INVESTING IN THE IMPROVEMENT OF MATHEMATICS AND SCIENCE EDUCATION IN RURAL APPALACHIA:

TEN YEARS OF ARSI AND ITS ACCOMPLISHMENTS

I. INTRODUCTION

The Rural Systemic Initiative (RSI) was designed by the National Science Foundation in the early 1990's to improve education in the communities of Appalachia and other regions that include the nation's most rural and impoverished communities. The Appalachian Rural Systemic Initiative (ARSI) was one of the first funded projects within the RSI initiative, and has worked in Appalachia to improve mathematics and science education now for over a decade.

ARSI pursued its goal by focusing its efforts on enhancing the indigenous capacity of local Appalachian counties for ongoing improvement in math and science. Initially ARSI identified the 66 poorest counties in six states in the Appalachian region, and since then has evolved a powerful strategy for helping them to further develop their own capacity for self improvement. Our study of the ARSI effort has focused on the capacity building that has taken place over its ten-year lifespan.

This report provides the reader with a summary of the rationale, strategies, and accomplishments of the Appalachian Rural Systemic Initiative. Drawing upon the data collected by researchers from Inverness Research Associates, and on the knowledge gained by working with many other rural initiatives, this summary report is intended to place ARSI in broader perspective. We aim to help the reader understand the ways in which the investment in ARSI has helped to provide the foundation for the ongoing improvement of mathematics and science education in the Appalachian region, and to illuminate implications for future work in other rural regions.

II. BACKGROUND AND CONTEXT

The Challenge of Improving Rural Mathematics and Science Education

When one thinks of the neediest families in the United States, the image of inner-city neighborhoods may first come to mind. But the fact is that many of the nation's poorest households are located in small rural communities. Scattered across the country pockets of often intense poverty remain isolated, largely unseen and unnoticed. Not all rural communities are poor however. Many can be described as middle class or lower middle class, but the rural counties specifically targeted by the NSF-funded Rural Systemic Initiative, to which ARSI belongs, are in fact extremely poor and suffer from a long history of poverty.
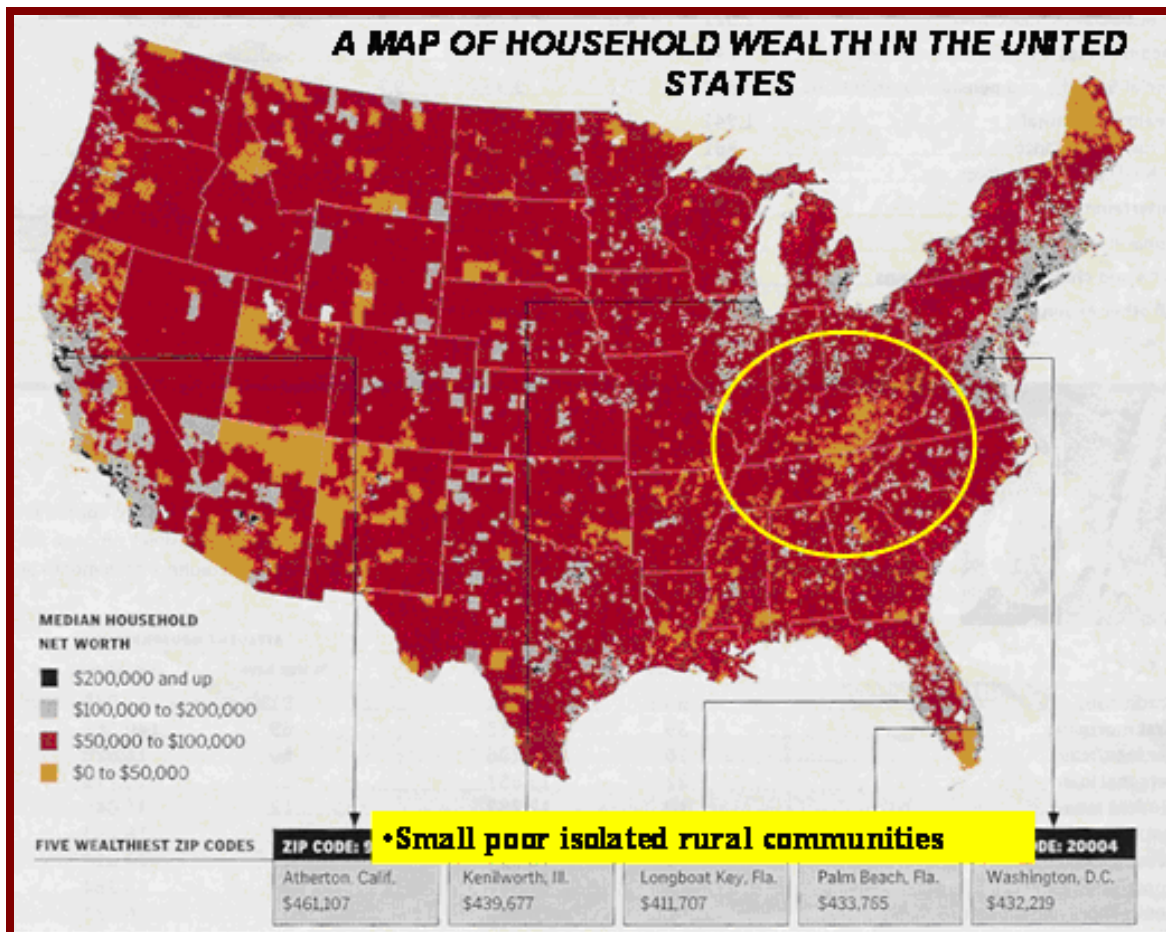
The chronic impoverishment of these RSI communities has deep roots, often found in an extended historical presence of an "extractive industry." For example, northern Maine has witnessed decades of logging; in the Mississippi

Delta the cotton business has eroded the land's natural resources for centuries; and in Appalachia, the coal mining industry has systematically and persistently drawn the rich mineral resources away from the region. In all of these cases, the local wealth in natural and human resources and capacity have been persistently extracted, while the benefits from their sale have gone elsewhere. The communities that are left behind are as depleted as the land, because little if any of the extracted profits have been re-invested back into the local communities. The local population has been left with limited and confining economic opportunities, and with future prospects that appear bleak. Thus decades of the presence of an extractive economy lead not only to a depletion of physical resources, but also to a pervasive undermining of social and human capital as well[1]. Such a long history of exploitation leads to a culture of hopelessness, and often, a widely shared sense of fatalism.

> *There is a fatalism that comes along with not having hope… The people in Appalachia are prone to accept their circumstances… they see things as inevitable and they think that they have no control over events and over the future… so there is a deep fatalistic attitude that pervades many communities and families…and this leads to a dysfunctionality that is widely shared.*

While many federal, state and private efforts to remediate past damage currently exist, the challenge of improving the economic and social conditions of Appalachia is still daunting. Improving education is a critical part of the overall strategy for long-term re-development. It is widely recognized that improving mathematics and science education in particular must be a central part of building a better trained workforce, but the challenge of improving education in rural impoverished regions is not simply a technical one. Rather it involves addressing the underlying attitudes that arise out of decades of declining economic and social opportunity. The interviews, discussions and site visits we have made to Appalachia make it clear that ARSI has taken on not only an educational challenge, but also a deeper cultural challenge. As part of its mission ARSI has worked hard not only to improve education, but also to infuse hope, energy and a sense of new possibilities into the region.

---

[1] These conditions are described in great detail in Cynthia Duncan's *Worlds Apart: Why Poverty Persists in Rural America* (New Haven, CT: Yale University Press, 2000).

