities to make instruction in mathematics and science relevant to students, finding the time to learn, plan, and conduct the activities could be overwhelming. Prepared instructional materials, like the FOSS kits, were helpful. Nonetheless, as one RSI instructor noted, “I also had to teach more procedures because the FOSS kits require it. You have to do procedures to keep students safe, procedures to pick up things, all the little but important things.” Using these activities with students required teachers to divert time to guidance in such simple procedures as “putting things away in the correct place.”

Colleagues and administrators who were unwilling to change constituted another barrier, according to those in the Appalachian focus group. Many teachers preferred the “chalk and talk” approach to teaching.

Instructional inertia was a common phenomenon among non-RSI peers unwilling to go beyond their comfort zones. When their school environments were discouraging, RSI teachers noted the importance of networking with other "motivated" faculty.

For some teachers who participated in the RSIs serving Appalachia, money was a major barrier. Some school districts simply did not have the necessary funds to purchase instructional equipment such as interactive white boards and up-to-date textbooks. For teachers seeking professional development opportunities, the RSI was the solution.

Delta RSI teachers in their focus group reported similar challenges. One recalled how his "old school" principal "wanted to see students practice, practice, practice test-preparation activities, and not permit students to be loud or noisy in the classroom." Another noted how some parents saw certain teaching practices as morally wrong for their children. For example, some parents complained that using cards and dice as instructional devices was tantamount to teaching their children how to gamble.

Delta RSI teachers also found that visiting "outsiders" expected to see students seated neatly in classroom rows. It thus became important to have parents witness firsthand students learning from new and unregimented approaches to teaching. Given this situation, one instructor remarked, "I had to think outside the box and be able to do what I learned as the new approach. For example, I had to give kids an activity soon after instruction and be able to always adjust, move with the kids." Another teacher noted, "I had to learn the difference between 'excited noise' and 'learning noise' in the classroom."

Focus group participants representing the two Texas RSIs experienced similar barriers. Some had administrators who prized a quiet classroom, "not understanding that the teacher needs to do activities with the students." Thus, the task of teaching science, ironically, was viewed as unimportant by some administrators.

> *One of the biggest barriers was that of actually getting the school principal to understand that students needed to . . . be doing science labs in the classroom. The principal didn't think I had time to teach students science. It was difficult getting the principal to understand that I needed to teach science, needed the equipment, and needed support. I think the RSI personnel helped pave the way by working with the principal to understand the importance of science, and that students needed to be "doing science." The principal had to understand that this was a much different classroom-learning environment than students sitting quietly at a desk.* (Teacher representing a RSI in Texas)

Teachers representing the Texas RSIs also commented on the lack of funds for purchasing instructional equipment and participating in professional development unless the RSI paid expenses.

Another participant in the Alaska RSI noted how difficult it was to find adequate time to organize and conduct native science fairs. Initially, district personnel helped to set up the fairs and teachers only had to get their students prepared to participate. However, the assistance soon ended.

> *After a few years, it fell away, and then it was up to the teachers to set the science fair up, with a little bit of help, but not much. It seemed as though the science fair unraveled a little bit because there was so much to do in planning, getting judges, etc. It lost some of its punch. The barrier was lack of time to teach and . . . organize the fair. What we ended up doing was a component of the fair, not like when it was a separate fair for a full day.* (Alaska RSI Teacher)

Getting village elders to come to classrooms and share their knowledge was a tremendous benefit for students, but one teacher in the Alaska RSI session believed that it was unfair to ask elders to do so without compensation. The teacher, consequently, wrote a grant proposal to solicit funding at $25 per hour, though many elders willingly donated their time gratis. Another teacher in the Alaska RSI session noted, however, that some elders developed a more "Western world view" of expecting payment for services rendered.

Alaska RSI teachers also faced the barrier of a principal who had little enthusiasm for a culturally responsive approach to teaching.

> *One barrier was that . . . the principal would give me negative observations and always say, "Well, those are not practical teaching and learning opportunities for our students. They will never use the language, not adapt the old culture to the way the world is now." But for three years, the test scores of my students kept going up. The cultural approach was increasing test scores. When I connected mathematics and science to culturally related ways of knowing, the student scores went up, and the principal became a supporter—but it took three years. I did not let the principal bully me into not teaching those cultural ideas.* (Alaska RSI Teacher)

Another teacher noted that the school had no curriculum for indigenous students. He overcame the barrier by getting together with other teachers and developing a more appropriate curriculum for native and non-native Alaskan teachers.

Support for New Teaching Practices

While the barriers that RSI teachers had to overcome were plentiful, the teachers also reported enjoying support in implementing new practices. School-district leadership, school administrators, parents, and community members played important support roles that encouraged teachers in implementing what they had learned in RSI professional development opportunities.

Teachers in the Delta RSI focus group recalled how willing, open-minded, and supportive parents of students were for the new instructional practices. Parents observed classrooms and talked with the teachers to learn about new classroom practices. One noted that her school's open-door policy encouraged efforts to involve parents on mathematics and science nights. Another commented on how a principal's supportive attitude toward the cooperative grouping of students encouraged implementation of the new practice. The curriculum director in another Delta district was particularly willing to plan professional development for the teacher to learn how to implement new practices.

In recognizing support inherent in her school's chain of command, a Delta RSI teacher pointed out the importance of the grade-level chairperson in her elementary school. The principal would often ask the chairperson whether the RSI teacher needed help in implementing new instructional practices. Also crucial for another teacher in the focus group session was the Delta RSI field representative, who would talk with the principal or superintendent to garner support for a new instructional practice.

Several Appalachian RSI teachers noted that their district provided funds to participate in cadres or other forms of professional development such as networking with RSI colleagues. One was given released time to attend multiple conferences and training sessions that benefited students. This teacher commonly returned from the workshops, made presentations, and shared resources with other teachers in the district. Yet another at an Appalachian school served as a cadre leader in the district, which purchased books for all teachers to participate in a collaborative study.

> *After I attended the high quality professional development offered by the RSI and had success in the classroom, I offered to start a cadre to help other teachers in mathematics and science learn the new practices. The district leadership was very supportive and paid each teacher in the cadre $20 per hour after school to participate in the cadre sessions.*
> (Appalachian RSI Teacher)

Some teachers in the RSIs serving Appalachian schools were supported by their school districts in sharing newly developed expertise with teachers in neighboring districts.

A teacher in the Alaska RSI acknowledged the important role of parents and principals in influencing school boards. When parents supported the teaching of students through native-based activities, such as dissecting fish and other animals legally harvested by students, their school board approved the start of a charter school that emphasized the new cultural approach to teaching and learning.

> *One of the parents of a student spoke to the school board members about it, and my principal came to bat for me because the kids were benefiting. He said for me to keep doing what I was doing. After one kid brought in the first fish and another brought in the first rabbit, we wanted to create native thematic ways of learning based on the seasons, and we got support from the district and started our own charter school. This is the fifth year that I have been at the charter school, and the whole focus is from the Alaska RSI culturally responsive approach. It is awesome.* (Alaska RSI Teacher)

Another Alaska RSI participant cited huge support by parents and the community in conducting a native science fair. Community members, particularly elders, mentored students in their projects. Parents also were supportive, particularly when participating in field trips related to science. One teacher remarked, “The parents loved going on the boat field trips. It also helped parents understand the connection of the trip activity with the curriculum once they get on the boat. A lot of organizations in town are supportive, and lots of parents are now supportive of the curriculum. I think we are pretty lucky.”

An American Indian/Tribal RSI teacher explained how critical support enabled the teaching of mathematics and science in a multigenerational way. Elders and grandparents were in the classrooms with the teacher and children every day. This was important because teachers are viewed as “outsiders” on the reservation.

> *The whole idea is that the teacher, who really is an honored guest on the reservation if she comes from the outside, isn’t the only authority figure who knows something—and the children pay more attention when they have their own community members right there with them learning with them and helping them at the desk for a learning experience.* (American Indian/Tribal RSI Teacher)

Some American Indian/Tribal RSI teachers also acknowledged the support of district administrators in buying consumable supplies for use in the FOSS kits. Moreover, school administrators kept teachers informed of RSI professional development opportunities. And one Tribal teacher noted, "The local college was also supportive, as they kept you up-to-date on professional development and tried to help you any way they could."

Teachers in the Texas RSI focus group session shared numerous examples of support for implementing new practices learned through professional development:

- Administrators found funds for science in elementary grades after a couple years into the RSI project.
- A district hired a mathematics/science consultant to assist teachers, and now that person is an assistant superintendent who has the background to understand the needs of mathematics and science teachers.
- After "specialists" from the RSI visited a school, the district strengthened its educational plan's focus on mathematics and science. It also added a second science teacher position that resulted in physics being offered at the high school.
- Districts and schools gave RSI teachers total freedom in using "extra funds" to create a science and mathematics lab for kindergarten students.
- A school board set up a special budget for science at the elementary, middle school, and high school levels.
- Parents supported family mathematics/science nights and related activities.

Unimplemented Teaching Practices

Numerous teachers participating in the five RSI focus groups and conference calls reported being unable to implement all the new practices learned in their RSI professional development. Teachers in the RSI focus groups and conference calls were asked to discuss new teaching practices that they tried unsuccessfully to implement or never had an opportunity to implement.

Lack of time prevented one teacher in the Texas RSI focus group from implementing an outdoor component of science education. Another teacher cited lack of time to organize a book study cadre. A third respondent noted the discontinuation of mathematics/science nights:

> *We have not continued at any level the mathematics/science family nights after the RSI stopped. I don't know if the elementary teachers needed more support and equipment or if they were just overwhelmed with the family night and considered it just one more thing that they would have to organize and get together. Also some of the teachers lived a long way from the school and had to travel a long way to get home after the event.* (Teacher representing a RSI in Texas)

In the American Indian/Tribal RSI, a participant revealed a somewhat different perspective about why some practices learned in professional development were not implemented. It was an issue, the person suggested, involving teacher involvement in RSI training, teacher turnover, and curriculum continuity from one grade level to the next. Only those who participated in RSI training implemented the Everyday Math curriculum and used FOSS kits in their classrooms. In this teacher's view, the new practices were something for the school to build on, and if the school did not, "students would go on to the next grade, and the teachers would not be doing the same practices." Therefore, "there was no continuity . . . from one grade to the next, particularly if the teacher in that grade had not gone to the RSI training." Teacher turnover at the school also contributed to the problem of implementing the new practices.

Another American Indian/Tribal teacher said that the lack of interdepartmental collaboration prevented implementation of some new RSI practices. "We found that science isn't just in the science classroom and mathematics isn't just in the mathematics classroom. I think we could have implemented more mathematics and science if we had a different style of educational model that encouraged collaboration and sharing." The same teacher noted that a block schedule rather than a 45-minute class period would better accommodate team teaching.

Teachers in the Appalachian RSI focus group mentioned several practices that they were unable to implement. For example, when one tried Algeblocks, students became "too excited" and lacked the background concepts necessary for implementation. Another RSI teacher noted that differentiated instruction required a lot of work given inadequate time for planning and implementation. Furthermore, the difficulty involving book studies, according to one teacher in the same focus group, was compounded by colleagues' unwillingness to stay after school because "it is not necessary, and they are busy."

Delta RSI participants reported that funding limitations prevented the purchase and use of interactive white boards as a new practice they wanted to implement. Another teacher experienced difficulty in keeping students on task and managing their rotation during cooperative grouping.

A teacher in the Alaska RSI acknowledged his desire to incorporate a salmon story into instructional activities "because it has so many lessons for students, particularly about respect for Native Ways of Knowing. But I had no place in the curriculum for it." Another explained the financial barrier to incorporating an herbal medicine activity in the curriculum:

> *I also wanted to fit in herbal medicine, making salves with the kids in my project class. I didn't have the money for it, so I used my own money, but it cost me so much. By the time I did it, I couldn't believe I had spent that much of my own money, so I discontinued it. Now I have formed a little club after school, and I am doing it with students after school.* (Alaska RSI Teacher)

Still another Alaska RSI teacher wanted to add a drum-making unit in which students would make everything from scratch, including tanning moose hide for the drums, but scarce external grants appeared to be the only way to fund the activity.

Replacing RSI Professional Development

Most teachers have discovered few professional development opportunities to replace the high-quality training available from their respective RSIs. One Alaska RSI participant, for example, commented:

> *Well, I feel as though there is a big hole since the Alaska RSI ended. But they left a lot of stuff on a great website. Preparing Indigenous Teachers for Alaska Schools is a grant-funded project that I am involved with. So there are some opportunities there, but not to the level we received with the Alaska RSI. It is frustrating. I am hoping that my participation in this session can help us get the Alaska RSI back. The Alaska RSI was something wonderful.* (Alaska RSI Teacher)

Alaska RSI teachers recalled fondly their opportunities to participate in camp-related professional development. But these were usually funded by grants, and such funding support ended. One person observed that, while it was possible to gain grants for student projects on snow and ice studies through the U.S. Department of Defense, it seemed that nothing was available from the Alaska Department of Education to support mathematics and science projects.

Teachers in the Appalachian focus group acknowledged that, when their RSI project ended, only generic versus content-specific professional development was available. Money was an issue for another teacher (the RSI had paid for all travel expenses, substitutes, and technical assistance). Even Appalachian school districts that could afford to offer professional development specific to the needs of mathematics and science teachers faced hurdles. One respondent said, “Our central office doesn’t have the expertise to find high-quality professional development that is current and research-based.”

Similarly, members of the American Indian/Tribal cohort reported missing networking opportunities available when their RSI was operative. Subsequent networking with other mathematics and science teachers never occurred.

> *Absolutely zip! It has been a pain not having the quality RSI professional development opportunities. If you want to go and get something, or if your school has not been providing it, it is difficult. It is either the summer time or the Montana Education Association conference time. Our school has not provided us with any on our Pupil Instruction Related days when we might learn increased techniques or skills that we could use in mathematics and science. It has really been a pain. I miss our RSI classes. I want them back.* (American Indian/Tribal RSI Teacher)

One American Indian/Tribal teacher explained the importance of RSI-subsidized college courses: “It took us out of the realm of the elementary classroom, and we got to talk with other adults in an adult setting.” These teachers also noted how, while college courses were available, they did not include direct technical assistance follow-up by a person who could come to the teacher’s classroom and provide demonstrations on how to implement the new instructional practices. Another American Indian/Tribal teacher observed that the RSI provided a unified approach to implementing STEM programs from the elementary through high school level. “This was not done before the RSI. We continued it through the mathematics-science partnership project funded by the NSF. But it was not quite as good as the RSI. There was a critical mass of educators who participated, on a voluntary basis, in the RSI which made the unified system approach possible.”

Delta RSI focus group teachers confirmed as well that content-specific mathematics and science professional development was replaced by mostly generic online courses that enabled teachers to earn continuing-education units (CEUs) for meeting license renewal requirements.

> *We needed CEUs to renew our license, and each course was worth so many CEUs. That's basically what we were left with after the Delta RSI ended.* (Delta RSI Teacher)

One Delta RSI respondent indicated that professional development requests were routinely denied by district leadership because of a tight budget and loss of instructional time with students.

