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Reforming Math and Science in Rural Schools

By Hobart Harmon, Stephen Henderson, and Wimberly Royster

What happens when you devote $10 million and five years to improving math and science programs in rural schools in districts in which 30% or more of the students live in poverty? As participants of the ARSI project discovered, it is a long and evolving journey.

A planning grant awarded in 1994 and a five-year, $10 million implementation grant awarded in 1995 from the National Science Foundation (NSF) launched the Appalachian Rural Systemic Initiative (ARSI) on its reform journey. Rural school districts where 30% or more students live in poverty were eligible for participation. More than 65 counties and 85 school districts in six Central Appalachian states—Kentucky, North Carolina, Ohio, Tennessee, Virginia, and West Virginia—participated in the original ARSI project.

As one of the four original NSF Rural Systemic Initiatives, ARSI’s mission was to “accelerate improved performance in mathematics and science for all students through high-quality, standards-based teaching supported by aligned, coherent local and regional systems.” The mission was a monumental challenge of changes; changes that we learned were deeply rooted in the culture of Appalachia and its schools.

Context for Change

Unlike the residents of most impoverished urban areas, the people who live in the hills and hollows, or “hollers,” of central Appalachia are primarily White. They have lived there for generations and have a tangible sense of pride and a strong commitment to community and family. Most Appalachian people grow up in one place and remain there once they’re adults. Communities are small, and people know one another well. Residents identify closely with their local communities, greatly value their local autonomy, and have a strong sense of place. The residents’ sense of community is not necessarily associated with counties or towns, but rather with small sections defined by geographic features, such as the local hollers.

Although there is much consistency among the population, it is often difficult to mount cooperative efforts, even within a single county. In Appalachian communities, poverty, isolation, and lack of resources too often combine to create cultures in which people suffer from low expectations and fatalistic attitudes. Even the best administrator preparation programs can teach few people how to reform math and science in Appalachian schools unless the candidates have lived there.

In 1996, the poverty rate in the most economically stressed counties in Appalachia was almost two times that of the rest of the United States (24% versus 14%). The moun-
Regional resource collaboratives bring teacher partners together to share expertise and support.

isolate towns from one another; sections of even small towns are spread out through several valleys, separated by mountains, and connected by poor roads. A little snow can shut down school for weeks and further isolate people.

Many of the cultural and educational opportunities taken for granted elsewhere, such as universities, zoos, and museums, simply do not exist in Appalachia. The social origins of isolation arise from a sense of pride in their own communities and a lack of interest in the nearby cities. Differences in language and culture also keep people confined within their own localities. Historically, the majority of jobs available in central Appalachia have been either hard labor (e.g., mining) or seasonal labor (e.g., farming). Recent advances in technology have left many Appalachian miners and workers unemployed. Many coal mines have closed, and good jobs are scarce.

In many rural Appalachian communities, the school district employs more people than any other business. Consequently, the politics of school employment become an important factor in determining the nature and quality of education in the region. When creating change in schools, principals without political savvy and connections are at a disadvantage, particularly when a good high school education means the graduates leave their communities to pursue more education or locate work.

Changing Needs
The NSF planning grant enabled ARSI leaders to visit schools and their communities, talk with principals and teachers, and observe students' math and science education. Generally, we found principals and teachers working diligently in their roles as educators. They willingly shared their trials and tribulations in trying to teach such subjects as math and science when so few students and adults saw any reward for learning the subjects—at least in the way they were currently being taught.

Community and education leaders acknowledged that the future economic prosperity of both the communities and their citizens (including youth) would be bleak without better education in math and science. In some communities where the school-age population was decreasing annually, school consolidation or closure was a recent reality or is a pending problem. Although principals and superintendents were being asked to reform schools to educate all students at a higher level, managing the decline in enrollment and the related reductions in fiscal resources and staff members was a
harsh reality. Many principals and teachers were accustomed to doing a lot with a little and welcomed the ARSI project because of its potential financial assistance.

Most federal attempts to improve the socioeconomic conditions and education systems in local communities of Appalachia have not created lasting change or benefits to local residents. Outside interventions typically are met with negativity from those whom they are intended to help. In many communities, however, there is increasing recognition that education is the key to long-term growth. As the coal mines have closed, community leaders have sought new opportunities for economic development. Building a skilled workforce is essential to local economic growth and a good education, particularly in math, science, and technology, is gaining recognition as necessary for creating a skilled workforce.