It would be highly inaccurate to leave the description of rural communities in general and of Appalachia in particular as one consisting only of problems of poverty. It is also important to note in Appalachia, as in many other rural areas, unrecognized assets and unique strengths often exist. The inhabitants of many poor Appalachian regions have a very strong sense of family, tradition and community. Appalachians share a palpable sense of place, pride in their beautiful rural settings and powerful allegiance to their homes and neighbors. People who live in the small towns and "hollers" of Appalachia know one another, and care collectively for their home communities. Many Appalachians live their whole lives in their communities. For the most part they do not leave, nor do they wish to leave. Many say that they do not miss the benefits of "modern urban life." Instead they value the simplicity and sense of belonging that come from their rural existence. And in fact those who do leave Appalachia end up "coming home." In designing and implementing its work ARSI recognized and built upon these kinds of "hidden" assets that commonly exist throughout Appalachia. In particular by focusing on long-term support of the development of local, indigenous leadership ARSI strategically took advantage of the strength of community and place that existed in the target areas.

Understanding Rural Schools and Schooling

As part of Appalachia's unique culture, social norms and economy, there exists a well-defined tradition of rural schooling. In order to understand the challenges ARSI faced and the contributions it has made it is important for the reader to have a sense of this educational "landscape" and its key attributes.

The schools and the school systems in Appalachia are very small and highly localized. School districts in Appalachia are usually organized by counties, and the counties are geographically and politically isolated from each other. Moreover many Appalachian counties are geographically isolated from the larger state educational system centered at the state's capitol. In addition, within each county, schools are often widely scattered, centered and intent on serving their own small communities. Thus, even within counties, when we visited Appalachia we found considerable isolation, and not infrequent intense, long-standing rivalries among schools.

Not only are individual school systems isolated, but they are also small in scale. This means that there are not many people to do the work of running the school. Both administrators and teachers are stretched thin. An individual educator for example may be responsible for not only teaching a full load of science courses, but also coaching the soccer team and driving the school bus. Resources for education in these relatively poor states and within them the very poorest

counties are often lacking. In short, there are no extras. Simply conducting the everyday business of schooling stretches what limited resources there are. Hence, the small scale, isolation and modest budgets of school systems makes it very difficult for schools and districts to draw on outside resources to undertake processes of improvement or change, or to develop their own improvement processes or expertise.

> *The same teacher teaches both math and science, either K-12, or 7th grade through 12th grade…and when we asked her to help the district align its curriculum, then she has to do that work at the same time she is teaching all these different courses—and also perhaps driving the school bus—so there are just enough people to do this kind of work…but they are stretched very thin.*

Also, in most ARSI target communities, there is a strong history of local control and decentralization, even an aversion to state control, or even district control over schooling. Appalachian communities want to maintain their autonomous control over their small schools. Decision-making and governance is often tightly held by local school boards and superintendents. Not surprisingly local politics also plays a strong role in school decision-making. Teaching is often a most valued job in this poor environment, and patronage is not uncommon.

Neither geographical separation, nor locals' suspicion of state bureaucracy spares small rural districts from the pressures of state accountability systems however. State funding, policies and mandates heavily impact the rural schools of Appalachia. Because the Appalachian economy is weak, many of the communities served by ARSI are populated by low SES families. Not surprisingly many of these schools often fall below the state norms on state testing, and as a result, are identified as "failing" schools, needing remediation. State Departments of Education then put pressure on these schools to perform better on state tests, but rarely, are the states able to provide the large amount of additional resources necessary to help rural districts meet the accountability challenges they face.

As a consequence of this sequence of pressures many rural Appalachian districts tend to focus heavily on the "basics," and to orient their instructional programs toward the kinds of knowledge and skills covered in state testing programs. Moreover, pressure to do well on state tests tends to re-enforce an already existing, strong bias toward very traditional schooling practices. In addition, in Appalachia, especially in its poorest counties, it is easy to discern a long-held

tradition of respect for (often male-dominated) hierarchical relationships within schools and schooling.

To add to these challenges there is also an underlying ambivalence towards schooling in Appalachia. Many of the few jobs that do exist in Appalachia have centered on mining and more recently the penal industry, both of which only offer relatively low paying, hourly wages to workers. So for many Appalachians there is no strong immediate evidence that schooling and success in schooling leads to a better economic opportunities or life style. In fact, ironically those who do succeed at school often gain the ability (and desire) to leave their communities, to attend community colleges and universities elsewhere, and ultimately to find employment out of state. Many parents do not want to support better schools if that leads their youth to abandoning their home communities.

Thus all of these forces—state accountability, traditional views of schooling, an often rigid respect for hierarchy, and ambivalent attitudes about learning -- tend to reinforce the status quo in Appalachia, helping to maintain a rather conservative and static view of schools and schooling, and making school change and educational improvement especially difficult. Moreover, the isolation of small, poor Appalachian communities, their small scale, and their lack of resources not only leads to a shortage of funds for **operating schools**, but they also produce a severe shortage of funds and expertise that can be dedicated to the **improvement of schools**. ARSI school districts have just enough resources to operate, but they have very little financial resources or internal capacity, and few external relationships that can be used to support educational improvement activities within their local communities. The shortage of resources for educational improvement is a problem across all of the United States, but the shortage is heightened and more severe in small, rural, isolated communities such as the ARSI target counties.

It is appropriate to end this description of rural schools and rural schoolings by pointing out the assets that Appalachian schools have that many other communities in the United States do not have. The strong sense of community we have already described extends to the school communities in Appalachia. Teachers know their students, students know each other, parents know the teachers, and the community at large cares a great deal for each other and for their children. Small towns and "hollers" in general, are less plagued by high rates of mobility, and by the kind of high turnover rates of students, teachers and administrators that occurs in large urban settings. In Appalachia the relative stability, both within the community and within the schools, allows for continuity and long-term work on school improvement.
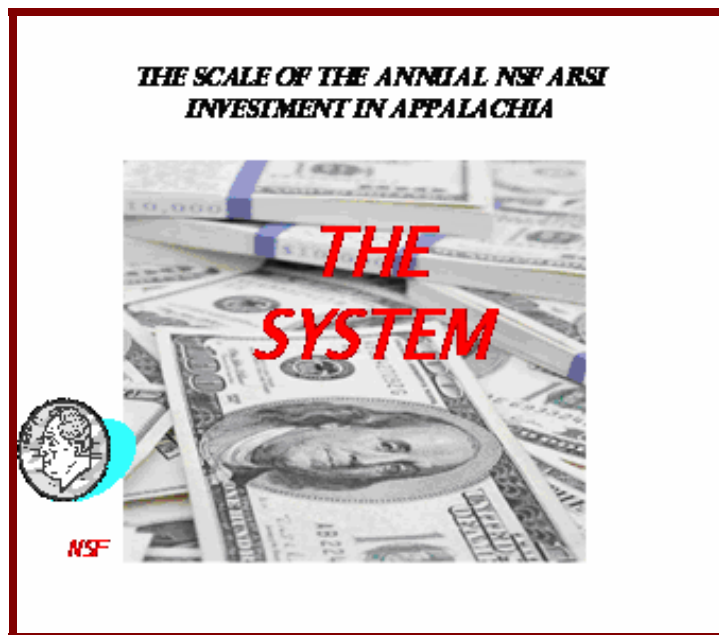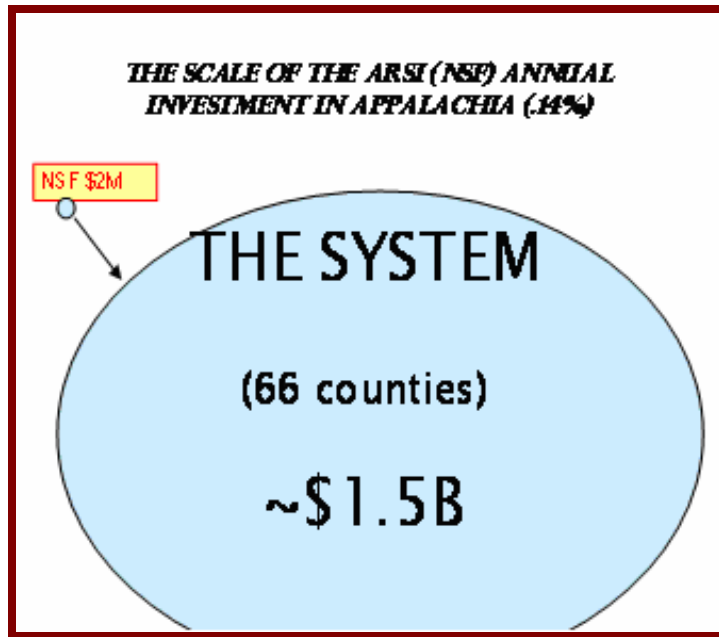
KEY ATTRIBUTES OF THE APPALACHIAN EDUCATIONAL LANDSCAPE