Teachers in the Texas RSIs, on the other hand, participated in numerous grant-funded projects after the RSI ended. These opportunities included training at universities and in field trips offered by regional cooperatives funded by the state department of education. For example, one teacher acknowledged attending sessions of the state-funded Regional Collaborative for Excellence in Science Teaching. A Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) grant, funded by the U.S. Department of Education, paid for another teacher's access to professional development.

Teachers' Professional Development Needs

Teachers cited numerous professional development opportunities they wished were available as follow-up training to their respective RSIs. Probing questions in the sessions sought to identify specific venues that would enable instructors to serve students better in learning mathematics and science. Table 5 charts these responses.

Table 5. Professional Development Needs of RSI Teachers

Focus Group/ Conference Call Session	Examples of Professional Development Needs
Alaska RSI	• Round-table sessions of former Alaska RSI teachers by grade level to review and discuss their most creative lessons for teaching mathematics and science focused on cultural values and tied to state and national standards • Sessions on ideas for experiments and projects that are place-based or connected to Native Ways of Knowing • Conferences or forums for teachers to share what they learned after implementing RSI practices • Another grant like the Alaska RSI that would support teacher sharing through online conferencing sessions, videos, downloadable PowerPoint presentations, and live chats
American Indian/ Tribal RSIs	• Another RSI that provides “refresher” classes for teachers to stay up-to-date • Person at nearest college available for teachers to contact or visit to explore how to implement a new or better instructional practice in mathematics and science • Person available to demonstrate on-site how to implement effective instructional practices • Paid opportunities to attend sessions of the National Council of Teachers of Mathematics and the National Science Teachers Association • Networking opportunities to share ideas and see exhibits of instructional resources in mathematics and science • Clearinghouse of museums and other places teachers and students might visit to see examples of mathematics and science applications
Appalachian RSIs	• Projects like the RSI where cohorts of highly motivated teachers and support providers with knowledge of practices result in high-quality professional development • Opportunities that pay expenses for teachers in districts with inadequate funds to support content-specific professional development in mathematics and science • Strategies that enable a teacher to have time to reflect on “What have I done, and what do I need to do better?” • Strategies that enable teachers to increase parent and community involvement in academics • Opportunities for teachers to share “best” mathematics or science activity in a district or regional education meeting • Opportunity to be part of a group of mathematics and science teachers that consistently meets as a learning community, unlike district professional development meetings focused on a general topic for all teachers
Delta RSI	• Workshops on how to do inexpensive lab activities with students rather than using the expensive Full Option Science System (FOSS) kits • Training on how to use computer labs in mathematics and science instruction, with appropriate follow-up; not training held at the end of the school year that the teacher will not need until August • Extensive training on how to implement new mathematics textbook series purchased by school district, including exercises for the lessons and more interactive instruction about how to use the series • Networking opportunities with other teachers of mathematics and science
Texas RSIs	• Technology training for teaching science • Professional development specific to grade level, including pre-kindergarten and kindergarten • Opportunities that include instructional equipment and materials to take back to the classroom • Mathematics and science specialists available to come to districts to help teachers • More content-specific professional development focused on cohorts of teachers (e.g., physics teachers)

Policymakers Need to Know

As the last topic in the focus groups and conference calls, teachers were asked to comment on other aspects of their professional growth that they thought resulted from participation in the RSI, particularly those that should be shared with national, state, and/or local policymakers. While respondents noted how participation in high quality, content-specific professional development provided by the RSIs was a once-in-a-lifetime experience, they pondered why such opportunities could not be provided more routinely. After all, states emphasized STEM education, and national policy leaders consistently advocated the linkage of America's global competitiveness to excellence in teaching mathematics and science in public schools. Numerous teachers perceived that state and national policymakers lacked a sufficient understanding of RSI's impact on teachers.

Tables 6-10 reveal statements expressed by teachers in explaining how experiences in their respective RSI helped them grow professionally as a teacher. Some statements also disclose important limitations in making use of the experience to benefit other teachers, or a lack of continuing growth opportunities without RSI support.

Table 6. Perceptions of Professional Growth by Alaska RSI Teachers

Teachers' Statements of Professional Growth Experiences
• "Alaska RSI helped me become more effective in both mathematics and science. Right from the beginning, it built self-confidence; it gave me lots and lots of ideas; and it enabled me to write better instructional units. I used many of those units when I applied for the Alaska State Teacher of the Year, and I was one of the four finalists. During the interview I used nothing but the topics that I learned in the Alaska RSI."
• "You know what the Elders in the Classroom program is going to do for the kids. But you don't realize what it is going to do for the teachers. It is a unique opportunity for training and discussion. Every time an elder comes into the classroom, it is training for the teacher. That is professional development, and it is very, very powerful."
• "I was one of those teachers who had not been exposed to the Alaska RSI as much as others had. I wish the Alaska RSI was still around. It was a great program. Teachers in it went on to influence other teachers."
• "I am ready to share my experiences with other teachers. But funding is a problem at a time when Western education is open to indigenous education (ways of knowing) and when students could learn from the two approaches to education growing together."

Statements by teachers in the RSIs serving American Indian/Tribal students highly valued the opportunity to learn about new teaching practices. Teachers also learned how to build the trust necessary for incorporating community elders into their instruction, making course content more relevant and culturally meaningful for students. A hallmark of these RSIs was hands-on instructional resources such as the FOSS kits.

Table 7. Perceptions of Professional Growth by Teachers in American Indian/Tribal RSIs

Teachers' Statements of Professional Growth Experiences
• "People in the U.S. Senate and House of Representatives need to know just how important the RSI really was to teachers, maybe they would fund it again. If they could hear the conversations that we have had today, they could learn how important it is for us to have a professional social outlet like this. It is important for educators to get together and discuss the day's events, or discuss the topics at hand, to be able to work through teaching issues. It rejuvenates you as a teacher."
• "I was selected for participation in a Tribal College and University Program grant because of my previous involvement in the RSI. I was able to gain access to computers, new resources, and opportunities for my students, which enabled them to better prepare for college."
• "RSI opened a big window for me to help the children learn in a better way. Not just the Elders in the Classroom program but also community members who had expertise in an area to share with teachers and students. Being rural means you have to make good with what you have. You may have saddle-makers and water hydrologists who work locally. They are our science museum."
• "RSI improved communications and trust for community members to come into the school setting. I don't know if it is true everywhere, but in our community lack of trust is definitely a hurdle to overcome. The Elders in the Classroom program helped build trust by asking the community members to teach the teachers, by reversing the role of the teacher as the ultimate authority. It had a huge impact on teachers and students."
• "Learning to use the FOSS kits was the best thing for me. There must be new kits since the RSI ended, but we don't have them. Our school district doesn't have funds to buy the new ones. All we are trying to do is to buy the materials to restock the ones we received in the RSI professional development experiences."
• "Before the FOSS kits, we had no supplies. I had only what I could bring from home to do the experiments for/with students. So it would be just one whole major group of students doing the experiment, not the smaller groups of two to four students, which was possible with the RSI funding."
• "Professional development on the FOSS kits, on Everyday Math, and Math and Science in a Nutshell. All of those resources came to us by way of the RSI."
• "Because of the RSI, we had so much science at our fingertips, an opportunity that would not have come my way. All the science courses that I took I would have had to pay thousands and thousands of dollars to take, and with RSI they were in our community and we got reimbursed. None of that would have been possible for me without the RSI."
• "We had a summer retreat for all teachers in the district, a full week once a year where the elders taught us about native plants, the stars, creation legions, and aspects of tribal life that were designed to reflect mathematics and science teaching. I don't think that would have ever happened without the RSI. We even had about 100 teachers from Minnesota come to one retreat in the third year of the RSI to participate in the learning opportunity. It was all started by the RSI."

Teachers' Statements of Professional Growth Experiences (cont.)

- "We had unique learning experiences for professional development, like trips to Yellowstone. We identified wolf packs and identified a unique strain of antelope. We measured the rise of Yellowstone Lake using technical equipment to see how much the land had raised from the preceding year. The activities were tied to the culture. I used examples from the RSI-sponsored field trips that helped me teach students in ways that fascinated and motivated them. We also could relate mathematics and science to protecting the environment."
- "Teachers who were not in the RSI don't have access to learning experiences like we received in the RSI. I have a library at my house with all my RSI references and notebooks. Other teachers came to my house to learn from the resources. My house might look kind of cluttered but by golly all the RSI stuff is there."
- "If we had, for example, a professional development book of best practices or best lessons learned that we could use to increase awareness of the practices with other teachers in our areas—to say that we are not an expert or anything, but here is a book that is free with 10 great science ideas and 10 great mathematics ideas. We need to tap those teachers who had the opportunity to participate in the RSIs to create something like the best practices book, and a way for those teachers to network and share the practices with other teachers."
- "Most teachers we know in the rural areas, located out in nowhere, are very dedicated people. They are not lazy. They are interested in improving teaching and learning situations that may not be perfect. But you would have to give them something for investing their time and traveling long distances to the professional development, such as advancement on the teacher salary scale or college credit. Also, many teachers in those locations will need some type of financial assistance to cover travel expenses."

Teachers who participated in the RSIs serving schools in Appalachia also noted a growth in self-confidence and valued access to new instructional resources. Teachers attributed their growth in large part to the exceptional helpfulness of RSI personnel who treated them as fellow professionals.

Table 8. Perceptions of Professional Growth by Teachers in Appalachian RSIs

Teachers' Statements of Professional Growth Experiences
• "RSI helped me learn a grant-writing process, which was valuable to my small district."
• "RSI gave me great confidence in my ability to teach and share my knowledge with other people."
• "RSI gave me access to research-based practices on how to teach and get inside a kid's head for more effective teaching."
• "Because of RSI professional development, I am no longer limited to the four walls of my classroom, stumbling around looking for useful information that will help me be more effective."
• "The sustained approach of the RSI caused me to develop into a continuous learner, leading to a more effective educator."
• "I learned how to go about creating sustainable change and became a more effective teacher leader in my school."
• "RSI gave me the confidence to go back to school to get degrees (i.e., master's in mathematics, master's in science education) and education specialties so I could be a leader."
• "I learned that I had to accept responsibility as a leader to change mathematics and science, and RSI gave me the confidence to do it."
• "RSI treated teachers like professionals who were valued. Professional development was designed specifically for us; meetings were held in beautiful locations; our opinions mattered, and our ideas were used. Professional development was not thrust upon us. We were not treated like you need to 'fix' a teacher to fix education that is broken."
• "RSI was directed by individuals who would work with the school district leadership. They made the extra effort to help district leaders see the need for improved mathematics and science education. They found resources in the RSI project budget to help districts buy into the vision of high quality mathematics and science and what teachers needed to be effective with students."

Participants in the Delta RSI also attributed their growth to exceptional field representatives, who came to classrooms and modeled lessons. Such RSI assistance enabled teachers to grow as facilitators of student learning.

Table 9. Perceptions of Professional Growth by Delta RSI Teachers

Teachers' Statements of Professional Growth Experiences
• "Critical thinking activities of RSI training helped us to teach children to think."
• "Field representatives of the RSI gave teachers extra help and support if they needed it; provided ongoing follow-up, not just offered workshop training and then disappeared. They actually came to the classroom and modeled lessons for teachers."
• "You could see personal growth in everyone. We grew as individuals (e.g., in doing lesson plans and becoming better organized)."
• "Without the RSI that helped me become a facilitator of learning, I would have stayed a traditional 'old school' teacher, as the person in front of the classroom in control (i.e., teacher-centered instruction). I also would probably not be using manipulatives in my classes to more effectively teach students."
• "RSI worked with teachers in lower and upper grades to see how each did it, which created a better understanding among teachers at both levels about how they were connected and helped us identify the student achievement gaps between the levels, or the gap in the curriculum between the two levels of education."
• "RSI helped me know how to look outside myself for new ideas and how to teach. For example, I discovered the professional development opportunities available at Delta State University."
• "RSI representatives came to the school and conducted the parent/family nights, where the teachers volunteered at stations but the RSI field representatives did the mathematics and science demonstrations for parents. So the RSI representatives showed the teachers how to do a parent/family night—not leave teachers hanging to do it the first time on their own with parents. Also, they stayed until all parents left, and they also left us the materials that we could use the next time with parents."
• "No field representatives now exist in mathematics and science to help teachers like those available in the RSI. Mississippi has even eliminated state-sponsored conferences because of budget shortages."
• "As was emphasized in the RSI, teachers who attend high-quality professional development must be resource persons for the school district and help others when they return from a conference, not just attend and share nothing with other teachers back at the school."

Some teachers in the Texas RSIs credited their decision to continue in the teaching profession to the exceptional professional development offered by the RSI, which provided unparalleled access to instructional resources and networking with other teachers of mathematics and science. Understanding what constitutes good teaching was a hallmark of Texas RSI professional development, as revealed in teachers' statements.

Table 10. Perceptions of Professional Growth by Teachers in the Texas RSIs

Teachers' Statements of Professional Growth Experiences
• "If not for the RSI, I never would have had access to high-quality professional development. It kept me in teaching." • "I developed lifelong friends with other teachers of mathematics and science in the RSI who will be a source of new ideas until I retire." • "I liked the subject-matter specialists available in the RSI, the general networking with other teachers, and the resources for teaching that I would never have had." • "As I gained more knowledge, I understood more about what was good teaching, and it renewed my enthusiasm for teaching. I learned that good teaching was more than a quiet classroom." • "I would not have implemented inquiry-based learning without the RSI professional development." • "Without the RSI, I could not have talked to other teachers in rural schools with circumstances like mine. I learned that my problems were not unique and that there may be answers." • "There is little chance in small rural schools for quality professional development like that offered by the RSI. Also, teachers don't have time to look for the resources." • "Educational service centers or collaboratives might be sources of professional development for some teachers in rural schools. Maybe some opportunities exist online or in other grant-funded projects."

Chapter 5 - Evidence of Success and Lessons Learned

Each RSI experienced valuable elements of success and lessons learned as it strived to implement its model of change for improving mathematics and science education in high-poverty rural areas. This chapter highlights examples of success as revealed in annual reports or other documents of RSI projects. A final section describes important lessons learned.

Impact on Teachers and Teaching

Prior to the Ozarks RSI, professional development available for teachers in the region frequently did not offer content that was appropriate for their actual teaching assignments. The unavailability of qualified substitutes also made many administrators disinclined to release teachers from classrooms. A fifth-grade teacher with 12 years of experience noted, “Before the Ozarks RSI, professional development wasn’t especially suggested, encouraged, or easy to find.”

Ozarks RSI project staff learned that the key challenge is to support teachers in effectively implementing a highly focused curriculum adopted by the school, one that emphasizes what students must learn to be successful in college, in careers, and as citizens (Harmon, 2006, p. 6). Compared to more traditional curriculum (i.e., nonstandards-based), adopting a standards-based curriculum required teachers to change areas of instruction. Table 11 illustrates how a teacher would place less or more emphasis on certain curriculum areas and instructional practices if implementing a K-12 standards-based science curriculum.