**Systemic Reform**

ARSI did not simply give grant funds to school districts, which had been the customary procedure in many education reform projects in Appalachia. Instead, ARSI involved districts in math and science reform by building regional and local infrastructure and greater understanding of the need for change among district, school, and community leaders. The key strategies included:

- Designating one school in each ARSI district to serve as a "catalyst school," which would become a model of reform in science and mathematics for the rest of the district.
- Selecting "teacher partners" in each school district who could broker resources and expertise for the catalyst school and connect to other ARSI teacher partners through an ongoing ARSI-support network.
- Providing resources and support to teacher partners through regional resource collaboratives, which were created by project members and located in major research or regional universities that have well-developed technology capacity and access to science and math expertise.
- Enhancing each district's technology infrastructure, so math and science teachers could use the Internet and computer technology to access instructional resources and overcome the isolation of the region.
- Creating community engagement teams, which were headed by school personnel and community members to facilitate active parent and community support for the improvement efforts in math and science.

Although each of these is important, the five ARSI resource collaboratives are the primary agents for supporting school improvement efforts. The collaboratives help ARSI establish a broad-based system to facilitate local planning and decision making, create collaboration, and align vital processes and resources. Their staff members are the field agents for the ARSI project, providing direct services to schools and districts, as well as being responsible for identifying resources at the sponsoring universities and other state and regional agencies that offer relevant professional development and technical assistance. Institutionalizing the functions of each resource collaborative taps regional capacity for improving math and science that is beyond the scope of NSF support.

**Model Evolution**

As Phase I unfolded, we learned that flexibility in the model was essential. School districts quickly embraced the technology emphasis of ARSI, partly because the state departments of education were giving schools funds and technical assistance. An on-site visit by NSF project officials in year two of the project found principals and others in the ARSI schools more willing and able to talk about technology than the improvement of math and science education. Consequently, the ARSI resource collaboratives began to focus more intensely on helping teacher partners address math and science improvement issues at their catalyst schools.

Also, we learned that the teachers most likely to be teacher partners were not always from the catalyst schools. Few teacher partners chose to work outside their own schools. To maintain a focus on districtwide reform, it became necessary for superintendents to designate district
liaisons to work directly with teacher partners and ARSI personnel. The teacher partners were the cornerstone of the ARSI model for building district capacity for improving math and science, and they helped each district implement almost all elements of the ARSI reform. Many teacher partners were quickly overloaded.

We also learned that making parent and community engagement a viable element in the reform required a large amount of hand-holding and community presence. Few schools had either experience in a high-stakes accountability environment or a tradition of parent and community involvement that could inform their efforts to create and implement effective community engagement teams. Nevertheless, some schools developed highly successful community engagement teams, particularly so in schools where the principal actively supported the team’s efforts.

The ARSI model has changed from the original. The current model is based on a comprehensive review of each participating school’s science and mathematics programs using the Program Improvement Review (PIR) process. Short- and long-range plans for program change are identified on the basis of the PIR. Led by the principal and a well-prepared teacher partner with support of the ARSI Resource Collaborative, a local leadership team implements the plan.

Most changes occur in schools. Activities also occur at the regional and district levels, but they support the changes in the schools, particularly changes that affect the classroom environment. There is flexibility in how ARSI interventions are actually implemented. Local context is more important to implementation now than in the original reform model. ARSI activities in a particular school or district are customized to respect the local school system’s readiness and ability to make changes that lead to systemic reforms in math and science.

Seeing Where They Are

ARSI’s PIR process evolved from schools’ need for a better understanding of their math and science programs. The PIR process helps districts assess their current state of instruction, curriculum, and instructional materials—especially the degree to which they match the state and ARSI vision for providing standards-based math and science programs.

The PIR process groups the standards and their indicators into eight major areas: curriculum; instruction; student thinking processes; school climate and community; usefulness; staff training and development; continuing assessment, redesign, and evaluation; and organization. Reviewers use a five-point rating scale, with a rating of 1 indicating inconsistency with the standard and best practices, and a rating of 5 signifying complete consistency with the standard and best practices.