- *Geographic isolation; small systems*
- *History of local control, decentralization*
- *Strong influence of local politics*
- *Strong state policy influence*
- *Cultural respect for hierarchy and traditions*
- *Ambivalence toward schooling*
- *Shortage of resources for the system and for improvement*
- *And yet strong communities, stability, commitment of educators*

III. THE APPALACHIAN RURAL SYSTEMIC INITIATIVE (ARSI): THE SCALE, THE THEORY OF ACTION, AND THE IMPROVEMENT INFRASTRUCTURE

The Scale of the ARSI Investment

Before describing the work and accomplishments of ARSI it is important to set the scale of its work in the broader context of the scale of the educational systems it serves. The NSF has invested approximately 2 million dollars per year in the ARSI initiative, a little bit less in later years. The 2 million dollars a year investment made by the NSF is rather dwarfed by the overall educational budgets of the 66 counties, which amount to (a very approximate) 1.5 billion dollars per year. This means that the NSF investment, when compared to the overall scale of the whole educational system that they are trying to influence is on the order of a one-tenth of one percent, which is approximately 10 cents on the 100 dollars.

THE SCALE OF THE ARSI (NSF) ANNUAL INVESTMENT IN APPALACHIA (.14%)

NSF $2M

THE SYSTEM

(66 counties)

~$1.5B

THE SCALE OF THE ANNUAL NSF ARSI INVESTMENT IN APPALACHIA

THE SYSTEM

NSF

Hence, the NSF investment is quite small when compared to the size of the scale of the system it seeks to influence. The investment can be considered small even when it is compared to the amounts of money that are expended directly in the teaching of math and science in these counties. So, the challenge for ARSI has been to find smart and strategic ways to invest comparatively small amounts of money in the ongoing improvement of the science and math education taking place in these counties.

The Logic of the NSF Investment in ARSI

As evaluators, we often seek to understand what we call the "theory of action" of the investment that has been made by a funder in any given project. A theory of action provides a vision or logical sequence of the steps and mechanisms by which the funder's investment is able to support work that ultimately leads to educational improvement. Because the NSF investment in the Appalachian Rural Systemic Initiative is relatively small, and because the challenges are large, ARSI has sought to find and develop a strategy that 1) is appropriate to the rural region it serves, 2) allows for a high degree of leveraging of its resources, and 3) is based on a coherent rationale. The theory of action that underlies the NSF investment in ARSI involves a multi-step chain of logic which we will describe in the ensuing pages of this report.

Improving the Achievement of Appalachian Students

The first step in the logic of the NSF investment in ARSI restates the imperative – namely that there is a great need to improve the achievement of Appalachian students. An examination of student test scores in math and science in the ARSI counties shows that students score lower than state averages. Other indicators such as graduation rates and dropout rates confirm the need for improvement and are also consistent with what one would expect to find in high poverty regions.

The economic conditions in most of Appalachia, where unemployment rates are high and high skilled jobs are rare, reinforce the fact that the Appalachian school systems are not yet successful in producing a highly educated work force. Nor is there yet local demand for such an education or workforce. In some sense, we see a "chicken and an egg" problem here. On the one hand, it is necessary to improve education in order to create the workforce that can attract and serve new industries; and, on the other hand, new industries need to come to Appalachia to create both a demand and a support for better schools.

Improving the Opportunities to Learn Mathematics and Science

Because there is a need to improve student achievement in Appalachia, there is also a strong need to improve what we and others call, "the opportunity to learn" mathematics and science. The fatalism and ambivalence toward learning we described earlier, create a kind of resignation about schools, a lack of interest in schooling, so that neither students, nor parents, and even in some cases educators, demand classrooms that are well designed to promote learning and to engage students in math and science. A traditional view that adheres to the rituals of schooling, rather than the potentials of teaching and learning seemed

widely accepted in the ARSI target counties we visited. Putting it simply, people did not know what they were missing; they did not know what they didn't know.

ARSI recognized that the disengagement of rural students and their lack of motivation were critical barriers that needed to be overcome. In this environment ARSI took a long term, high level view of educational improvement. Their view of improvement included, but was not limited to improving student scores on state tests. Their broader focus was on achieving a richer vision of teaching and learning, one described in the NCTM and NRC Math and Science Standards. As the next step in the chain of logic, ARSI focused heavily on helping teachers improve the nature and quality of their students' opportunity to learn mathematics and science, in ways that were aligned with the national standards.

A richer more motivating opportunity to learn depends upon schools and classrooms that have well designed programs and motivating activities in math and science. Such instruction certainly includes math and science content that is important, accurate and central to the discipline. But a rich opportunity to learn also includes classroom activities in math and science that are diverse, multi-faceted and age appropriate. Rather than a monochromatic approach and pedagogy to teaching math and science, there needs to be diverse and multiple approaches so that there are multiple roads to success. They have to be accessible to the local Appalachian youth and invite their participation. They have to be seen as relevant to their lives and to the place that they live. In short, ARSI set out to find ways to improve student achievement by improving the quality of the student learning experience, by generating a range of supports that could make local Appalachian classrooms more rigorous, more rich and more engaging environments for the rural youth they served.

OPPORTUNITY TO LEARN

Opportunity to learn includes:
- Motivation and incentive
- Well-designed activities
- Important and accurate mathematics and science
- Age-appropriate activities
- Accessible, attractive, inclusive invitation to participate
- Activities relevant to the audience, place
- Diverse and multiple approaches

Making Teachers Stronger and More Effective in Mathematics and Science

The third step in the logic of NSF's investment in ARSI and its 66 target counties centered on the need to make local school systems better able to help their local teachers improve the instruction and opportunities to learn they offered their students. ARSI recognized that teachers in rural areas were largely unsupported in improving their classroom practices. However, if teachers were to improve, then local school systems needed to do a better job in providing supports to teachers. Thus ARSI recognized that their efforts ultimately needed to increase the capacity of the local educational systems to provide a system of supports in multiple dimensions for their teachers to improve their instruction in math and science.

Improving the Ability of the System to Support Teachers in Improving Their Classrooms

There are many kinds of supports that schools and districts can provide teachers. ARSI's aim was not only to educate the counties about the range of systematic supports classroom teachers needed to bolster their math and science programs, but also to provide direct assistance in achieving those supports.