Table 11. Changing Emphasis in Standards-Based K-12 Science Curriculum

Less emphasis on:	**More emphasis on:**
Knowing scientific facts and information	Understanding scientific concepts and developing skills in inquiry
Studying subject-matter disciplines (physical, life, earth sciences) for their own sake	Learning subject-matter disciplines in the context of inquiry, technology, and the history and nature of science
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students analyzing and synthesizing data after defending conclusions
Doing few investigations to leave time to cover large amounts of content	Doing more investigations to develop understanding, ability, values of inquiry, and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of material and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates
Developing science programs at different grade levels independently of one another	Coordinating the development of a K-12 science program across grade levels
Using assessment unrelated to curriculum and teaching	Aligning curriculum, teaching, assessment
Maintaining current resource allocations for books	Allocating resources necessary for hands-on inquiry teaching aligned with the National Science Education Standards (NSES)
Textbook and lecture-driven curriculum	Curriculum that supports the NSES and includes field trips and laboratories emphasizing inquiry
Broad coverage of unconnected factual information	Curriculum that includes natural phenomena and science-related social issues that students encounter in everyday life
Treating science as a subject isolated from other school subjects	Connecting science to other school subjects, such as mathematics and social studies
Science learning opportunities that favor one group of students	Providing challenging opportunities for all students to learn science

A fifth-grade teacher with 18 years of experience seemed to sum up what teachers in the Ozarks RSI worked to achieve: "I now implement practices that enhance and fine-tune my teaching of *the child* instead of *the class*."

The Sisseton Wahpeton RSI encompassing seven school districts on or near the Lake Traverse Reservation—two tribally controlled schools, four South Dakota public schools, and one Minnesota public school—emphasized cooperation between local school systems and Sisseton Wahpeton College that greatly increased the availability of professional development for teachers (see Figure 7 for hours of available professional development).

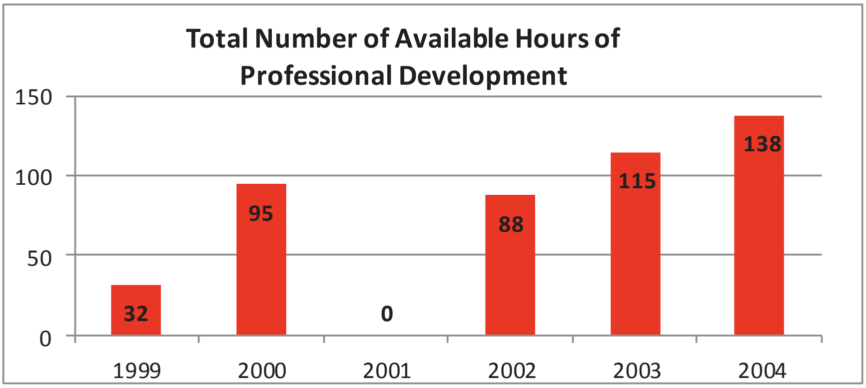

Figure 7. Availability of Professional Development in the Sisseton Wahpeton RSI

The Hawaii RSI operationally redefined desired teacher and student outcomes as parallel statements (see Table 12). Thus, expectations became clearer regarding teacher and student responsibilities for effective teaching and learning. To achieve better teacher impact on student learning, the Hawaii RSI aligned statements of what a teacher would do and subsequently what a student would do. For example, the teacher will "build inquiry around place-based issues and topics involving culture and environment," and the student will "investigate environmental issues and topics that are relevant to their neighborhoods and communities."

As part of the Hawaii RSI evaluation, a sample of the team leaders for the participating schools was surveyed and interviewed to determine their assessment of the change in curriculum and instruction at their schools. The team leaders were asked to assess the level of impact that the Hawaii RSI had on teachers' application of the inquiry process and the use of technology for instruction. Survey results were plotted on a 4-point scale ranging from "Not at all" (1) to "Consistently evidenced" (4).

Table 12 reveals that teachers from Cohort 2 were moderately consistent in their implementation of the principles of teaching and learning emphasized by the Hawaii RSI. They are particularly strong in standards-based instruction and the use of research-based pedagogy to design instructional activities. The teachers are fairly consistent in providing real-life learning experiences and more opportunities for all students to learn. Cohort 3, comprised of teachers new to the RSI project, had less experience with Hawaii RSI professional development in the design of curriculum and place-based learning, a fact that may explain their slightly lower ratings.

Table 12. Team Leader Assessment of Instructional Change in Hawaii RSI

From your observations, what impact has the Hawaii RSI had on the teacher application of the inquiry process and the use of technology for instruction?	**All interviewees**		**Cohort 2**		**Cohort 3**	
	Total	**Mean**	**Total**	**Mean**	**Total**	**Mean**
Instructional content is based on Hawaii standards and priorities	10	3.7	4	4.0	6	3.5
Teachers use research-based pedagogy to design instructional activities	10	3.4	4	3.8	6	3.1
Instruction provides for increased real-life learning experiences	10	3.4	4	3.5	6	3.3
Teachers increase collaboration and communication with peers on instructional issues	10	3.3	4	3.3	6	3.3
Teachers expand opportunities for learning to occur for every student	10	3.2	4	3.5	6	2.9
Approaches to teaching to take advantage of technology are often considered	10	3.1	4	3.0	6	3.1
Assessments are more authentic and directly related to instructional tasks	10	2.9	4	2.5	6	3.1
Teachers help students to construct their own projects	10	2.9	4	2.8	6	3.0
Instruction is more individualized to meet student needs	10	2.8	4	2.8	6	2.8
Student assessments are integral to the learning process and are used to change/ improve instructional strategies	10	2.7	4	2.5	6	2.8

**** Interviewee Responses on a 4-Point Scale***
1=Not at all; 2=Little; 3=Moderately noticeable; 4=Consistently evidenced

The Appalachian RSI developed a strong network of committed and competent teacher partners in participating districts. The teacher partners became the primary change agents for individual district reform. No participating school district in the Appalachian RSI project had fully developed *and* aligned science and mathematics curricula at the outset of the project. Consequently, teachers participated in curriculum-development workshops, and Appalachian RSI curriculum specialists provided on-site technical assistance to participating districts. Ultimately, more than 80% of participating districts developed and implemented K-12 science or mathematics curricula aligned with their state's standards.

In the Texas RSI, the introduction of teacher partners was a crucial step in building local leadership and making RSI efforts sustainable. In the spring of 2004, the Texas RSI leadership found that, of 433 teacher partners who returned a survey, 94% shared with teachers in their districts, 75% with their administrators, and 47% with others outside their districts. Of teacher partners who reported sharing, 74% indicated that they did so at least once a month. Teacher partners reported sharing in the following ways:

- 11% led professional development
- 12% made district-level presentations
- 21% modeled lessons
- 31% made campus-level presentations
- 34% made grade-level presentations
- 50% led demonstrations
- 90% shared Texas RSI materials with other teachers

The Alaska RSI provides another excellent example of how RSIs influenced curricula and related teaching practices. Supported by the Alaska RSI, Native educators produced the Alaska Standards for Culturally Responsive Schools. These standards, which embody the reform strategy of the Alaska RSI, were adopted by the state board of education for use in rural and urban schools. The standards provide guidelines for teachers, schools, and districts as they develop curricula and instructional strategies that address state and national standards while remaining responsive to the indigenous knowledge systems and ways of knowing in rural/Native communities.

In addition, the Alaska Staff Development Network, under contract with the Alaska RSI, developed two graduate courses for teachers and administrators on creating culturally responsive schools. More than 2,500 teachers and principals have enrolled in these three-credit distance education courses since they became available in 2000.

Similarly, the Navajo Nation RSI introduced amendments to the tribal education code (Title 10) regarding academic achievement, accountability, technology, and cultural infusion. The adopted amendments were a tremendous accomplishment for the Navajo Nation in exercising tribal sovereignty in education.

The Coastal RSI also achieved considerable success in helping teachers to implement standards-based teaching practices. Figure 8 shows a steady increase over the years in the percentage of teachers who implemented three key practices: written lesson plans, written objectives, and use of a lesson/unit from the local curriculum.

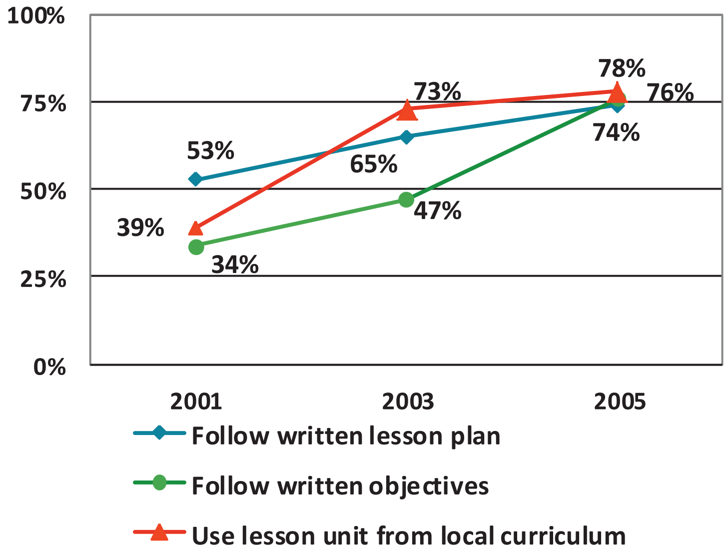

Figure 8. Coastal RSI Teachers' Implementation of Key Instructional Practices

The Texas RSI leaders found that the implementation of the state's standards-based curriculum framework, Texas Essential Knowledge and Skills (TEKS), was a major challenge for many districts. Texas RSI teacher partners used vertical curriculum alignment activities with math and science teachers across grade levels to facilitate a broader understanding of who was responsible for teaching what content and at which grade levels it should be taught. An online survey in the spring of 2004 revealed that 60 of 65 administrators (92%) reported increased coordination by teachers across multiple grade levels to ensure that math and science TEKS were taught appropriately. All 58 districts surveyed reported an increase in the use of problem-solving, inquiry-learning, and hands-on activities due to work with the Texas RSI. Moreover, 54 of the 57 reporting districts (95%) indicated that their teachers were better prepared to use technology for instruction; 52 districts (91%) reported an increase in the use of various technologies for instruction.

In the Coalfield RSI, two teacher leaders were selected from each of the 17 school districts in the coalfield regions of Virginia and West Virginia. The 34 selected teachers gained a wide range of valuable experiences as teacher leaders. Coalfield RSI teacher leaders documented their activities annually in logs. Table 13 shows that they logged more than 25,000 hours among the various activities during 2002-2007. These activities increased local capacity for systemic improvement of mathematics and science programs.

Table 13. Coalfield RSI Teacher Leader Log Summary for 2002-2007

Activities	Hours	Percentage of Total Hours
Personal training/development	8,816	35
Training other professionals	1,804	7
Preparation for training	1,729	7
State- and regional-level work	1,720	7
Mentoring	1,572	6
Tutoring	1,227	5
Curriculum topics	1,156	5
Instructional material review	1,081	4
School district plans	1,056	4
Recruitment	1,002	4
Data collection and analysis	809	3
Grant development	629	2
Dissemination	605	2
Teacher prep/college	479	2
Study-group activity/leadership teams	382	2
Research	338	1
Community training	301	1
Unassigned	281	1
Modeling	221	1
Total	**25,208**	**100**

Of the 53 systemic reform practices listed by the Ozarks RSI external evaluator in a 2004 survey, mathematics and science teachers rated principal-related practices highly when asked about the degree to which the reform practices were implemented at their schools (see Tables 14 and 15 for ratings of practices).

Table 14. Top 10 Implemented Practices Based on Ozarks RSI Math Teachers' Ratings

Systemic Reform Practice	No. of Teachers	Mean Rating*
Principal encourages using standards-based instructional strategies	114	8.55
Principal encourages using standards-based curriculum	114	8.52
Principal encourages using standards-based assessment strategies	114	8.48
Students participate in appropriate hands-on activities	115	8.46
Principal encourages participation in high-quality professional development aligned with teaching standards-based curriculum	113	8.42
Students work in cooperative learning groups	115	8.40
School/district policy supports alignment of curriculum, instruction, assessment, and professional development	117	8.28
Curriculum is taught by most teachers at school	107	8.22
Teachers have access to in-service opportunities specific for teaching math/science	115	8.18
Students engage in inquiry-oriented activities	114	8.16

**Rating scale: 0 (not implemented/low) to 10 (high/fully implemented)*

Table 15. Top 10 Implemented Practices Based on Ozarks RSI Science Teachers' Ratings

Systemic Reform Practice	No. of Teachers	Mean Rating*
Students participate in appropriate hands-on activities	103	8.49
Principal encourages using standards-based instructional strategies	100	8.39
Principal encourages using standards-based curriculum	100	8.35
Principal encourages using standards-based assessment strategies	100	8.35
Students work in cooperative learning groups	103	8.31
Students engage in inquiry-oriented activities	102	8.16
Principal encourages participation in high-quality professional development aligned with teaching standards-based curriculum	97	8.13
School/district policy supports alignment of curriculum, instruction, assessment, and professional development	103	8.11
Students are required to record, represent, and/or analyze data	101	8.01
Teachers use informal questioning to assess student understanding	102	7.97

**Rating scale: 0 (not implemented/low) to 10 (high/fully implemented)*

Impact on Students and Learning

Improving student achievement was a key outcome in the NSF concept of systemic reform, and all of the RSI projects placed a premium on this outcome. Numerous examples of this emphasis are cited in the annual reports of RSI projects across the country. The examples provided below include interpretations by the authors of these various reports. The purpose for presenting these examples is not to suggest that any one RSI model achieved a better result than another; it is instead to illustrate the hard-earned success achieved by the various RSI projects—and to reveal the challenge faced by project leaders in capturing consistent performance data amid constant changes in state assessment instruments.

Figure 9 reveals the positive change that occurred in mathematics achievement in a cohort of high-implementation schools served by the Coastal RSI in Virginia and the Carolinas. Note that the greatest gains in student pass rates were achieved in South Carolina and Virginia, which had the lowest pass rates among the three states in 2001.