In years two through four, 124 schools, several of which were not in the ARSI project, chose to use the ARSI PIR. Inverness Research Associates analyzed the PIR ratings to identify the strengths and weaknesses of the schools. Because the PIR tool was changed slightly during this time, the analysis focused on 96 schools. The reviews included the math and science programs in 56 schools, only science programs in 19 schools, and only math programs in 21 schools. The ratings for ARSI schools differed little from the ratings for non-ARSI schools. Inverness Research Associates reported:

• The schools’ greatest asset is leadership that supports excellence in teaching math and science. Overall, the schools were given highest ratings in the area of the principal’s leadership. In two out of three schools, the principals’ main focus is instructional leadership that increases teaching excellence.

• There is a question about whether the districts in which the ARSI schools are located have the infrastructure to handle issues of curriculum and instruction effectively. Budget allocations are clearly insufficient to meet the needs of the math curriculum in 33% of the schools where math
was reviewed and the science curriculum in 39% of the schools where science was reviewed. Students do not have access to appropriate materials in 44% of the schools that underwent the math review and 30% of the schools that completed the science review.

- Fewer than half of the schools had math or science curricula closely aligned with their states' framework or standards. Science curricula were more often aligned with frameworks or standards than were math curricula (true at 49% of the schools reviewed in science versus 34% of schools reviewed in math). Only one in five schools provided materials that reinforced the objectives of its curriculum.

- Fewer students or teachers had experiences that were designed to promote problem solving, exploration, reasoning, or an inquiry approach. Teachers' capacity to provide high-quality instruction was seldom enhanced by the local professional development that they received. Professional development seldom involved reasoning, problem solving, investigation, or communication of findings in 72% of the schools that were reviewed in math and in 47% of the schools reviewed in science. Only 1 in 10 schools provided standards-based professional development.

**ARSI’s Impact and Next Phase**

Resource collaboratives and ARSI leadership use PIR results and external evaluation to guide assistance to schools. After five years with ARSI, 94% of catalyst schools are showing improvements in mathematics, science, or both on state assessments. Although ARSI alone cannot claim credit for the gains, an analysis of trends in assessment results indicates that ARSI catalyst schools are improving relative to comparison schools in nonparticipating districts. Three-fourths of catalyst school teachers (and half of all the teachers) report that ARSI has influenced their mathematics and science teaching. ARSI teachers differ significantly from their colleagues, in that they:

- Hold attitudes more consistent with standards-based approaches.
- Are better prepared to implement standards-based strategies.
- Use standards-based strategies in their classrooms regularly.
- Identify fewer barriers to implementing their math and science teaching.
- Have stronger attitudes, consistent with standards-based math and science.
- Have higher level of preparation to use standards-based practices.
- Use technology more frequently to support instruction.

Administrators and teachers in catalyst schools report improvements in their schools’ mathematics and science programs:

- Better availability of curriculum materials that are aligned to standards.
- Better availability of professional development that is appropriate for mathematics and science teachers.
- Greater amount of funds allocated to mathematics and science.
- Better availability of local resource personnel who support implementation.

Support by the NSF for a second five-year phase of ARSI testifies to the commitment of each school district and state department of education that has helped ARSI be a success. The new $6 million effort has enabled ARSI to expand the capacity-building strategies that were developed during the first five years, including leadership training for school administrators. Principals have come to appreciate and rely on the help ARSI and other such efforts bring to their schools, particularly principals of schools where barriers related to poverty must be overcome.

Manchester High School in Adams County, OH, has been one of the participating schools in the ARSI project. Says Principal Pat Kimble, “In a rural high school like ours with limited resources, it is critical that the curriculum is aligned and we are all on the same page. Something ARSI really helped us with... It is imperative that we continue improving because of the emphasis on student testing and school report cards. We want to be the best we can be. Our improving test scores are proof that you don’t need all the cultural things that more wealthy areas have to get students to do well on proficiency exams if instructional materials and teaching are appropriate. Efforts from ARSI, Project REAL, and NCREL help us greatly.”

ARSI’s educational reform journey in the hills and hollers of central Appalachia has been both difficult and rewarding. Like the jobs that residents in these mountainous communities have traditionally held, improving the math and science achievement of students requires hard work. Improving achievement in math and science for all students is a new form of labor—not only for students but also for school leaders, teachers, parents, and community members. **PL**

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For more information about ARSI, visit [www.arsi.org](http://www.arsi.org).