First and foremost, is the dimension of a **shared vision of high quality teaching and learning**. Such a vision is often to be found within state math and science standards, which were largely unfamiliar to the teachers and administrators in

the ARSI regions. ARSI quickly realized that teachers and administrators needed the support of a richer, more nuanced and rigorous vision of how well-designed mathematics and science instruction should look. Consequently, ARSI worked hard to make state and national standards familiar in schools and districts, and to infuse teachers and principals with the more complete vision of teaching and learning held aloft by national experts.

Another key dimension of support for improved teaching is **professional development**. Rural Appalachian counties, however, largely lack the capacity to design and implement high quality math and science professional development opportunities for their staff. Hence it is not surprising to learn that most Appalachian teachers do not have regular access to such experiences. But if students were to be provided with better opportunities to learn math and science, then ARSI reasoned, teachers had to have more and better professional experiences to learn about and reflect on the best ways to teach math and science. ARSI provided considerable professional development directly to teachers and districts, but in addition sought to educate regional and local educational systems about where to find outside professional resources and to how to provide more and better professional experiences for their teachers themselves.

Still another dimension of support necessary, but alone not sufficient to help teachers improve their practice is the presence and use of **well-designed and appropriate curriculum and curriculum materials**. NSF has spent decades and millions of dollars developing high quality curriculum and few of these were to be found in use in Appalachia. Indeed many Appalachian counties we visited early on in our study did not even know of the existence of such curricular programs. And in Appalachia as in most rural districts local school systems lacked the capacity needed to identify, adopt and implement challenging curricular programs. Most systems are unable to coach and advise teachers in how to teach with new materials and to use them to improve their teaching. Recognizing the need, ARSI began to help local schools, districts and ARSI teacher leaders become aware of the current field of curriculum and materials in math and science. They helped key decision-makers in their target areas adopt and begin to use better quality instructional materials, thereby supporting local teachers with better programs.

A fourth dimension of support that local educational systems can offer teachers is to help them find ways to use **assessment tools and processes** productively. The ability to gather data and analyze it and use it as feedback to guide the improvement of their instruction was not a skill that many ARSI teachers possessed before the initiative began. ARSI thus sought ways to help local districts, schools and teachers use assessment approaches and tools to better understand where their instruction was strong and weak, and where students

were learning and not learning. ARSI sought to provide teachers and administrators with multiple tools to use to create a ongoing feedback cycle that could greatly support teachers and schools in guiding the improvement of their practice.

Another area in which ARSI sought to help local systems was in the area of **policy alignment**. Often local policies and state policies work to constrain or discourage teachers from engaging and learning about how to teach math and science better. These policies tend to discourage both students and teachers from working toward a higher level, more sophisticated vision of teaching and learning. Where it could ARSI worked to help administrators and teachers understand and manage the pressures of conflicting and inconsistent policies, and to align their policies with processes to improve math and science instruction.

Similarly, ARSI realized in the process of its work that **administrator support** was critically important if teachers were to be encouraged in improving their instructional practices. Hence, ARSI worked to help district and school administrators understand the need for and nature of high quality math and science teaching. They helped administrators learn about the kinds of supports teachers needed, and how they might support their districts and schools to move toward stronger overall mathematics and science programs.

Finally, ARSI recognized the critical importance of **community engagement**, and sought ways to help local leaders gather the support of the community for improving the math and science teaching in their schools. Particularly, in small rural regions, schools are closely held by local citizens and serve as the hub of community life. Community opposition and misunderstanding could easily doom local improvement efforts. Thus it was critical for local districts and schools to be able to explain and make the case for improving math and science education to their school boards and involved parents.

**SYSTEM SUPPORTS THAT CAN HELP
TEACHERS IMPROVE THEIR CLASSROOMS**

- A shared vision of good teaching and learning (Standards)
- High-quality Professional Development
- Appropriate curricula
- Well-designed Instructional Materials
- Productive use of assessment and data
- Policy alignment
- Administrator training and support
- Community engagement and support

In summary, the logic that under-girded the ARSI investment can be stated in the following way:

1. Improving the achievement of Appalachian students in mathematics and science is critical to the future of Appalachia youth and even to the future of the Appalachian economy and its overall social well-being.
2. Therefore improving the opportunity to learn math and science is a critical step towards improving the interest, motivation and achievement of Appalachian students.
3. The ARSI strategy was then to find ways to support teachers in becoming stronger and more effective in math and science instruction, and to make their classrooms richer, and more successful classroom environments for such instruction.
4. This in turn requires finding ways to enhance the capacity of local educational systems to support the improvement of the knowledge, skills, and classroom practices of their teachers. This meant that ARSI had to find ways to improve the ability of the local systems, including the district leaders and school leaders such that they could better support teachers in their efforts to teach their students and to improve the teaching of their students.
5. Thus, ARSI took upon itself the task of seeding and developing capacities for ongoing local systems' improvement. That is ARSI sought ways to help the target school systems get stronger and to continue getting stronger in supporting teachers in improving their practices.

We describe the theory of logic or logic of the ARSI investment again graphically in the chart below:
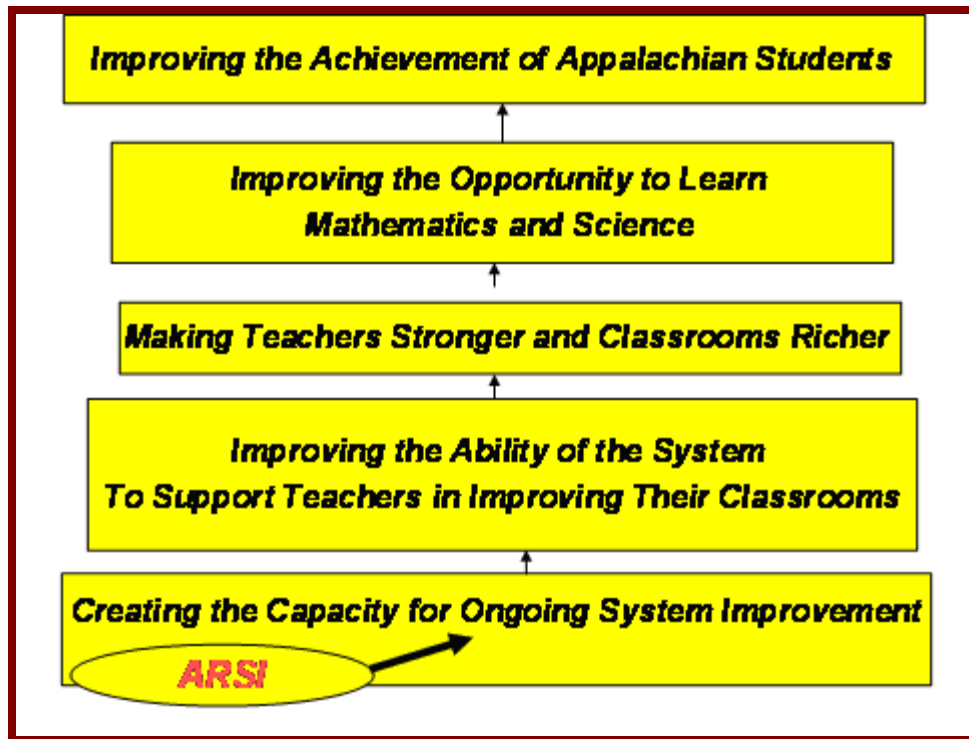
The Need for an Improvement Infrastructure

As a consequence of studying educational improvement efforts for many years, we at Inverness Research have discovered and applied a theoretical construct to our work which helps illuminate the kind of investments that NSF, as well as many other private and public funders make to enhance education. Simply put, we see such investments as helping to strengthen the local **educational improvement infrastructure**.