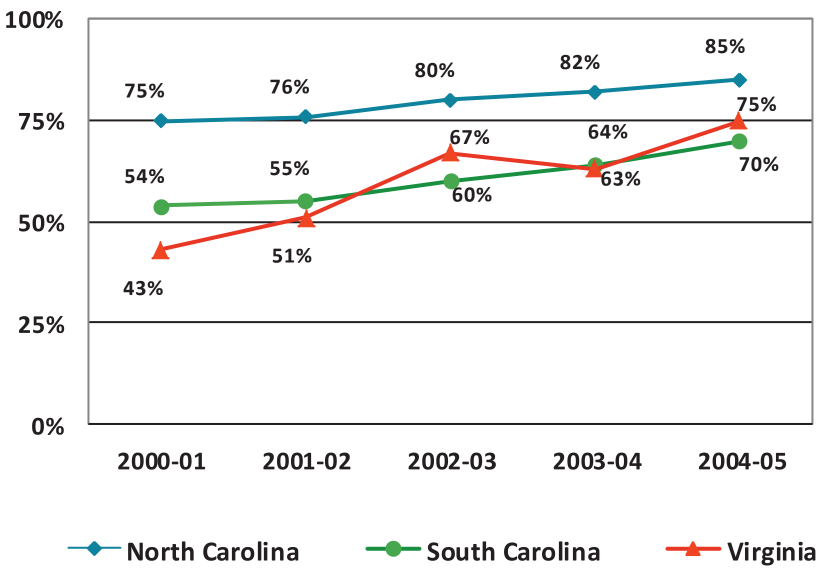

Figure 9. Coastal RSI Student Achievement in Mathematics from 2000-01 through 2004-05

All eight of the Appalachian RSI school districts in Ohio improved student mathematics achievement in either the fourth or sixth grade between 2003 and 2005. The districts also improved on the mathematics assessment at the high school level. Because this assessment was instituted in the 2003-2004 academic year, comparison data for Grade 10 are available only for the last two years of the project (see Table 16).

Table 16. Mathematics School District Data from State Proficiency Testing, Appalachian RSI, 2002-2005 Percent Proficient

School District	Grade Level	2002-03	2003-04	2004-05
Adams County	4	44.0	54.0	47.4
	6	36.6	70.9	57.9
	10		63.5	81.3
Morgan County	4	49.0	50.6	48.5
	6	50.0	68.0	64.9
	10		72.6	76.7
Eastern Local—Pike County	4	41.5	34.3	50.0
	6	32.8	47.0	63.0
	10		63.8	66.0
Waverly City Schools, Pike County	4	67.4	67.9	56.5
	6	32.9	63.8	44.4
	10		70.6	79.1
Meigs Local School District	4	35.3	42.5	39.4
	6	46.6	65.6	54.9
	10		62.6	75.0
Eastern Local—Meigs County	4	56.9	51.7	64.5
	6	34.8	51.5	61.4
	10		57.6	90.8
Southern Local—Meigs County	4	17.0	51.8	59.0
	6	31.6	45.1	29.5
	10		46.4	59.6
Vinton County	4	35.9	54.9	46.5
	6	31.9	52.2	50.3
	10		50.3	69.1

Table 17 shows that all six Appalachian RSI districts in Tennessee exceeded the state's three-year average in 2005 and improved the performance for both "all students" and those identified as "economically disadvantaged." Five of the districts reduced the achievement gap between "all students" and "economically disadvantaged" students.

Table 17. Tennessee Grade K-8 Combined Percentage of Mathematics Proficiency (Proficient plus Advanced) Scores (Comparing the Percentage of All Students with Economically Disadvantaged Students)

District	Student Type	2004 Proficient/ Advanced	2005 Proficient/ Advanced	State 3-Year Average
Oneida Special	All Students	87%	96%	83%
	Economically Disadvantaged	80%	92%	75%
Johnson County	All Students	77%	89%	83%
	Economically Disadvantaged	72%	86%	75%
Fentress County	All Students	87%	89%	83%
	Economically Disadvantaged	82%	86%	75%
Cocke County	All Students	82%	86%	83%
	Economically Disadvantaged	80%	85%	75%
Scott County	All Students	77%	86%	83%
	Economically Disadvantaged	76%	85%	75%
Campbell County	All Students	82%	85%	83%
	Economically Disadvantaged	79%	81%	75%

The Alaska RSI also achieved important gains in student performance. The most notable feature of the data in Figure 10 (shown on the following page) is the increase in RSI student performance for Grades 9 and 10 each year between 2000 and 2003. The tenth-grade students in all groups showed a substantial gain in mathematics achievement between 2000 and 2003, but the average performance of all Alaska students declined somewhat in 2004. The overall decline in 2004 is largely attributable to a reset of the cut scores for the test instrument. However, the RSI students posted a lower decline than students in non-RSI rural schools, resulting in a slight reduction in the achievement gap.

Norm-referenced test results are available for ninth-grade students who had been taking the TerraNova/CAT-6 since 2002 (see Figure 11 for Grade 9 results). Though the differentials for each group between 2002 and 2003 were small, the RSI students achieved an increase in performance in 2004. The non-RSI students experienced a small decrease in their performance over the three-year period.

Leaders of the Alaska RSI noted consistent improvement in the academic performance of students in Alaska RSI-affiliated schools during the seven-year period. These leaders have concluded that the cumulative effect of utilizing the Alaska Standards for Culturally Responsive Schools to increase the connections between what students experience in school and what they experience outside school appears to have had an important impact on students' academic performance.

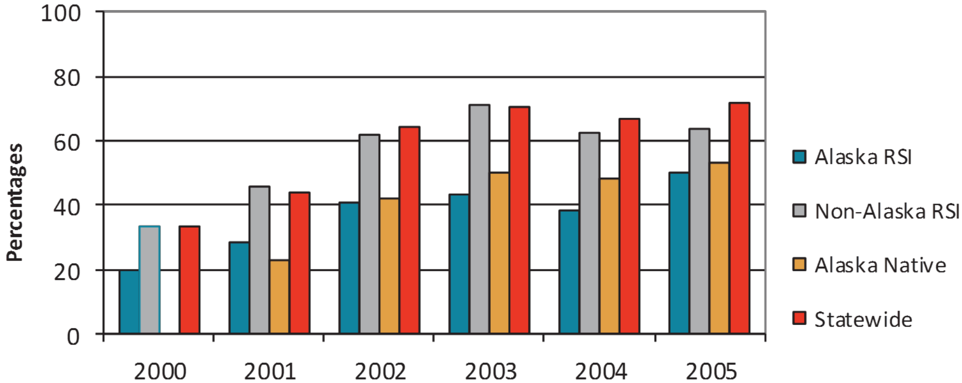

Figure 10. Alaska RSI Grade 10 Mathematics High School Graduation Qualifying Exam, 2000-2005 (Percentages of Rural Students Achieving Advanced/Proficient Level)

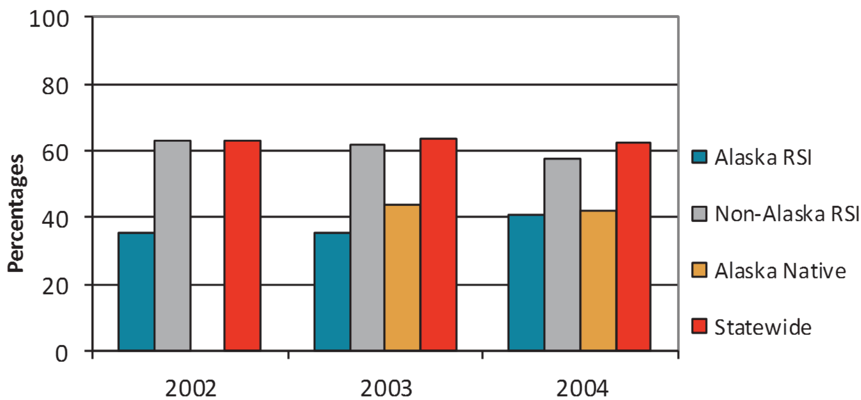

Figure 11. Alaska RSI Grade 9 Mathematics TerraNova/CAT-6, 2002-2004 (Percentages of Rural Students Scoring in the Third and Fourth Quartiles)

Additional examples of student-achievement gains in mathematics are revealed in project reports for the Texas RSI. Texas Assessment of Academic Skills (TAAS) math tests were administered in Grades 3 through 8 and Grade 10. Passing the Grade 10 TAAS was required for graduation. Math TAAS data are presented in Table 18 for the 1997-1998 Texas RSI baseline year through the final administration of the TAAS in the 2001-2002 school year. Data are presented for the 60 original districts with which TRSI worked during this time.

Between 1998 and 2002, the overall Math TAAS passing rate (grade-level performance) for all students tested in 60 Texas RSI districts increased from 79% to 91% (see Table 18 for percent of students passing by grade level). The passing rates increased at every grade level tested, with an average grade-level increase of 12 percentage points.

Table 18. Changes in Math TAAS Passing Rates in Texas RSI Districts*

Grade	Percent Passing 1998	Percent Passing 2002	Change in Percent Passing
3	75	83	+ 8
4	80	93	+13
5	85	94	+ 9
6	81	91	+10
7	79	91	+12
8	79	92	+13
10	75	92	+17
All Grades Combined	79	91	+12

** Average number of students tested per grade level: 4,643 in 1998 and 4,363 in 2002.*

Longitudinal comparisons also revealed increases in passing rates. The first analysis considered the passing rate of third-grade students in 1998, then followed the progress of this grade-level group through the fourth grade in 1999, and continued each year through seventh grade in 2002. A similar analysis started with fourth-grade passing rates in 1998 and continued each year through eighth grade in 2002. Regression trend analysis showed significant increases in passing rates for the third-grade analysis and for the fourth-grade analysis.

The percentage of students meeting the 2004 passing standard increased at every grade level tested in Texas RSI districts, ranging from a three-percentage-point increase in Grade 10 to a 19-percentage-point increase in Grade 11. The average grade-level increase was eight percentage points (see Table 19 for percent of students passing by grade level).

Table 19. Math TAAS Percentages Meeting 2004 Passing Standard in Texas RSI Districts*

Grade	Percent Passing 2003	Percent Passing 2004	Change in Percent Passing
3	78	88	+10
4	74	82	+ 8
5	71	77	+ 6
6	64	72	+ 8
7	55	66	+11
8	57	62	+ 5
9	50	55	+ 5
10	54	57	+ 3
11	63	82	+19
All Grades Combined	62	71	+ 9

** Average number of students tested per grade level: 3,112 in 2003 and 3,076 in 2004*

The Science TAAS was administered only in the eighth grade. Of the 60 districts participating in the Texas RSI when TAAS was the assessment system from 1998 through 2002, 59 districts included the eighth grade. The average number of eighth-graders tested each year was 4,648. The percentage of those passing the eighth-grade Science TAAS increased from 78% in 1998 to 93% in 2002.

The passing rate of economically disadvantaged students increased by 19 percentage points. Data disaggregated by ethnic subpopulation revealed an 18-percentage-point reduction of the gap in passing rates between African American and White students and a 14-percentage-point reduction of the gap between Hispanic and White students (see Table 20 for passing rates).

Table 20. Science TAAS Grade 8 Passing Rates for Texas RSI Districts and Ethnic/Economic Subpopulations*

	Project Year					
Student Group	1998	1999	2000	2001	2002	Change from 1998 to 2002
Economically Disadvantaged (%)	69	79	81	88	88	+19 pp
African American (%)	61	73	77	86	86	+25 pp
Hispanic (%)	69	80	80	87	90	+21 pp
White (%)	90	95	95	97	97	+ 7 pp

** Average number of students tested per year: 2,539 Economically Disadvantaged; 316 African American; 2,276 Hispanic; and 1,954 White*

In the Appalachian RSI, 13 Kentucky school districts were actively involved during the 1999-2005 school years. All of these districts increased science achievement scores, resulting in significant improvement of their index scores (see Table 21 for index scores). Such increases ranged from a low of 3% to a maximum of 48%, with a mean increase of 27% for the 13 districts at the elementary level, 26% at the middle school level, and 20% at the high school level. Table 21 reveals science achievement increases in elementary schools for the 13 Appalachian RSI school districts in Kentucky.

Table 21. Science Achievement for Appalachian RSI Districts: Elementary Schools, 1999-2005

Appalachian RSI Counties	1999 Academic Index	2005 Academic Index	1999-2005 Index Change	% Index Increase
Bath County	67.49	81.75	14.26	21
Floyd County	61.39	82.07	20.68	34
Johnson County	74.66	106.10	31.44	42
Knott County	61.80	72.15	10.35	17
Lewis County	60.41	82.33	21.92	36
Lincoln County	65.87	86.41	20.54	31
Menifee County	77.92	87.65	9.73	12
Owsley County	64.20	82.18	17.98	28
Pikeville Independent	75.15	111.59	36.44	48
Powell County	82.68	94.06	11.38	14
Rockcastle County	85.96	106.25	20.29	24
Rowan County	75.19	90.43	15.24	20
Wolfe County	72.04	91.47	19.43	27
Averages	**71.14**	**90.34**	**19.21**	**27**

Note: Index scores are assigned by the Kentucky Department of Education with a maximum of 100.

The Wind River RSI strived to increase the content knowledge of culturally relevant mathematics and science. Professional development activities addressed helping schools transition into using research-based math programs and others such as FOSS, Global Positioning Systems (GPS), Geographic Information Systems (GIS), and NWOK. These programs were regularly provided to teachers for integration into their schools and classrooms. Based on state test data, proficiency levels of Grade 11 Wind River RSI students increased 4.5% between 1999 and 2002 (see Figure 12 for proficiency levels achievement).

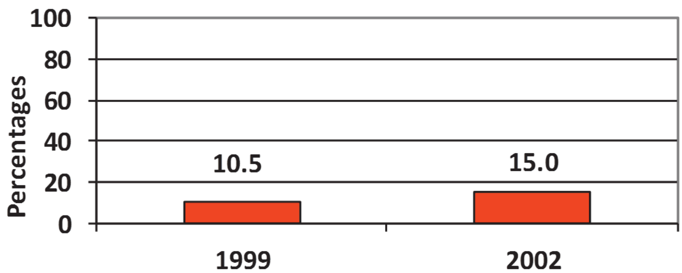

Figure 12. Percentage of Grade 11 Wind River RSI Students Achieving at Proficiency Levels in Science

During the 2004-2005 school year, Ozarks RSI leadership and staff sought to determine whether teachers using FOSS science kits were getting positive results in student achievement. Thirty classrooms were selected to conduct pre- and post-test analysis. Teachers administered a pre-test to students in their classes during the first month of the school year and again administered the same test toward the school year's end. Table 22 shows the results (2-tailed test, $p< .05$).

Table 22. Pre- and Post-Test Results for Science Kits by Topic and Grade Level, Ozarks RSI

Science-Kit Topic	Grade	# of Classes	# of Classes with Mean Score Test Gains	# Classes with Statistically Significant Gains
Animal studies	3	20	16	11
Balancing and weighing	1	24	23	16
Catastrophic events	6	16	16	16
Changes	2	23	23	23
Classifying living things	5	10	10	10
Ecosystems	4	14	14	14
Electrical circuits	4	20	20	19
Energy, machines, and motion	7	5	5	5
Land and water	5	10	10	10
Life cycle of butterfly	2	26	26	25
Motion and design	4	20	19	14
Organisms	1	21	21	16
Plant growth and development	3	16	16	14
Soils	2	22	22	21
Solids and liquids	1	8	8	6
Sound	3	16	15	13
Weather	1	26	25	22
Totals (#)		**297**	**289**	**255**
% of Total Classes		**100**	**97.3**	**85.9**

Teachers taught 17 science-kit units to students in classes at the appropriate grade level. Pre-and post-test results (mean scores) were calculated for 297 classes. Post-test mean scores increased compared to pre-test mean scores for 289 (97.3%) of the classes. The *t* test results revealed that 255 (85.9%) of the classes experienced a statistically significant gain in mean test scores.

Lessons Learned

Leaders of each RSI project reported learning many valuable lessons in seeking to improve mathematics and science education in high-poverty rural areas. We offer a list of 22 lessons learned based on a review of project or evaluation documents provided by the leadership of the RSI projects. Although a specific lesson learned may be applicable to more than one category, the lessons learned were grouped under four broad categories: (1) Providing Administrative Understanding and Support; (2) Accessing Ongoing External Expertise, Materials, and Support; (3) Developing and Sustaining Leaders; and (4) Maintaining Communications Across All Partners. The purpose here is to provide examples of lessons learned across a variety of RSIs. It is not implied that each lesson is appropriate to all models of change implemented by the RSIs or that the list is exhaustive.

Providing Administrative Understanding and Support

Teachers want administrators to demonstrate their support of improvement initiatives by scheduling time for teachers to share and plan with each other. Teachers appreciate an "engaged" administrator; for example, an administrator who participates with teachers in professional development activities and district leadership meetings. An administrator needs to show an understanding of the improvement initiative (i.e., RSI project) in some detail when expecting teachers to be committed to a new initiative. School and district administrators play a critical role in making decisions to purchase instructional materials for teachers and in sustaining efforts of an RSI because they control resource allocation. Six of the 22 lessons learned are examples of the Administrative Understanding and Support category, as follows:

1. School and district **administrators** play a critical role in sustaining RSI efforts because they control resource allocation. During the RSI project, administrators devoted funds to the purchase of standards-based curriculum materials, graphing calculators, and data-acquisition devices; to the creation, renovation, and staffing of science labs for use by elementary students; and to released time for teacher partners to share new knowledge with other teachers. All of these instances point to changes in administrative, and therefore district, priorities that form the needed foundation for long-term impact.

2. A significant problem that school and district administrators may face in sustaining the RSI investment is how to fund the continuing instructional needs of teachers trained by the RSI. This issue may intensify, as RSI-experienced teachers may be much more assertive than previously about their need for materials and may consistently advocate for administrators to purchase additional **instructional materials**.

3. Teachers view it as "essential" for administrators to engage fully with the new program to understand the needs of teachers in completing the transformation. Teachers want administrators to demonstrate their support of RSI initiatives by scheduling **time** for teachers to share and plan with each other.

4. The importance of **administrative engagement** in the reform process cannot be overemphasized. In districts where administrators understood the RSI model, teacher partners were encouraged to participate in workshops, time was provided for them to share with colleagues, and funds were allocated to support reform efforts. Astute administrators maximized the impact of visits of regional specialists to teacher partners by finding ways to include other teachers in those meetings. Perhaps most important to administrative engagement was participation with teachers as professionals at RSI events and at district leadership meetings.

5. It is necessary for RSI staff to visit new administrators and teachers early in the school year in order to increase their **understanding of the project** and cultivate their ongoing support and involvement. Frequent nurturing of relationships established with district personnel is critical in guarding against misunderstanding or miscommunication that could hinder reform efforts.

6. Time is a major hurdle when it comes to training teacher leaders and improving their effectiveness with leadership teams and study groups. **Training principals** to enable common group/team planning and work time may be the most powerful strategic investment for improving mathematics and science programs and student learning.

Accessing Ongoing External Expertise, Materials, and Support

Leaders of RSI projects report that they quickly learned that teachers required the assistance of mathematics and science specialists external to the school system to acquire new attitudes and skills to implement a standards-based curriculum and instructional practices. Parents can also be valuable support partners for teachers who are trying to change the curriculum or access instructional resources. The need for ongoing partnerships with parents, businesses, faith-based organizations, government agencies, and institutions of higher education can be essential to acquire the instructional materials and other supports required to implement a major improvement effort like the RSI. Nine of the 22 lessons learned are examples of the Accessing Ongoing External Expertise, Materials, and Support category, as follows:

7. Mathematics and science **specialists** can help teachers on an individual basis to move from lower levels of implementation (i.e., changing beliefs and the mechanics of using the curriculum) to higher levels (i.e., examining the effect of the curriculum and pedagogy on student learning).

8. Parents will come to school improvement family events, even in high-poverty rural areas with a history of low participation at other kinds of activities. Parents can become proactive in their support for mathematics and science education by helping teachers to purchase and/or make materials needed for hands-on and inquiry-based lessons. These kinds of **parental involvement** indicate a long-term investment in their children's mathematics and science education.

9. Teachers must learn to use the resources in their area, such as state parks, to provide field experiences for their students. Teachers and administrators also need to build relationships with university faculty members and informal science providers that will continue after the NSF's RSI funding ends. Districts can learn that working with other districts is an effective way to obtain external funding. All of these **partnerships** contribute to reducing the isolation of rural school districts.

10. Specialists can be a source of new ideas, encouragement, and materials for teachers. In many cases teachers view specialists as vital to their professional growth. On the other hand, some specialists may be poor matches. Those who are mathematicians may not know science well enough to help science teachers (or vice versa). It is important to make good choices in the **selection of specialists**.

11. An RSI can meet with school district leaders and help them form leadership teams for the program's implementation, but the regional RSI must also provide immediate tasks to help the team develop a vision for the reform needed and to understand the team's role in leading the reform efforts. Not having an **engaging task** for the district's team to work on right away can greatly diminish the momentum of starting the partnership and delay the district's engagement in true reform efforts.

12. A critical part of teachers' successful implementation of new learning strategies is the **on-site support** provided by RSI regional specialists. A major reason teachers cited for not implementing new strategies and models in their classrooms was lack of time to prepare and refine the new lessons. Regional specialists make classroom implementation easier for teachers by providing encouragement, materials, and technological assistance.

13. For many Native American educators, a **culturally responsive science curriculum** has to do with their passion for making cultural knowledge, language, and values a prominent part of the local school system. It involves presenting science within the whole of cultural knowledge in a way that embodies that culture, demonstrating that science standards can be met in the process.

14. **Partners** are absolutely essential for systemic change, but it is important to select partners who add value and provide diverse resources. Leaders of change need to know what potential partners bring to the table and what they expect to gain or achieve through their partnering.

Developing and Sustaining Leaders for Change

Rural school districts may become dependent on the RSI project, as a provider of high quality professional development for teachers of mathematics and science, to learn how to be effective leaders of change. Cohorts of teacher networks are valuable conduits of professional development for teachers in isolated rural schools, but the network can be difficult to sustain. Teacher and administrative turnover in a small rural school district can greatly slow progress in a major reform initiative like an RSI. Classroom teachers can develop into teacher leaders, but progress can be slow, as a teacher may require attention and support over an extended time (e.g., three or more years). Five of the 22 lessons learned are examples of the Developing and Sustaining Leaders for Change category, as follows:

15. Without RSI support, administrators may be greatly concerned about how to replace the high-quality experiences of **professional development** made available to the teachers by RSI specialists. This problem is compounded by the high rates of teacher turnover in high-poverty rural school districts.

16. **Teacher cohorts** may be the most fragile of all RSI project artifacts. The rural districts are very likely to return to the isolation forced on them by distance and scarcity of resources.

17. **Progress** in reform efforts can be very fragile, especially in small districts where a single teacher is the entire science department or where there are only a few administrators. In those cases, a single person's leaving the district can significantly slow the reform process.

18. **Moving teachers into roles as leaders** in the improvement of mathematics and science is a delicate process. Most teachers require an extended period of nurturing, whereas, others have just been waiting for the opportunity. Both types, however, need attention and support over time.

19. Many teachers will step up to leadership roles given adequate professional development opportunities as well as **encouragement** by their school and/or district administrators.

Making Decisions and Maintaining Communications

Implementing the model of change created by an RSI may require difficult decisions by school system personnel, for example, in deciding to introduce a standards-based curriculum and inquiry-based instructional practices. New opportunities for communications may be necessary to align the curriculum among different grade levels (e.g., middle school and high school). Sharing new instructional practices may require more consistent and broader communications if teachers, other than those originally trained, are expected to implement the practices. Three of the 22 lessons learned are examples of the Making Decisions and Maintaining Communications category, as follows:

20. Adopting a **standards-based curriculum** is a critical and difficult decision for schools. Doing so, however, creates a catalyst for all teachers to examine their teaching practices. It also allows all professional development opportunities and assessment strategies to focus intensively on teaching all students to achieve the higher levels of content and conceptual understanding that are key elements of the new curricula.

21. The **“share”** portion of the Learn, Implement, Share model (used by the Texas RSIs) was less successful than originally anticipated. Mixed results exist on how often and how well what was learned was shared with teacher partners’ colleagues. Teachers commented on how they would return from a workshop and try to explain what they learned to colleagues, only to be met by blank stares. Something gets lost in translation, and it is “hard to bring home the enthusiasm.”

22. At the district level, it was common for a middle school mathematics teacher never to have met the high school counterpart before they both became involved with the RSI. This was true even in very small districts. Such lack of interaction made it difficult to align curricula or even to communicate problems. The RSI created facilitated free-flowing **communication** up and down the instructional line.

Chapter 6 - Leveraging the RSI Legacy: Concluding Thoughts and Future Directions

Clearly, no one RSI model of change for mathematics and science education reform fits the diverse cultures, communities, and economies in rural America. Leaders of the RSIs report important lessons learned that can help guide future reform efforts in mathematics and science education in rural areas, particularly in places with high concentrations of impoverished students. So, where do we go from here?

This is the question that Dr. James Rubillo, executive director of the National Council of Teachers of Mathematics, seemed to pose at the *Forum on Leveraging a Legacy of Leadership in Mathematics and Science Education* that was held in Washington, DC on July 16, 2008 in the U.S. House of Representatives Standing Committee on Science and Technology's conference room. In his remarks, to provide a summary of what was said at the forum during the day-long event, Rubillo stated,

> *But what I am not sure happened for policymakers is I did not hear the answer to the question that I most commonly either hear, or see in a legislator's eyes: What do you want me to do, and why? And what will the outcome be? I heard about the RSI legacy, but I did not hear about what to do next.*

In this final chapter, the authors attempt to answer this question. While the authors' thinking is informed by the three efforts reported in this monograph to document the work of the RSIs, and their personal involvement in directing or consulting roles in RSIs, they also draw extensively on their prior roles as state department of education officials with major responsibilities to assist a state board of education and state legislature in formulating education policy in one of the most rural and impoverished states in the nation (i.e., West Virginia). One author also served as vice chair of a state rural development council. The authors also draw upon extensive experiences in providing technical assistance to rural school districts and/or in evaluating numerous grant-funded school improvement initiatives. Lastly, they draw upon their own contribution to and understanding of the rural education literature. The thoughts and recommendations in this chapter are the authors and do not represent the opinions or policy of Edvantia, Inc. or the National Science Foundation.

During the 1990s and the first decade of the new millennium, the NSF invested more than $140 million in 30 RSIs. RSIs operated in some of the most impoverished areas of rural America, advised by individuals and partnering organizations with a high interest in improving mathematics and science education in public schools during an era dominated by a global, knowledge-oriented, and highly technological economy.

The RSIs functioned in settings where many children in public education were left behind decades ago because of persistent poverty, geographic isolation, inadequate financial investment, race/ethnicity, and/or other social issues. In most of these regions, success in the workplace required little education, if a decent job was available at all. Obtaining a good education frequently contributed to a larger pattern of "brain drain" within the local area. Community leaders thus faced the dilemma of investing scarce resources to prepare the "best and brightest" to leave for productive lives elsewhere, resulting in few benefits to rural communities. Carr and Kefalas (2009) argue that such a process creates a gradual "hollowing out" of the community's human and social capital required for local development.

Since the RSIs' inception in the mid-1990s, STEM education increasingly gained importance as essential preparation for success in college, a career, and in life. High achievers in mathematics and science were proclaimed scarce in the United States as compared to other countries. For example, only about 10% of U.S. students scored in the two highest achievement categories in mathematics on the Program for International Student Assessment, well short of the figures for a host of other nations. In fact, the U.S. results were below average for the 34 nations comprising the Organization for Economic Cooperation and Development (Robelen, 2011).

During the economic recession of 2008 and 2009, Americans for the first time in history forecast less prosperous futures for their children than did previous generations (Foroohar, 2010; Pew Research Center, 2010). Public schools face an uncertain future, and fresh approaches to STEM education may be necessary for getting more American workers into jobs and refueling the U.S. innovation economy (Atkinson & Mayo, 2010). What appears increasingly clear is that educators and community leaders need to work together closely to offer educational opportunities and achieve levels of student performance that promise prosperity for both the individual student and the local community (Beaulieu & Gibbs, 2005; Harmon & Schafft, 2009; Schafft & Harmon, 2010). Tough decisions by national policymakers and education reformers should be grounded in what has been learned from the RSIs. Clearly, one model of reform does not fit the diverse cultures, communities, and evolving economies of rural America.

So where do we go from here? Previous chapters of this monograph reveal the innovative approaches and important lessons learned from selected RSIs. The authors' goal in this final chapter is to offer some insights into the future improvement of mathematics and science education in rural America. They address three themes that build on the evidence of challenges addressed by RSIs. These themes are instructional leadership capacity, teacher recruitment and retention, and policy actions.

Instructional Leadership Capacity

Research consistently documents that the most important influence on student performance is the teacher (Marzano, 2003; Southeast Center for Teacher Quality, 2004), but a rural school faces challenges unique to its context. Research must recognize what leadership in a rural context means. A good resource in this regard is Donald M. Chalker's *Leadership for Rural Schools: Lessons for All Educators* (1999).

Economically disadvantaged and geographically isolated rural schools face enormous challenges in providing adequate instructional leadership capacity. Common challenges include teacher recruitment and retention, administrative turnover, declining tax revenue, elevated transportation costs, and obsolescent facilities with limited access to technologies that support modern instructional practices. Few rural school districts will have adequate central office staffing to perform the numerous functions commonly mandated by state and federal laws.

Thus, rural school districts frequently employ personnel who must wear many hats, generalists who can "do it all" while meeting minimum requirements. Day-to-day demands often mean that talent and time are unavailable to plan aggressive improvement in mathematics and science education. Frequently, the school district superintendent will serve as the director of such programs, leaving little time for actual leadership of instructional programs and teacher development.

Future Directions for Instructional Leadership

The RSIs found that three strategies ensured instructional leadership. First, *provide intensive technical assistance to school district personnel responsible for curriculum and instruction*. Such assistance frequently included review of student assessment information (e.g., test score results) for schools in the district. This information, as disaggregated data, helped to guide a review of the curriculum for weaknesses and to determine the specific professional development needs of teachers in content knowledge and pedagogical practices. RSI personnel also offered recommendations for incorporating higher quality curriculum standards and inquiry-based instructional approaches.