The theoretical construct of "improvement infrastructure" was created by Doug Engelbart, a professor emeritus at Stanford, the inventor of the computer "mouse," and a visionary who thinks and writes extensively about the nature of organizations and the improvement of organizations. Engelbart distinguishes between what he calls a **capability infrastructure** and an **improvement infrastructure**, and it is this critical distinction we have applied to understanding education and the nature of the kind of educational investments NSF has made through ARSI.

Englebart points out that every organization has a **capability infrastructure**, that is, it has a kind of set of supports that help people do their work. The capability infrastructure, or what we at Inverness Research prefer to call the "operational infrastructure" is what within any organization we use to do our jobs . In schools there is a capability infrastructure or operational infrastructure that supports teachers doing their jobs, namely teaching. It consists of the school building, the bus system, the textbooks, the labs, the desks, the computers, the janitor etc.

What Englebart also recognized was that organizations also need an **improvement infrastructure**. The improvement infrastructure lies below, under-girds, and helps support the ongoing improvement of the capability or operational infrastructure. By making the capability or operational infrastructure stronger, the improvement infrastructure is critical to the long term, effective functioning of an organization. The capability infrastructure supports people in doing the work; the improvement infrastructure helps the organization get better at doing its work.

Jennifer Stone Gonzalez, in writing about Engelbart's work states the following:

> *Engelbart argues that we are still focused around projects and task forces with short term expectations and short term life cycles. The most important activity that we can do is to help develop the improvement infrastructure and to encourage and fund cross functional improvement communities whose members work on common challenges to explicitly improve improvement. Then that community itself thus becomes a knowledge accelerator. In essence, the human network … is the way to get better at getting better.* [2]

We believe this explication of the need for an improvement infrastructure and an improvement community lies at the heart of the ARSI investment. ARSI sought to go beyond what a short-term project could accomplish, and to accomplish more than provide direct services to target districts. Rather, ARSI sought to build the long term capacity of rural communities to improve themselves. Thus, ARSI helped to put in place the very early foundations of an improvement infrastructure for mathematics and science education in Appalachia. The most critical piece of this foundation was creating a network of people, what Gonzalez referred to as an **improvement community** that could learn about how to improve mathematics and science education, and how to support each other in ongoing ways to do that work.

---

[2] Jennifer Stone Gonzalez, *The 21st Century Intranet*. (Upper Saddle River, NJ: Prentice-Hall, 1998), p. 39.

It is perhaps useful to pause here, and summarize again the logic of the ARSI investment using this construct of the improvement infrastructure. The argument for ARSI can thus be stated as follows:

1. If one believes that the current status of teaching and learning in Appalachia is not what it should be, that the health of the region, and in fact the health of the nation would be bettered by having a higher quality of teaching and learning in Appalachia, then one has to say, there has to be an concerted and deliberate effort made to improve that current status of teaching and learning in Appalachia.

2. And over the last 20 or 30 years it is also fair to say that while there have been efforts to improve the economic status and the educational status of life in Appalachia, the efforts to improve the teaching and learning have not been sufficient yet to bring about the kind of results that we all would like to see.

3. Thus there is a kind of dissatisfaction, not only with the current status of teaching and learning, and, at a deeper level, there is also a dissatisfaction with the sufficiency of the improvement efforts made to enhance the quality of Appalachian teaching and learning.

4. In short, there need to be efforts to improve the efforts to improve the current status of teaching and learning in Appalachia.
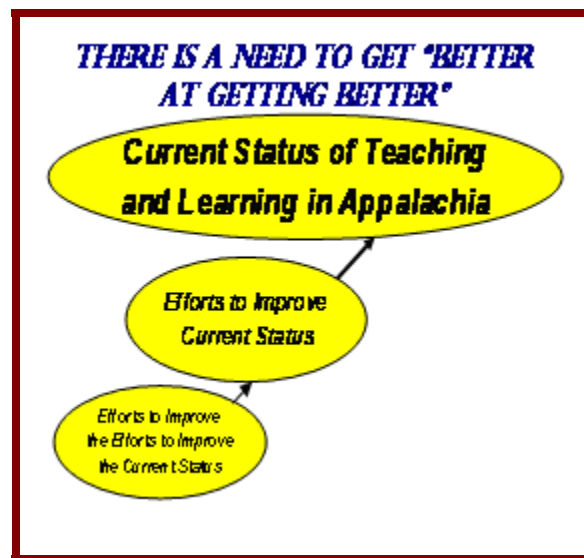
Mathematically speaking, this is the equivalent to saying that one wants to influence the function of education, but that to change the function, one needs to alter the first derivative, which in turn requires a change in the second derivative. By building an **improvement infrastructure** (the second derivative), the ARSI project can strengthen the **capability or operational infrastructure** (the first derivative), which in turn can help improve the function of teaching and learning of mathematics and science in an ongoing fashion.

ARSI is thus an effort that can be viewed as seeking to "improve the improvement process" in Appalachia, seeking to improve the way in which and the extent to which improvement efforts take place there. Therefore it makes most sense that the primary focus of ARSI was on creating an improvement infrastructure. And the first step in achieving that goal was to develop what Englebart called "an improvement community" that could support ongoing enhancement efforts in math and science teaching in Appalachia.

IV. THE ARSI IMPROVEMENT COMMUNITY

ARSI decided the key step to local improvement was the expansion and enhancement of local leadership. Because its communities are tightly knit, because they are averse to outsiders, and because ultimately they must become self-reliant, ARSI realized that the only strategy that would be effective in Appalachia was one that worked effectively in building indigenous leadership within each of the target counties. Therefore ARSI designed an initiative-wide strategy whereby outside resources and expertise were used to develop and support local teacher leaders who, in turn, could work on the improvement of their own communities. The improvement community ARSI deliberately nurtured and developed was composed of these local teacher leaders who are supported by state and regional people with specialized skills and expertise.

The Teacher Partners

It was not originally planned that the ARSI improvement community would consist primarily of ARSI Teacher Partners. The ARSI Teacher Partner role was an invention, a construct that evolved early on in the life of the initiative, and that allowed ARSI to identify strong, local educators who were successful in their own classrooms and also who had credibility and stature in their own systems. By identifying leading teachers, and by creating a new role, position and identity for them, ARSI was able to elevate them into a position where they not only were teachers of mathematics and science but they could also work on the broader improvement of mathematics and science programs in their local schools.

ARSI designers realized that in order to support their colleagues within their local schools and districts the ARSI Teacher Partners (TPs) themselves needed to be well supported. They were good teachers but they were not necessarily experienced of skilled in helping their own districts, schools and colleagues improve their practices. The ARSI improvement community thus needed to include a variety of people who could teach, coach and help the TPs. Ultimately, ARSI evolved three different types of people and related positions that were geared to helping to support the ARSI Teacher Partners.

To learn more about ARSI Teacher Partners and the kind of work they performed see "A Portrait of an ARSI Teacher Partner in Oneida, Tennessee," which is a report within the website ARSI Evaluation Portfolio.

Resource Collaborative Coordinators

The Resource Collaborative Coordinators were housed in universities nearby ARSI target counties. The Resource Collaborative Coordinators (RCCs) provided ongoing support to a group of local ARSI Teacher Partners, with the advantage of understanding the state context and regional context, and having access to a wide range of knowledge and resources about math and science education improvement. They helped support the TPs, both individually and collectively in their region through professional development, through assistance with resources, and through other kinds of lobbying and advocacy efforts.

ARSI discovered that the TPs benefited greatly from being networked together, both regionally and across all of Appalachia. The RCC role was instrumental in providing the forums and events which brought Teacher Partners together and let them learn from each other, as well as from the Resource Coordinators. In addition the RCCs provided their cohorts of ARSI TPs with access to national resources and expertise so that they could incorporate the most current thinking, strategies and tools into their local work.