Second, *target the principal as the instructional leader of the school.* Principals of RSI schools commonly used generic protocols for gauging classroom instructional practices. To strengthen this approach, RSI mathematics and science specialists routinely provided direct assistance to school principals in how to identify a quality curriculum and how to observe classroom practices specific to mathematics and science education. Forming a network of administrators in schools served by the RSIs enabled principals to talk with district peers about avenues of instructional improvement in mathematics and science.

Third, *require a focus on teacher leaders for improving mathematics and science education*. The approach in creating a shared leadership model varied among RSI schools. Generally, the approach involved either helping a teacher to become the designated resource person for other teachers of mathematics and science or forming a team of teachers to provide leadership for improving instructional practices. Capable teacher leaders and the promise of technology entail important applications for improving teaching and learning practices in rural schools (Hodges, 2007; Mayers & Desiderio, 2007).

These three capacity building strategies for instructional leadership at the district, school, and teacher levels required careful planning in each RSI. External NSF funding was essential to supporting the RSI effort, employing mathematics and science specialists, securing curriculum and instructional resources, and providing professional development opportunities for teachers at or near their schools. Attracting and retaining effective teachers thus became a critical issue in maximizing instructional leadership capacity

Teacher Recruitment and Retention

Teacher recruitment and retention is one of the greatest challenges confronting rural schools and their communities (Barley & Brigham, 2008; Cassandra, Santibañe, & Daley, 2006; Hammer, Hughes, McClure, Reeves, & Salgado, 2005; Harmon, 2003a; Jimerson, 2003; Monk, 2007; U.S. Government Accountability Office, 2004). In conducting the focus group sessions for the third phase of this study, the authors were quickly reminded of the dilemma. Great effort was required to identify teachers who participated in the RSIs and remained in the classroom as teachers of mathematics and/or science. Many had retired or accepted administrative positions.

Interventions to improve mathematics and science education must address long-standing problems in recruiting and retaining effective teachers for rural schools, particularly those with a large proportion of economically disadvantaged students. Marzano (2003) cites numerous research reports providing evidence that teachers are the most important factor in what a school does to impact a student's academic achievement. He concludes that "schooling accounts for about 20% of the variance in student achievement" and that "about 67% of this effect is due to the effect of individual teachers" (2003, p. 74).

Barley (2009) notes that the teachers recruited by rural schools must be prepared for the conditions of such employment: "They not only must have the credentials they need, but they should also be aware of the nature of small schools in small communities" (p. 10). Teaching in a rural area often involves geographical and social isolation, demanding workloads (McClure & Reeves, 2004), and lower pay (Jimerson, 2003). Professional development opportunities and the mentoring of new teachers may be greatly limited or non-existent in some rural areas such as the Black Belt in Georgia (Hodges & Tippins, 2009).

Prospective teachers are also often unprepared for rural realities that demand knowledge in multiple subjects and know-how in conducting a range of school activities. Consequently, rural administrators find it extremely difficult to hire qualified teachers who will stay in the job. Some characteristics of the "ideal" rural teacher include the following (Harmon, 2003a):

1. Certified and able to teach in more than one subject area or grade level
2. Prepared to supervise several extracurricular activities
3. Able to teach a wide range of abilities in a single classroom
4. Able to overcome the student's cultural differences and add the teacher's understanding of the larger society
5. Able to adjust to the uniqueness of the community in terms of social opportunities, lifestyles, shopping areas, and continuous scrutiny.

In examining the issue of teacher recruitment and retention, Monk (2007) enumerates some problems unique to rural areas: small populations, sparse settlement, distance from urban centers, and economic reliance on agricultural industries that are increasingly using seasonal and immigrant workers to minimize labor costs. Challenges faced by rural schools include a below average share of highly trained teachers, low salaries, and large numbers of students with special needs, limited English skills, and poor college attendance rates. "It is hard to escape the conclusion," writes Monk, "that the real beneficiaries of the localized teacher market are the wealthy suburban districts that turn out high shares of college graduates and have attractive working conditions" (2007, p. 164).

Numerous other researchers have recognized these problems (Barton, 2003; Collins, 1999; Hammer et al., 2005; Harmon, 2003a, 2003b; Horn, 1995; Luft, 1992-93; Miller & Sidebottom, 1985). In assessing the challenges faced by rural school districts in implementing the No Child Left Behind Act, a U.S. Government Accountability Office study (2004) found that 52% of rural administrators, compared to 36% in non-rural districts, reported difficulties in offering competitive salaries to teachers, thereby limiting recruitment efforts. Increasing the capacity for recruiting and retaining teachers is a critical challenge in small rural school districts. Their local communities must collaborate as capacity building partners.

Future Directions for Teacher Recruitment and Retention

If teacher turnover is to be reduced, recruitment efforts must take into account some reasons why teachers remain in a rural area: (1) they have family ties to the region; (2) they place a premium on the quality of rural life consistent with their upbringing; (3) they desire a close-knit and familiar community support system for raising their own children; (4) they have a passion for the outdoors and recreational activities unavailable in an urban setting; and (5) they feel professionally and personally rewarded by working in a less bureaucratic school system where teachers can get to know their students and their families well.

While other reasons may exist, one promising practice being explored in rural areas is to *establish "grow your own" teacher recruitment and retention initiatives*. This practice requires principals, teachers, and counselors to become more aggressive in identifying high school students who have an aptitude and interest in teaching as a career. A local foundation, perhaps operated by the school system, may offer a scholarship to defray a student's tuition at a regional college or university. School systems may also collaborate with local community colleges to offer special encouragement to prospective teacher candidates, whether a recent high school graduate or a long-time community resident. Partnerships with institutions of higher education may enable school systems to provide alternative paths to teacher certification for residents who desire a switch in careers. All of these efforts support a "grow your own" strategy for increasing the applicant pool of teaching candidates who are likely to spend their careers in the rural school district.

A second promising practice is to *form a regional, cooperative approach among multiple school districts to address teacher recruitment and retention*. The small scale realities of most rural and geographically isolated school districts severely hinder their individual efforts to recruit teachers. By working together, school districts and their immediate communities can share the work of functions that help to recruit and retain teachers (Ahearn, Harmon, & Sanders, 2005; Collins, 1999; Hammer et al., 2005; Harmon, 2003a; McClure & Reeves, 2004; Monk, 2007).

A regional educational agency or consortium of school districts can offer support services that make it possible for mathematics and science teachers in rural schools to participate in a high-quality mentoring program, access professional development opportunities, and share ideas and instructional resources in a network specific to the subject taught (Cook, 2003; Harmon, 2003c; Stephens, 1998; Stephens & Keane, 2005). As a key partner in the regional effort, a university can expand the new teacher's access to research-based practices and applications of technology (Harris, Holdman, Clark, & Harris, 2005). Web-based technologies can help teachers in rural and remote places have access to important support resources, research, and networks of colleagues (Herrington & Herrington, 2001).

A third promising practice is to *develop a holistic approach to teacher recruitment and retention*. Rural school districts seldom have the funds to compete with districts that offer much higher salaries and "bonuses" at a regional or statewide teacher recruitment fair. Even if they are successful in attracting a top teaching candidate, the likelihood of keeping him or her in the district is low. The realities of being paid less than colleagues in wealthier districts, having fewer professional development opportunities specific to subjects taught, and experiencing geographic/social isolation all work against retention of the new teacher. Therefore, a more holistic approach to teacher recruitment and retention can be helpful.

Such an approach requires the school district to comprehensively examine how it recruits teacher candidates. For example, do district recruitment materials include information that "sells" the rural schools and community to prospective teachers? How is information from applicants for teaching positions collected (e.g., Internet, paper) and screened? How are interviews of applicants conducted to determine those likely to be most successful in the school district? How much do administrators actually know about why teachers leave the district before retirement? How can they identify resources in the community that support beginning teachers?

This approach runs counter to the conventional wisdom espoused by too many rural school district leaders that "we can't compete with larger, more urban school districts" in attracting and retaining teachers. A holistic approach requires a deliberate effort to understand how teachers and others perceive the district, its schools, and the rural area in which they operate. It also requires partnerships with parents, community organizations, and businesses to attract and retain quality teachers. For example, locating desirable housing may be a huge problem for a new teacher in a rural area. Temporary housing can be provided through a partnership while a permanent residence is located. Moreover, a local bank could offer to delay payments on auto or home loans until the new teacher can address increased financial demands in transitioning from college to a job in the district.

Attracting and retaining talented teachers for mathematics and science education is a critical challenge in many rural school districts. The three practices of "grow your own," regional cooperatives, and a holistic approach are useful strategies for addressing the challenge.

Policy Actions

Effective teacher recruitment and retention strategies can benefit from sound decisions by policymakers. Educational reform initiatives, however, are frequently criticized by researchers and practitioners for failing to consider the realities of rural schools' circumstances. One example is the "one size fits all" approach that critics claim the federal No Child Left Behind Act imposed on small schools in rural communities (Jimerson, retrieved January 16, 2011 from Rural School and Community Trust; Schafft & Jackson, 2010). Rural education advocates understandably criticize the imposition of what are claimed to be evidence-based research models on rural schools and their communities that were not tested in a rural context.

In this section, 12 policy actions are offered, which has been grouped into three categories that could be considered for improving mathematics and science education. The three categories are: (1) planning improvements, (2) implementing improvements, and (3) providing incentives for improvements.

Planning Improvements

A policy that supports appropriate planning of the improvement effort could address how the policy places duplicate time demands on teachers, demands duplicate improvement plans of the school, supports learning mathematics and science in practical ways, encourages broad community support, and reinforces careers and postsecondary education counseling for students. Five considerations are included in this category.

1. *Carefully plan implementation of a policy to prevent overwhelming teachers with duplicate time demands*. For example, any policy requiring the simultaneous implementation of improvements in mathematics and science in elementary schools will overwhelm teachers. This usually occurs because the same person teaches both subjects. Requiring participation in extensive professional development in mathematics and science, while also expecting the teacher to carry out his or her usual classroom assignments in a rural school, is impractical. Worse, this demand may force talented teachers to leave the profession or deter them from working in a school that is constantly under "improvement" mandates.

2. *Avoid improvement policies that stipulate another plan for a subset of the school district or school curriculum*. Rural school districts with few administrative staff and teachers with multiple grade assignments are easily overwhelmed by a state or federal policy that requires a separate plan for modest funding. For example, a school improvement plan should include a section on improving mathematics and science education. However, a state or federal source of funding for a grant that would provide necessary professional development for teachers should not require a separate plan.

   More realistically, justification for funds should require a data-based explanation of how the professional development enables the school to accomplish its plan for improving mathematics and science education. This approach makes the best use of the school's planning process, rather than treating the activities supported by the funding source as a separate project. Moreover, it prevents forcing a "one size fits all" model of improvement on a school or district. Separate projects and inappropriate models of improvement are seldom sustained by the rural school and community.

3. *Create policies that support the practical application of mathematics and science content in a rural context*. Rural students are reared in an environment that rewards and demands pragmatism. Their circumstances require efficient "doing more with less" approaches to problems, including a reliance on family members, neighbors, and religious institutions, rather than social service programs. Incorporating project-based learning and/or practical examples that connect to their existing knowledge base helps to build interest in learning mathematics and science content. Such approaches also bridge the gap between traditional blue collar or manual labor economies and those that require information-savvy workers.

4. *Create broad community support for improvements in mathematics and science education initiatives*. Rural schools and their communities have symbiotic relationships that serve to strengthen the quality (or decline) of both. Families, schools, and religious institutions are the bedrock of most rural communities. Such communities also have a predominance of small businesses with one or two large employers. Commonly, the public schools or a hospital will be the largest employer in the area. Efforts to improve mathematics and science education must intentionally garner the support of local businesses, the community, and religious leaders. These entities sway the decisions of local school board members about what educational improvements are worth supporting.

Religious institutions can be valuable in helping the school and teacher communicate with the parents of students who may need additional help to succeed academically. Businesses can provide incentives in the workplace that support higher expectations for student achievement in mathematics and science, as well as allow parents to bring children to the workplace to answer the question, "Why do I need science or math to be successful in life?"

An accountant, agribusiness entrepreneur, agronomist, auctioneer, banker, dentist, farmer, judge, lawyer, nurse, physician, teacher, veterinarian, electrician, or environmental technician, among many other professions, can serve as a role model for students with relevant career interests. Scientists and engineers may be available in a state or federal government agency (e.g., Forest Service, Department of Agriculture, Environmental Protection Agency) to foster support for learning mathematics and science. All of these professionals can be valuable in gaining support of a bond levy for the acquisition of better learning facilities and technologies. Policies need to encourage collaborative relationships between the school and its community.

5. *Reinforce a school counseling support function to help all students and their families receive essential guidance about careers and postsecondary education*. A school counselor will likely be overburdened with a variety of administrative tasks in the rural high school. Guidance concerning career interests and postsecondary opportunities may be scant except for those students whose parents have reinforced aspirations since elementary school. Consequently, students without a parent, family member, or role model who has completed postsecondary education will be inadequately served—a vast majority of students in the typical rural school. The teacher may be the only person the student meets who has acquired a college education. Teachers and counselors therefore must collaborate in developing a support system that addresses students' future options.

   While most school personnel understand the requirements for earning a bachelor's degree, few may fully understand careers and related educational requirements other than a baccalaureate degree. Postsecondary education leading to a certificate or associate degree in an applied science field may be the most appropriate choice for students interested in a technical career (e.g., medical technician, veterinary technician, engineering technician, legal assistant, environmental technician, agricultural/forestry technician, energy technician). Such careers are replacing traditionally defined "vocational" or blue collar occupations in rural communities.

The “college for all” mentality in America, meaning the attainment of a baccalaureate degree, is being reexamined as an appropriate goal for all students (Education Week Diplomas Count, 2011). Slow recovery of the U.S. economy from its recent recession clearly demonstrates the need for high school graduates, parents, and educators to better understand the link between learning and a career. Meaningful alternatives to the four-year college degree exist, offer good wages and career opportunities, and should be the preferred choice for many students. Such careers may also be essential in the revitalization plans of rural communities.

Public education that serves only the educational needs of those who aspire to leave rural areas contributes to what Carr and Kefalas (2009) describe as the “hollowing out” of rural America, and it ultimately fails to serve either the majority of students or communities well. Policies need to support school counseling functions that enable all students and their families to align career interests with educational preparation, including knowledge about selecting a postsecondary education, applying for admission, and pursuing financial aid options. Rural schools also can take advantage of national online resources such as www.college.gov.

Implementing Improvements

A policy that supports implementing improvements could address time allocation for teachers to learn and implement new practices, student access to facilities with laboratories and technologies, training expectations of the school principal, involvement of parents/family members of students, and use of student data in making decisions about improvements in mathematics and science programs.

6. *Allocate time for teachers to learn and implement expected changes for improving mathematics and science education*. Teachers should not be expected to undertake major changes in curriculum, instruction, and assessment practices without adequate time to learn new pedagogical skills. A lone teacher of science in an isolated small high school, for example, needs time to network with colleagues in other rural schools who are making similar changes or who have been successful in implementing the desired changes. Policies mandating change without adequate time allocations are destined to perpetuate failure.

7. *Provide access to facilities with laboratories and technologies as essential support for the effective teaching of mathematics and science*. Inquiry-based curricula and instructional practices require access to appropriate forms of learning support. Technologies are evolving that will increase teacher and student access to learning resources, experiences, role models, and scientists. Cyber technology will increasingly provide students in rural schools with virtual laboratories and distance learning courses. It also will eliminate the need for teachers in rural settings to travel long distances to workshops and other professional development activities. Organizations such as the Association of Educational Service Agencies are beginning to embrace the online delivery of professional development for teachers (Harmon, 2011).

8. *Prepare experienced administrators to create successful change in the rural context*. Improving mathematics and science education in a rural setting is more likely to succeed if policies that drive the preparation of public school administrators reflect an understanding of leadership in a rural context. Principals' dependence on state regulations and federal mandates to effect meaningful change are unlikely to succeed in most rural communities.

   Chalker's *Leadership for Rural Schools: Lessons for All Educators* (1999) offers important insights for rural school leadership. Arguably, financial incentives may be necessary to attract principal candidates in impoverished rural communities with consistent high turnover in the position. "Grow your own" strategies appear promising, particularly where a regional consortium approach to principal development is a collaborative partnership with a university. Attracting an inexperienced candidate with aspirations to move to a higher-paying, more urban school district is a counterproductive strategy for fostering sustainable improvements in mathematics and science education in most rural schools.

9. *Make parents, families, and peers of students an important part of the equation for improving mathematics and science achievement.* Policies should support the involvement of parents and family members in implementing school improvements, particularly clarifying the need for change and high student expectations. First, parents and families should not be expected to help their child learn science or mathematics content that they do not know, or do not know why it is needed for their child to be successful in life. Family mathematics and science nights should strive to illuminate the importance of learning the content in relation to the student's future success in life and the workplace.

Parents who have primarily worked in a blue collar culture seldom appreciate a condescending approach that says the child needs a certain subject because it will make the student better educated or successful in college. Their life experience tells them that few jobs available in their world required a college education. While a college education may be viewed favorably by many rural parents, the costs of acquiring it is daunting for families who struggle simply to make ends meet on a daily basis. Some parents with conservative financial viewpoints question how being thousands of dollars in debt as a new college graduate, for an education that may or may not result in a reasonably well-paying job or career, is a wise way to start life's journey. Ensuring wide dissemination of accurate information about postsecondary options, costs, and financial aid resources should address parents' financial concerns.

Second, rural parents tend to be trusting of educators who demonstrate a genuine interest in their children and can explain how education is connected to a student's evolving career interests. Parents in the community who know the mathematics and science teachers well should be considered valuable resources as partners in improving student achievement in mathematics and science. Most parents will want access to information that helps them to motivate their child and provide a positive home learning environment. They are unlikely to welcome directives from the school about how to "be a better parent."

Third, most communication about what is happening at a school travels fast among parents in close-knit rural communities. Thus, it is essential that key parents are involved in clearly explaining any changes in mathematics and science programs. Unfortunately, it takes considerable effort to counteract any inaccurate or poorly communicated information that circulates among parents. Holding events at the school and in the community that build positive relationships with parents and family members is necessary to create a welcoming atmosphere for improving mathematics and science education.

10. *Support a school's decision-making process based on objective analysis of student data and other factors important for improving teaching and learning in mathematics and science*. An accurate understanding of student performance and needs must drive the creation of a school culture that supports appropriate instructional practices, learning experiences, and support services. These data are essential in focusing the school's improvement plan. Accurate data also can refine professional development opportunities for administrators, teachers, and other school personnel, as well as provide a rationale for parent/family involvement.

External assistance may be essential to ensure that data collection and analyses are accomplished in a timely, accurate, and objective manner, including the protection of confidentiality. An external consultant may be essential in interpreting data accurately and devising appropriate actions for improving mathematics and science education. Accurate data also are crucial in competing successfully for grants. Therefore, policies need to ensure that empirical data guide decisions intended to improve mathematics and science education and student achievement.

Providing Incentives for Improvements

Policy actions could also address incentives, such as giving rural school districts greater flexibility in using state and federal funds, or encouraging collaboration and sharing among school districts.

11. *Give rural school districts greater flexibility in using state and federal funds, and loosen regulations on length of the school year, week, or day*. The current recession is making the need for schools to customize the use of available funds in meeting desired educational outcomes more evident. Innovation and customization must become the drivers of improvement in mathematics and science education. All funds available to a rural school district must be eligible for making such improvements, especially small districts disadvantaged by state and federal funding based on enrollment. If results are to drive accountability efforts, accepting state or federal funds should not require implementing an expensive and unneeded program or service in all schools simply because those elsewhere, whether urban or rural, need it.

12. *Provide incentives for external support and resource providers, specifically for improving mathematics and science education*. The RSIs served as an important catalyst for stimulating improvements in mathematics and science education. NSF funding made possible a regional approach to providing school districts in rural settings with technical assistance previously unavailable. In essence, discipline-specific specialists were employed by a regional entity and shared among RSI schools. This approach provided direct assistance to schools and also formalized networks of administrators and teachers who benefited from the sharing of limited resources.

State and federal policies could offer incentives for such collaborative, multi-district approaches as compared, for example, to consolidation strategies that strive to accomplish economies of scale. While achieving cost savings, sharing strategies also make available curricular and instructional expertise in rural districts with similar needs in a consortium. The cooperative purchase of instructional supplies in mathematics and science might also be realized. This approach facilitates, as well as demonstrates, capacity for winning competitive grant funds from state, federal, and philanthropic sources.

Conclusion

The NSF-funded RSI projects strategically planned to improve the performance of students in mathematics and science. Models of change varied from one RSI to another, and each RSI strived to build leadership capacity among teachers and administrators in its respective region. RSIs assisted school districts in implementing important curricular, instructional, and assessment practices. Teachers gained access to high-quality professional development and networking experiences. School districts were able to leverage resources from numerous external sources.

The RSI story is particularly important as mathematics and science education accelerates to the forefront of improvement agendas under consideration by federal, tribal, state, and local policymakers. Also significant is that the needs of rural America have come to the attention of the nation's leaders. On June 9, 2011, for example, President Barack Obama signed an executive order (White House Press Office, 2011) to establish the first White House Rural Council. The President noted:

> *Strong, sustainable rural communities are essential to winning the future and ensuring American competitiveness in the years ahead. These communities supply our food, fiber, and energy, safeguard our natural resources, and are essential in the development of science and innovation. Though rural communities face numerous challenges, they also present enormous economic potential. The Federal Government has an important role to play in order to expand access to the capital necessary for economic growth, promote innovation, improve access to health care and education, and expand outdoor recreational activities on public lands (p. 1).*

As a federal agency, the NSF played an important role in funding the RSI effort for almost 15 years. It was an investment of more than $140 million to create a foundation of capacity for educating students in rural America. Much of the project's legacy lies in the educators who strived to implement innovative changes in rural schools and their communities. The RSI legacy provides a foundation of innovation, leadership, teacher development, and lessons learned for communities across rural America to improve educational opportunities and student performance in mathematics and science education.

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Appendices

Appendix A
Rural Systemic Initiative (RSI) Projects Awarded by the National Science Foundation

Title	Principal Investigator	Organization	Amount	State
1. Alaska Native/Rural Education Consortium for Systemic Integration of Indigenous and Western Scientific Knowledge	Hill, Frank	Alaska Federation of Natives	$10,000,000	AK
2. Alaska RSI, Phase II	Barnhardt, Raymond	Alaska Federation of Natives	$7,199,438	AK
3. Appalachian RSI	Royster, Wimberly	Kentucky Science & Technology Corporation	$10,822,306	KY
4. Appalachian RSI, Phase II	Royster, Wimberly	Kentucky Science & Technology Corporation	$6,707,398	KY
5. Arizona RSI	Brighton, Karen	Arizona State University	$4,634,444	AZ
6. Cankdeska Cikana Community College RSI	Esser, Efthalia	Cankdeska Cikana Community College	$1,250,000	ND
7. Coalfield RSI	Smith, Keith	Edvantia, Inc.	$4,855,871	WV
8. Coastal RSI	Blanton, Roy	Fayetteville State University	$6,298,996	NC
9. Delta RSI Project	Alexander, Charles	University of Mississippi	$11,063,745	MS
10. Dull Knife-Northern Cheyenne RSI	Littlebear, Richard	Chief Dull Knife Memorial College	$1,250,000	MT
11. Fort Belknap College RSI	Taylor, William	Fort Belknap College	$1,384,444	MT
12. Fort Peck Community College RSI	Campbell, Margaret	Fort Peck Community College	$1,325,770	MT

Title	Principal Investigator	Organization	Amount	State
13. Hawaii Networked Learning Communities	Harada, Violet	Hawaii Department of Education	$6,134,444	HI
14. High Plains RSI	Monette, Gerald	Turtle Mountain Community College	$10,336,718	ND
15. Little Big Horn College RSI SMT	Yarlott, David	Little Big Horn College	$1,384,440	MT
16. Michigan RSI Comprehensive Regional Plan for Systemic Reform in Mathematics, Science, and Technology	Douglass, Claudia	Cheboygan Otsego Presque Isle Intermediate School District	$1,885,328	MI
17. Navajo Nation RSI	White, Kalvin	Navajo Nation	$10,134,444	AZ
18. New Mexico Tribal Coalition RSI	Scruggs, Debra	Santa Fe Indian School	$2,615,595	NM
19. Ozarks RSI	Gordanier, Arch	Southwest Center for Educational Excellence	$3,634,444	MO
20. Reforming Math, Science and Technology Education in Northern New Mexico	Atencio, Carlos	Jemez Valley Public Schools	$4,993,002	NM
21. RSI in Science, Mathematics, and Technology Education—RSI: TCRSI Phase II, Implementation	Salois, John	Blackfeet Community College	$1,250,000	MT
22. Salish Kootenai College RSI	McClure, Roger	Salish Kootenai College	$1,356,000	MT
23. Sisseton Wahpeton RSI	Morgan, Scott	Sisseton Wahpeton Community College	$1,330,000	SD
24. Sitting Bull College RSI	Vermillion, Laurel	Sitting Bull College	$1,250,000	ND

Title	Principal Investigator	Organization	Amount	State
25. South Texas RSI	Marinez, Diana	Texas Engineering Experiment Station	$6,329,527	TX
26. Texas RSI	Guffy, Norman	Texas Engineering Experiment Station	$10,057,553	TX
27. Turtle Mountain RSI	Davis, Carol	Turtle Mountain Community College	$1,415,480	ND
28. United Tribes RSI	Gipp, David	United Tribes Technical College	$1,380,036	ND
29. Utah-Colorado-Arizona-New Mexico RSI	LLamas, Vicente	New Mexico Highlands University	$9,500,000	NM
30. Wind River RSI	Berlin, Karl	Fremont County School District #21	$1,384,444	WY
Total NSF Funds Awarded			**$143,163,867**	

Appendix B
STEM Resources from NSF Research and Development Projects

RSI implementation projects ended with school districts in impoverished rural areas having additional capacity for reforming mathematics and science education in systemic ways. The NSF continues to support the development of resources for teachers that enhance the education of students in STEM fields. This appendix provides examples of instructional materials developed from projects funded partially or totally by NSF.

Each research-based resource has been pilot- or field-tested in schools or with teachers. The websites identified may offer additional information derived from their development by stakeholders. These resources and websites represent the work of the RSI principal investigators and do not necessarily reflect the views of the NSF. No endorsement of commercially published materials from NSF-supported research and development projects are implied by Edvantia, Inc.

The resources described below can be found on a prototype website hosted by the NSF to inform states and school systems that are developing strategies for improving K-12 STEM education (see http://www.nsfresources.org/home.cfm). Assessment and teacher-development resources are also listed on the website, which was created for the sharing of NSF-sponsored resources in support of the U.S. Department of Education's Race to the Top program.

An important lesson learned in the RSIs is that "one size fits all" approaches seldom meet the unique context of schools, teachers, and students in rural America. Consequently, this monograph should be a valuable lens for considering any teaching and learning resource for use in rural areas, particularly those with highly concentrated populations of African American, American Indian/Tribal, Alaska Native, Appalachian White poor, or Hispanic American students.

Instructional Resources

1. *Think Math!*
   Think Math! is a comprehensive kindergarten through fifth-grade curriculum. This pilot- and field-tested curriculum was developed by the Education Development Center, Inc. in Newton, Massachusetts, under the working title of *Math Workshop* with support from the NSF. The series builds computational skills as students investigate new ideas and solve meaningful problems. Lessons let students develop conceptual understanding as they apply, sharpen, and maintain skills they already have.

   Website: http://www.harcourtschool.com/thinkmath/index.html

2. ***Young Scientist Series***

Young Scientist is a curriculum for children three to five years old. The series, developed with NSF funding, explores materials and phenomena while providing opportunities for children to learn from that experience. They develop theories about why things are the way they are, act the way they do, and relate to one another. As their experience broadens, their ideas grow closer to current scientific understanding. The series consists of three teacher guides and three comprehensive professional development packages including a video. The titles in the series are:

Discovering Nature with Young Children
Building Structures with Young Children
Exploring Water with Young Children

Website: http://cse.edc.org/curriculum/youngscientistseries/default.asp

3. ***WorldWatcher***

WorldWatcher is a visualization environment for the investigation of scientific data in K-12 and college classrooms. Its goal is to provide students with access to the same features found in the powerful, general purpose visualization environments that scientists use, while also offering students the support they require to learn through use of the tools.

Website: http://www.worldwatcher.northwestern.edu/softwareWW.htm

4. ***Video Mosaic Collaborative***

Video Mosaic Collaborative is a portal that integrates the Robert B. Davis Institute for Learning Video Collection, which captures mathematics learning across a range of grades and types of schools, with a collaborative platform. It combines innovative research into the teaching and learning process with tools that enable educators to utilize the videos to make new discoveries in math education.

Website: http://www.video-mosaic.org/

5. ***Understanding Science***

Developed by the University of California Museum of Paleontology in collaboration with its Advisory Boards, *Understanding Science* provides a fun, accessible, and free resource that accurately communicates what science is and how it really works.

Website: http://undsci.berkeley.edu/

6. ***Modernizing Instruction in Taxonomy and Systematics: Materials for High School Biology***
An NSF-funded project led to two high school curriculum supplements, one on taxonomy and the other on developmental biology, that are available as a set. *Climbing the Tree of Life: Taxonomy and Phylogeny* includes interactive, inquiry-oriented activities with videos, animations, simulations, and printable documents along with a teacher's implementation guide. *Developmental Biology* includes animations and interactive simulations, an annotated instructor's guide, background material in developmental biology, and student laboratory investigations.

Website: http://www.bscs.org/curriculumdevelopment/highschool/othersupplemental/taxonomy/

7. ***Exploratorium Science Snackbook***
Ever since the Museum of Science, Art, and Human Perception opened in San Francisco in 1969, teachers from the Bay Area have brought their classes on field trips to the Exploratorium. This science "snackbook" takes the exhibits to the kids. For three years, nearly 100 teachers worked with staff members to create scaled-down versions of Exploratorium exhibits. The result was dozens of exciting "snacks"—miniature science exhibits that teachers can make using common, inexpensive, easily available materials.