District Liaisons

A second kind of support for the teacher partners was found in the ARSI-designated District Liaison role. The District Liaisons (DLs) were county, e.g. district administrators, who helped support their Teacher Partner by providing a direct link, critical access and support from the upper level of the local school system. They also provided district level policy and financial supports that enabled the work of the Teacher Partner, as well as a kind of "anointment" that gave legitimacy to the work of the TP in the county. In the best cases the ARSI DL and TP became true colleagues and partners, working together in a particular

county over multiple years to further the improvement of math and science instruction.

See "A Portrait of a Collaborative ARSI Team in Knott County, Kentucky," a portrait of the efforts of four women at different levels of the system to realize the goals of ARSI in their region. This is a report within the website ARSI Evaluation Portfolio.

Regional Teacher Partners

A third type of support to the ARSI Teacher Partners evolved over the course of ARSI, the role of the Regional Teacher Partner which was created and funded by a special add-on grant that took place in Kentucky. The Regional Teacher Partner (RTP) program identified some of the strongest ARSI Teacher Partners and elevated them into a role and a position whereby their job was not only to serve as a TP, but also to support other TPs in their region. This group of RTPs, working together, was quite effective in supporting other TPs , because, of course, they had been ARSI Teacher Partners themselves.
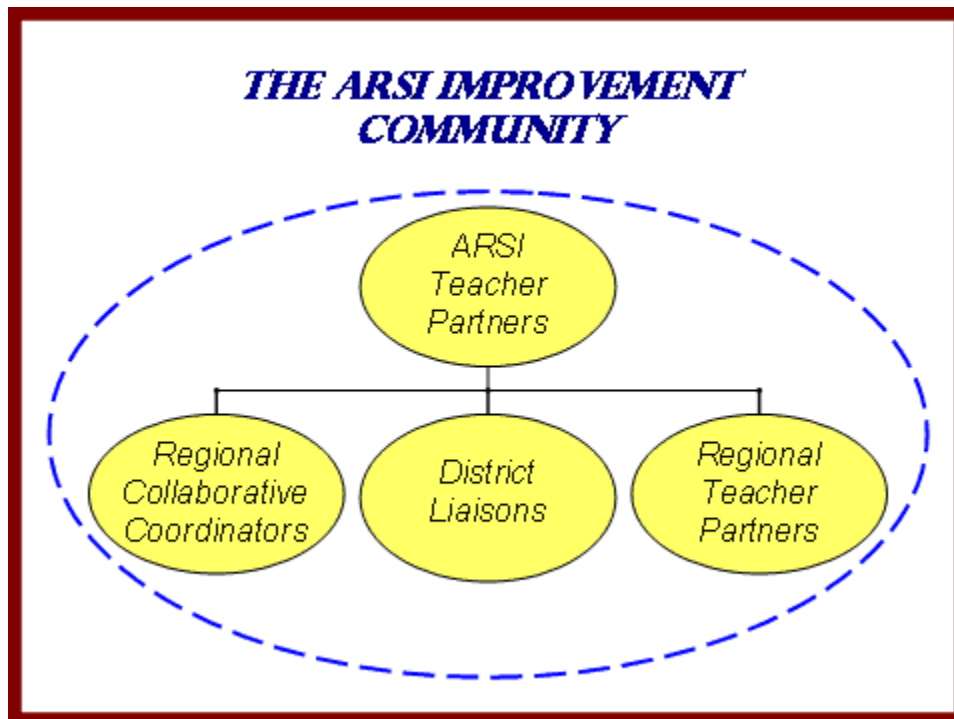
The people who fulfilled the three support positions to the ARSI Teacher Partner cadre all became part of the broader improvement community. The creation of these positions allowed for and promoted the involvement of university faculty, district administrators, and some of the region's strongest teachers. The

Resource Collaborative Coordinators, the District Liaisons, and the Regional Teacher Partners all worked in concert in a myriad of ways to support improvement of math and science education in their respective domains. Together with the ARSI TPs, the group at large created for the first time in Appalachia a strong regional improvement community for math and science education.

IV. THE FUNCTIONS
OF THE ARSI IMPROVEMENT COMMUNITY

The most critical function of the ARSI improvement community was the ongoing support it offered to the ARSI Teacher Partners in initiating and guiding local improvement efforts. One of the important aspects of the ARSI approach was that it was individualized. TPs conducted their work within in their home sites as they saw fit, and as they knew how. In ARSI they ended up doing quite different things in different districts, depending on their background and skills, on their national and regional connections, and on the sophistication and readiness of their local communities. Thus each of the ARSI Teacher Partner-led improvement efforts involved a relationship-intensive, customizing process, designed to meet the needs and to address the opportunities that were available in their own regions. But because of the fluidity and responsiveness of the improvement community this case-by-case approach proved surprisingly effective.

The ARSI improvement community, spear-headed locally by individual TPs, not only provided direct services to local teachers, but also worked to build the regional and local capacity for the ongoing improvement of math and science in Appalachia. The community supported the growth of people at a range of levels—teachers, administrators and higher education faculty—all of whom were or could potentially be involved in improvement work. Over the years ARSI formally sponsored many professional experiences to which the ARSI community members were invited and invited to bring colleagues, but myriads of other professional activities and interactions aimed at math and science improvement were initiated by local individuals or groups of individuals seeking to share their knowledge with others within their community. And the vast majority of learning experiences occurred informally, opportunistically and through the process of the kind of day to day work that occurred for a decade in ARSI schools and districts. A TP might share the latest version of state standards with her principal, the ARSI DL might spend time reviewing district test scores in mathematics with the elementary principals in the county, an ARSI Regional Teacher Partner might convene a study group of interested TPs—theses examples illustrate the hundreds of different ways individuals involve in ARSI

expressed their interest in improving mathematics and science education, and how the work these ARSI leaders supported not only helped teachers, but also helped to establish local leaders that could continue the improvement work in the future.

Another very important function of the ARSI improvement community was to provide local efforts access to the national improvement infrastructure for math and science education. NSF and others have funded many institutions and projects across the US that have developed resources and capabilities for improving math and science over many, many years. These include curriculum development projects, national professional development institutes, and a wide array of improvement tools and resources. In addition NSF and others have also funded research projects that have yielded a great deal of knowledge about the strategies and approaches that can be employed in regional and local improvement efforts in math and science. These include processes for conducting school-wide reviews, mapping and aligning curriculum, using data to guide instruction, developing curricular leadership, engaging the community, etc. All of the assets contained in the national knowledge base and in the national pool of expertise became more available to local Appalachian communities through the interface of the ARSI improvement community.
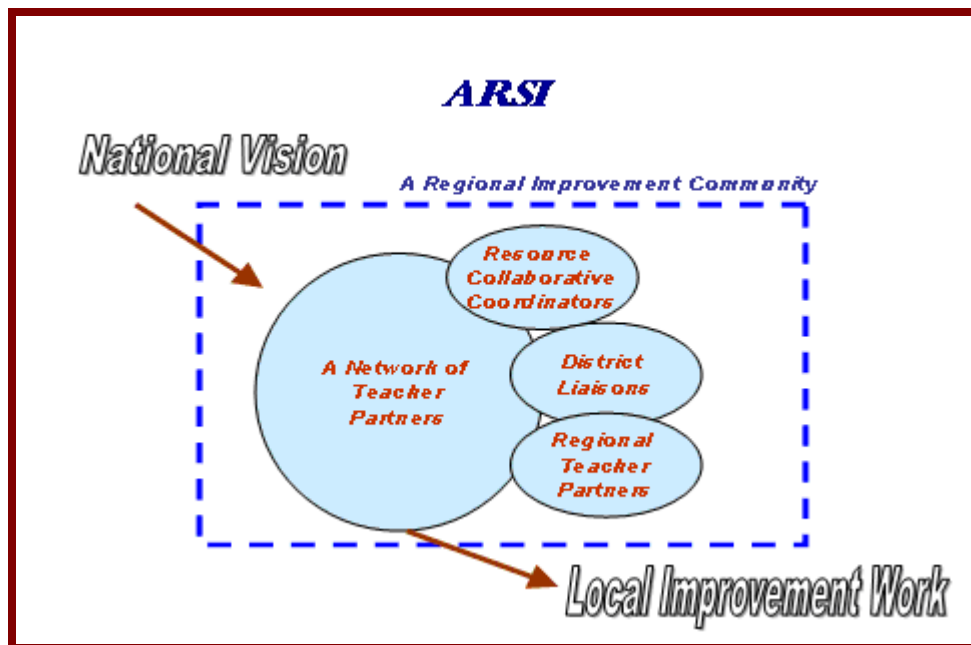
It is also important to point out that the ARSI improvement community served an important interfacing function between the national infrastructure we have just described and local ARSI efforts. Members of the ARSI improvement community helped "translate" the tools and resources "imported" from the