Website: http://www.exploratorium.edu/snacks/

8. ***Science Notebooks in K-12 Classrooms***
Science notebooks help students to develop their understanding of science while also enhancing reading, writing, and communication skills. As teachers involve students in inquiry-based investigations, the need to communicate science learning in new ways has become evident. Students use notebooks as a scientist would to formulate questions, make predictions, record data, compose reflections, and communicate findings.

Website: http://sciencenotebooks.org/

9. ***My World GIS***
My World GIS is a geographic information system (GIS) designed for use in middle school through college classrooms. It was developed by the GEODE Initiative at Northwestern University as part of a research program on the adaptation of scientific visualization and data analysis tools to support inquiry-based learning. *My World GIS* offers easy-to-use tools to explore critical issues about the environment, geography, geology, demography, history, and much more. Features include multiple geographic projections, table and map views of data, distance measurement tools, buffering and query operations, and a customizable map display.

Website: http://www.myworldgis.org/

10. *Minds on Physics*

Minds on Physics is a one-year curriculum for high school physics. The curriculum is driven by activities rather than by a textbook. Students learn to analyze physical situations conceptually, thereby improving both their scientific understanding and problem solving ability. Although the curriculum is activity-based, there are no traditional labs. Students instead work together using simple equipment to learn about fundamental physical concepts and principles. This approach encourages them to explore and communicate their thoughts about motion, forces, momentum, and energy to their peers. Teachers thus play the role of coaches rather than dispensers of information.

Website: http://www.kendallhunt.com/index.cfm?PID=219&CID=219&CEL=992&PGI=148

11. *Science and Technology for Children BOOKS*

Science and Technology for Children BOOKS adds a literacy component to a popular curriculum for elementary students. Launched as a new series by the National Science Resource Center, each book is designed to be used in conjunction with teaching the *Science and Technology for Children* unit of the same name or as a stand-alone resource that makes science interesting and relevant. Each of the 16 books in the series is 64 pages in length, colorfully illustrated with drawings and photographs, and has been reviewed by a nationally recognized reading specialist. The books are designed to meet the needs of schoolchildren from diverse cultural and ethnic backgrounds.

Website: http://nsrconline.org/curriculum_resources/science_readers.html

12. *Mathematics: Modeling Our World*

Mathematics: Modeling Our World is an integrated core curriculum for high school that is based on the premise that students learn best when they are actively involved in the process. Students first ask important questions about the real world, analyze situations, and apply the mathematical concepts needed to solve problems. Contextual questions drive the mathematics. In each unit students build, test, and present models that describe a real-world situation or problem. Each course covers the mathematical content found in National Council of Teachers of Mathematics (NCTM) Standards.

Website: http://www.comap.com/mmow/

13. *Mathematics in Context*

Mathematics in Context is a comprehensive curriculum for students in Grades 6 through 8. They develop an understanding of mathematics by solving problems in realistic contexts. The approach motivates the most reluctant learner while challenging the accelerated learner to explore complex math concepts. The pedagogy and mathematical content are consistent with NCTM Standards. The program also incorporates formative assessment opportunities to verify students' ongoing progress.

Website: http://info.eb.com/html/print_math_in_context.html

14. ***Math Trailblazers***
Math Trailblazers is a complete, research-based K-5 program that integrates math, science, and language arts. It embodies the NCTM Standards and is based on the premise that mathematics is best learned by solving problems in real-world contexts and that a curriculum should balance conceptual understanding with procedural skills.

Website: http://www.kendallhunt.com/program.aspx?id=3722&libID=3743

15. ***Math Pathways and Pitfalls***
Math Pathways and Pitfalls provides professional development for teachers and intervention lessons for students in Grades K-8. Together, they address the need for improving instruction in key mathematical standards and learning pitfalls, regardless of the core instructional materials being used. There are four books with 20 to 22 lessons per book. Those for students in Grades K-3 focus on whole number concepts, place value, and operations. Books for students in Grades 4-8 focus on fractions, decimals, ratios, proportions, and percentages. Algebra readiness is integrated into the lessons for students in Grades 1-8.

Website: http://www.wested.org/cs/we/view/pj/81

16. ***Living by Chemistry***
Living by Chemistry is a full-year high school curriculum that meets state and national standards. It is aligned with the Benchmarks for Scientific Literacy, the National Science Educational Standards, and the National Physical Science Standards. *Living by Chemistry* is the product of a decade of research and development in high school classrooms. The curriculum is inquiry-based and seeks to promote critical thinking skills. It is organized around six themed units that focus on the big ideas of chemistry and frame core concepts within real-world contexts.

Website: http://www.keypress.com/x5166.xml

17. ***Lego Engineering***
Legoengineering.com is a resource for educators using *Lego Mindstorms* or the RoboLab tool set in their classroom to engage students in STEM. *Lego Engineering* provides teacher and student resources for building, programming, and troubleshooting robotics and other engineering projects. Materials include curriculum modules, programming challenges, quick reference guides for all ages, and a searchable knowledge base with code examples. The site hosts an online community for Lego engineering teachers and offers podcasts on the uses of Lego engineering in the classroom.

Website: http://www.legoengineering.com/

18. *Resources for Environmental Literacy*

Resources for Environmental Literacy is designed for teachers of middle school life science and physical science as well as high school biology and physics. The modules offer teaching strategies plus high quality resources to deepen students' understanding of science and deal with five real-world environmental topics: biodiversity; genetically modified crops; earthquakes, volcanoes, and tsunamis; global climate change; and radioactive waste.

Website: http://www.nsta.org/store/product_detail.aspx?id=10.2505/9781933531151

19. *Project-Based Inquiry Science*

Project-Based Inquiry Science is a middle school curriculum predicated on students' thinking like scientists. Individual units revolve around "Big Challenges" and "Big Questions." In this context, students learn the way that scientists learn: through designing and running experiments as well as by sharing ideas with each other.

Website: http://www.its-about-time.com/pbis/pbis.html

20. *Physics That Works*

This year-long curriculum situates standards-based physics learning in authentic contexts. High school students undertake extended workplace-related projects where they acquire and apply science knowledge and skills. The curriculum is based on the principle that all students learn better in a practical rather than abstract context.

Website: http://www.terc.edu/work/452.html

21. *Science and Math Informal Learning Education*

This online pathway collects the best educational materials on the Web for those who teach in non-classroom settings. The pathway empowers educators to locate and explore high-quality education materials. It is the informal educators' portal to the National Science Digital Library and is dedicated to bringing science, technology, engineering, and mathematics out of the academic cloister and into the wider world.

Website: http://www.howtosmile.org/

22. *Investigations in Number, Data, and Space*

Investigations in Number, Data, and Space is a complete K-5 mathematics curriculum designed to help children to understand fundamental ideas of number and operations, geometry, data, measurement, and early algebra. Investigations utilize a research-based, child-centered approach to teaching mathematics through engaging activities and problem solving.

Website: http://investigations.terc.edu/

23. ***Investigating Earth Systems***

Investigating Earth Systems is a curriculum for sixth- through eighth-grade students. Inquiry and the interrelation of Earth systems form the backbone of all its activities. Developed by the Education Department of the American Geological Institute, with support from NSF, the various modules require students to use the same set of inquiry processes as scientists.

Website: http://www.its-about-time.com/htmls/ies.html

24. ***Interactive Mathematics Program***

The *Interactive Mathematics Program* is a growing collaboration of mathematicians and teachers who created a four-year program of problem-based mathematics to replace the traditional Algebra I/Geometry/Algebra II/ Trigonometry-Precalculus sequence. The curriculum integrates traditional material with additional topics such as statistics, probability, curve fitting, and matrix algebra. Units are generally structured around a complex central problem.

Website: http://www.keypress.com/x5436.xml

25. ***InterActions in Physical Science***

InterActions in Physical Science is a year-long course for middle school students. It uses a combination of guided inquiry and direct instruction. In guided inquiry activities, students perform experiments and explore many physical science concepts based on evidence from the experiments. Additional concepts are taught via direct instruction. The program is complemented by innovative computer software.

Website: http://www.its-about-time.com/htmls/iaps_e2/iapsintro7.html

26. ***Girls Communicating Career Connections***

This is a youth-produced, web-based media series on science and engineering careers that targets girls from minority, economically disadvantaged, and disability populations. The project's video segments, produced by middle school students, capture the inquiry-based learning experiences of six girls as they investigate what it means to be a scientist or engineer. The videos encourage girls to see science’s relevance to the things most important to them now (e.g., sports, art, music) and leverage that connection to spark interest in science and engineering careers.

Website: http://gc3.edc.org/default.asp

27. ***Full Option Science System***

The *Full Option Science System* is a K-8 curriculum developed at the Lawrence Hall of Science, University of California at Berkeley. Teachers and students do science together when they open the FOSS kits, engaging in hands-on experiences that lead to a deeper understanding of the natural world. The publisher's website includes correlations to national and state standards. Development of the FOSS program was, and continues to be, guided by advances in the understanding of how youngsters think and learn.

Website: http://www.delta-education.com/science/foss/index.shtml

28. ***Everyday Mathematics***

Everyday Mathematics is an elementary mathematics program celebrating 20 years of research and development. The program was developed by the University of Chicago School Mathematics Project in conjunction with feedback from education specialists, administrators, and classroom teachers in order to enable children in elementary grades to learn more mathematical content and become lifelong thinkers.

Website: https://www.mheonline.com/discipline/narrow/1/4/231/math

29. ***EarthComm***

EarthComm is a comprehensive secondary-level program that includes student learning materials, teaching resources, and assessment tools. Although not covering as many topics as the traditional textbook, it emphasizes important concepts, understandings, and abilities that all students can use to make wise decisions, think critically, and understand and appreciate the Earth.

Website: http://www.its-about-time.com/htmls/ec.html

30. ***Environmental Inquiry***

Environmental Inquiry is a website and curriculum series developed at Cornell University to help high school students conduct environmental research. It is organized into two levels of inquiry modeled after research activities conducted by professional scientists. Students first learn standard research methods or protocols. Then, they use these protocols to address relevant environmental research questions. After planning and carrying out one or more interactive experiments, students present the results to their peers and possibly also interested community groups.

Website: http://ei.cornell.edu/

31. ***Core-Plus Mathematics***

Core-Plus Mathematics is a field-tested and college preparatory program. The curriculum emphasizes the integrated development of fundamental concepts and skills in algebra, geometry, trigonometry, statistics, and probability. Included are student-centered investigations in the context of realistic problems and applications, leading to a robust understanding of mathematical concepts, principles, techniques, and habits of mind.

Website: https://www.mheonline.com/programMHID/view/0078615216

32. ***Connected Mathematics***

Connected Mathematics is a complete middle school curriculum developed by the Connected Mathematics Project, the aim of which has been to help students and teachers develop an understanding of important mathematical concepts, skills, procedures, and ways of thinking regarding numbers, geometry, measurement, algebra, probability, and statistics.

Website: http://www.phschool.com/cmp2/

33. ***Chemistry in the Community***

Chemistry in the Community is a ninth-grade textbook that covers chemistry concepts in the context of societal issues. Seven study units emphasize organic chemistry, biochemistry, environmental chemistry, and industrial chemistry. Students learn concepts on a need-to-know basis, evaluate data, and make decisions based on their knowledge and observations. The lab-based course features activities that give students practice in applying their knowledge of chemistry.

Website: http://www.whfreeman.com/ChemCom/index.htm

34. ***BSCS Science: An Inquiry Approach***

This is a three-year program in the sciences for high school. It introduces students to core concepts in the physical sciences, life sciences, and earth space sciences. In addition, the curriculum engages students across disciplines in relevant contexts that explore the standards related to science and technology. *BSCS Science: An Inquiry Approach* provides high school students with a rigorous, coherent alternative to the traditional sequence of biology, chemistry, and physics.

Website: http://www.bscs.org/curriculumdevelopment/highschool/comprehensive/inquiry/

35. ***MATH Connections***

MATH Connections focuses not only on skills and problem solving found in other secondary math programs, but it also focuses on conceptual thinking and the connections that make mathematical sense to students. As its name suggests, it is built around meaningful connections between mathematics and the real world of people, business, and everyday life.

Website: http://www.its-about-time.com/math/

36. ***BioComm: Biology in Community Context***

This is a full-year biology course correlated with national and state standards as indicated on the website. However, it covers far more than biology per se by teaching how the discipline connects with technology, society, and the student. In each of the eight thought-provoking units, a real-world issue is presented. Students conduct "guided inquiries" and "extended inquiries."

Website: http://www.its-about-time.com/htmls/biocomm/biocomm.html

37. ***ATE Central: Advance Technological Education***

ATE Central: Advance Technological Education is a freely available online portal and collection of materials and services that highlight the work of the ATE projects. These NSF-funded initiatives collaborated with educators from two-year colleges to develop ideas for improving the skills of technicians and the educators who teach them.

Website: http://atecentral.net/

38. ***Astrobiology***

Astrobiology, a yearlong curriculum for high school, is an inquiry-based, interdisciplinary program of study. Through a series of hands-on activities, students explore diverse concepts in chemistry, physics, and biology. Concepts are integrated with no artificial divisions of scientific disciplines. Students consider the fascinating story of searching for life in the universe. *Astrobiology* is a science course designed to reach students with a wide range of abilities.

Website: http://www.its-about-time.com/htmls/astro/astro.html

39. ***Engineering is Elementary***

Engineering is Elementary fosters engineering and technological literacy among K-12 science students. Storybooks featuring children from a variety of cultures and backgrounds introduce students to engineering problems. Students are then challenged to solve them, working in teams to apply their knowledge of science and mathematics, use their problem-solving skills, and draw on their innate creativity.

Website: http://www.mos.org/eie/

40. ***Active Chemistry***

Active Chemistry is a full-year program that covers all core concepts and fulfills national and state standards. It is a challenge-driven instructional strategy that was created to awaken the enthusiasm for learning in students by bringing chemistry into everyday life situations.

Website: http://www.its-about-time.com/htmls/ac/ac.html

41. ***Active Physics***

Active Physics introduces students to physics concepts as they explore such issues as communication, home, electricity, medicine, predictions, sports, and transportation. This approach diverges from that of a traditional physics course on mechanics, optics, and electricity.

Website: http://www.its-about-time.com/htmls/ap.html

42. ***CME Project***

This project offers an innovative high school mathematics curriculum wrapped around the familiar course sequence of Algebra 1, Geometry, Algebra 2, and Precalculus. It meets the goals of mathematical rigor and accessibility for all students through problem-based and student-centered instruction.

Website: http://cmeproject.edc.org/

43. ***The Geometer's Sketchpad***

The Geometer's Sketchpad is a software program that enables students of all ages to build and investigate mathematical models, objects, figures, diagrams, and graphs.

Website: http://www.keypress.com/x5521.xml

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