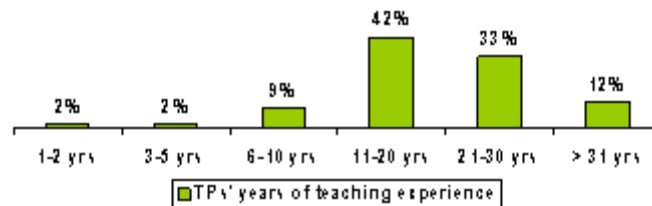national improvement infrastructure into forms appropriate for and palatable to their own local communities.

In particular the ARSI Resource Coordinators, District Liaisons, Regional and regular Teacher Partners almost all learned freshly about a new vision of teaching and learning as laid out in the NCTM standards and the National Resource Council Standards when they began their ARSI work. This is a very rich and ambitious vision and the ARSI deliberately urged members of the improvement community it had created to become deeply versed in that vision and to understand it thoroughly, so that they might then draw upon that vision as they engineered efforts to improve teaching and learning in their own individual communities. Local norms and values were different though than national norms and values. Each ARSI Teacher Partner faced the "translation" problem we described, with the challenge of designing processes of improvement that were both compatible with local concerns and interests, but simultaneously as aligned with the national vision as possible. ARSI TPs had to hold at the back of their minds a vision of science and math improvement that corresponded with the national standards, and on the other hand, they had to work within the cultural mores of their local community. This negotiation between the national and the local – the ambassador-like function of the Teacher Partners -- was critical in the overall success of ARSI.

V. THE CONTRIBUTIONS OF
THE ARSI IMPROVEMENT COMMUNITY

ARSI achieved its greatest contributions to the improvement of mathematics and science education through the work of the ARSI Teacher Partners. The TPs were a highly experienced group of teachers. While originally envisioned as a one-year position, ARSI wisely recognized that TPs needed to grow into their roles as improvement agents in their local communities. As a result many teachers built their expertise, and increased their effectiveness, by serving for many years in their role.

The data from the following graphs is taken from the ARSI Teacher Partner and ARSI District Liaison surveys Inverness Research Associates administered in the spring of 2006. For the complete results of these surveys see "ARSI Teacher Partners and District Liaison Survey Data," which is a report within the website ARSI Evaluation Portfolio.

TPs bring *years of classroom and district savvy* to their work for ARSI

2%	2%	9%	42%	33%	12%
1-2 yrs	3-5 yrs	6-10 yrs	11-20 yrs	21-30 yrs	> 31 yrs

TPs' years of teaching experience

Most current TPs have worked as Teacher Partners for a number of years

23%	43%	35%
1-2 years	3-5 years	6-10 years

Years TPs engaged in work for ARSI
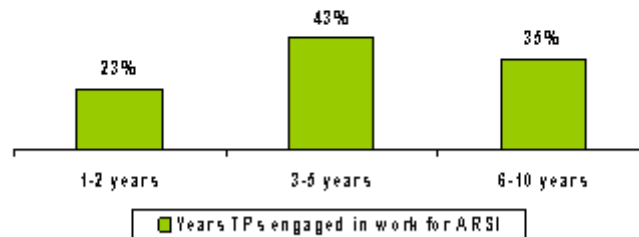
The Teacher Partners have fulfilled several important leadership functions. First and foremost they have elevated the importance of math and science education in their local counties, breaking through the invisible wall of fatalism and lethargy about the possibility of improvement which many encountered in their schools and districts during the first years of their efforts. They have also made it clear to teachers, administrators and community members that it is both important, possible, and indeed do-able to improve mathematics and science instruction in their own districts.

THE ARSI TEACHER PARTNER AS "STANDARD BEARER"

One of the things that struck me is that at the time ARSI began its work, there really wasn't a keeper of the vision for math and science in those districts. There wasn't someone to lead the charge... there were no - and still are no - math or science supervisors; everyone is a generalist... The 'central office' staffs tend to be very small and so the ARSI-supported "teacher partner" became the standard-bearer for math and science reform in those districts...

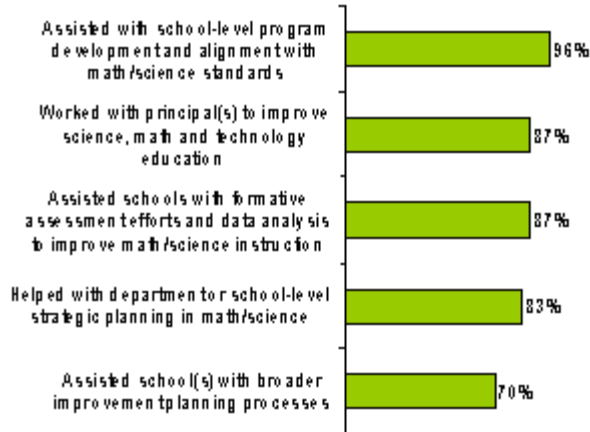Although the work of the ARSI TPs varied greatly across districts, collectively over the decade life span of ARSI they helped improve the overall level of professional development, curriculum and instructional materials, and assessment practices throughout Appalachia. The work of the ARSI TPs generally began with assisting other teachers on a one-to-one basis. As their skills and confidence increased, ARSI teacher partners took on the task of working with whole schools and/or departments. Finally, many ARSI Teacher Partners moved into the work of helping the whole district improve its programs. In this role many TPs worked themselves into a role of district math/science coordinator—a position that was at times formally recognized and other times more informally acknowledged.

How TPs supported teachers in improving math and science teaching (% of district DLs)

Category	%
Shared knowledge of state and national standards	100%
Shared expertise in how to teach math and/or science with standards-based curriculum materials	100%
Provided support through modeling lessons and effective classroom strategies	100%
Provided informal support and resources on an as-needed basis	96%
Provided access to curriculum or materials	91%

How TPs supported <u>schools</u> in improving math and science teaching (% of district DLs)

- Assisted with school-level program development and alignment with math/science standards — 96%
- Worked with principal(s) to improve science, math and technology education — 87%
- Assisted schools with formative assessment efforts and data analysis to improve math/science instruction — 87%
- Helped with department or school-level strategic planning in math/science — 83%
- Assisted school(s) with broader improvement planning processes — 70%

How TPs supported <u>districts</u> in improving math and science teaching (% of district DLs)

- Provided a connection to national and state visions of exemplary math and science education — 100%
- Advocated for science and math improvements in the district — 96%
- Led discussions to promote SMT improvement — 87%
- Conducted or organized SMT professional development activities — 87%
- Assisted with K-12 math and/or science program articulation — 83%
- Helped increase awareness of math and science standards — 83%
- Helped leaders to interpret state assessment data for classroom instruction — 78%
- Assisted with broader improvement planning processes — 65%

% of districts in which TPs supported _other_ _groups_ on behalf of ARSI

Maintained relationships with other districts and outside groups in the support of SMT improvement — 83%

Met with parents and/or community members about SMT education improvement — 61%

Our research over the years has shown that ARSI did, in fact, help improve the quality of classroom instruction. In those classrooms where ARSI has done the most extensive work, the quality of classroom instruction was equal to the quality observed in the classrooms of districts participating in the NSF LSC initiative[3].

VI. THE ACHIEVEMENTS OF ARSI AND THE CHALLENGES THAT REMAIN

The successes of ARSI are significant. They are also important for those interested in educational improvement in mathematics and science to understand because they illuminate the potential power of the strategic approach that ARSI pursued.

ARSI is a vivid example of an initiative designed to develop and support indigenous leadership. Particularly relevant for other rural settings, ARSI demonstrated the critical importance of local ownership of improvement efforts and the centrality of the role of "home grown" leaders who were not only accepted by but also often highly respected in their communities, and of course understood well local conditions and values. The principle of supporting the development of indigenous leadership was especially faithfully and effectively implemented in the form of the ARSI Teacher Partner. This approach is particularly needed and promising in regions that are geographically isolated

---

[3] See the Inverness Research evaluation report "The Appalachian Rural Systemic Initiative: A Report for Field." April 2000. You may access this report via http://www.inverness-research.org/reports/ab2000-04_%20Rpt_ARSI-4Year.htm>.

and distrusting of the "outside" world. By funding and supporting leaders who were knowledgeable and becoming increasingly effective at working within their own communities, ARSI assured that improvement work would be incremental and culturally appropriate each step of the way. By trying to impose a "one-size fits all" improvement process ARSI would have foundered, suffering from a great deal of inefficiency, and more likely encountering much more local resistance. Many rural efforts have failed because of the pursuit of a strategy whereby "outside experts" are asked to come into a community and somehow help "fix" the situation. The distrust and the lack of relationship between outsiders and the insiders often lead to failure of such reform efforts. In contrast, ARSI tapped into the local assets – the pool of potential leaders, the strong community pride, and the Appalachians self-reliance—to build indigenous human capital.

ARSI is also a good example of deliberately doing the very localized and very customized work that is required in small rural communities. As we have described, the ARSI improvement community worked closely with local leaders, especially the Teacher Partners, in doing customized local work that was appropriate to particular community norms and values. Fundamental to this individualized approach was ARSI trust in and respect for the local leaders it had identified and supported. ARSI trusted the locals to know what was best and most appropriate for their particular situation. At the same time it worked locally, ARSI was able to help Teacher Partners and District Liaisons tap into gain guidance from a larger national vision of teaching and learning and of educational improvement. Here again, ARSI trusted indigenous leaders to know how to "translate" national level resources and expertise into local terms.

The ARSI approach and model also demonstrates the power of teachers as leading change agents. Teachers teaching other teachers is a powerful strategy, particularly when those teachers are supported by outside expertise and a strong network of collegial relationships. The ARSI strategy is a very good example of local teacher leaders who are part of and become supported by a broader improvement community. For this reason, we believe, particularly, that the invention and refinement of the Teacher Partner concept was a particularly important achievement of ARSI. It was the TPs who successfully straddled both the worlds—their home schools and districts and the larger, nationally-connected ARSI improvement community – bringing new knowledge and expertise to the former, while simultaneously bringing lessons learned from the field to the latter.

The success of the teacher serving other teachers concept is best illustrated by the fact that many of the ARSI districts have institutionalized the ARSI Teacher Partner position, continuing to fund it after the NSF funding expired. As a

particularly vivid example, in Kentucky all 35 of the TPs were later funded by the districts themselves. This degree of support and institutionalization by districts is perhaps the strongest statement we have of the degree to which the districts themselves became convinced of the value of the TP role, and became committed to continuing their work. Also, we should point out that the Teacher Partner idea has been used successfully by other rural systemic initiatives.

Moreover, the work of the ARSI TPs has led to tangible improvements in the kinds of supports their districts were able to begin offering their teachers to improve their math and science instruction. There is evidence across ARSI target districts and schools that there was significant improvement of the curriculum and instructional materials that the districts became acquainted with and chose to implement. From our surveys and interviews we have learned that more and better professional development was also made available to rural administrators and teachers of math and science. And ARSI participants have reported that there was also clear improvement in assessment processes, all the way from assessing the health and status of the school math and science program to the use of classroom based assessment processes. Another area of success, less tangible perhaps but nonetheless worth noting here, is that ARSI helped to heighten the community's awareness of the need for and possibility of improving math and science education.

It is also important to note the limitations or the bounds of the ARSI work as well as its contributions. As noted before, ARSI constitutes a very small investment in a large rural and impoverished area. ARSI provided critically important support for the development of an improvement community, but within any given district, the District Liaison, the ARSI Teacher Partner and perhaps some other teacher leaders constituted only a small group of people who were directly involved in the work of improvement. Although the ARSI initiative helped to put in place in each ARSI district an initial nucleus of people who could provide a foundation of leadership, their influence was often weaker than they had hoped, and their existence always more vulnerable. They did not always have the resources or time to carry that work to all of the teachers and schools in a large and fragmented rural county. And, of course, their members were subject to the change and flux of any personnel, vulnerable always to retirements, illness, and relocations. Hence, ARSI did not solve *all* of the math and science education shortcomings in Appalachia. Rather it might be more appropriate to view ARSI more as a nucleation effort, taking on the very difficult first step of creating initial capacity and stimulating some incipient desire to pursue the continuing improvement of local math and science programs.

It is worth noting again that ARSI worked in an environment, described earlier in this summary report, where many contextual factors exist that make change

difficult. From poverty, to geographic isolation, to the pressure of state accountability measures the Appalachian context is not an easy one within which to pursue educational improvement. Over the course of the ARSI lifetime, economic conditions changed, community priorities changed, and national policy changed (e.g., No Child Left Behind[4] legislation emerged as a powerful influence on instructional priorities). Working against all of the ARSI efforts, were turbulent forces and shifting contextual features that made improvement successes hard to sustain.

But to end on a positive note, we focus on what can be seen as ARSI's final achievement, the legacy of people and ideas remaining throughout Appalachia. The members of the ARSI improvement community continue to contribute to subsequent improvement efforts in the region. A few examples may help illustrate the multiple ways in which indigenous leadership developed and can be used as an asset in future efforts:

- The Rural Coalfield Systemic Initiative grew out of and used both the model and the leadership developed by ARSI

- The AMSP drew heavily on the ARSI Teacher Partners in its work as they looked to develop new partnerships in the region and design new professional development courses.

- The ACCLAIM Center for Teaching and Learning used ARSI Teacher Partners as mentors and local leaders; additionally, some ARSI TPs became doctoral students in the program.

- Several state-funded MSPs have used the ARSI Teacher Partners as key members of the people involved in the work of their mathematics and science improvement efforts.

In conclusion we wish to point out that ARSI represents an important exception from the norm of how NSF and other foundations fund projects. The ARSI investment played out over nearly 11 years and thus represents a kind of extended project lifetime that is not typical of most grant-making. The investment of relatively small amounts of money over a longer period of time allowed for cumulative capacity building and slow, but sustainable growth that

---

[4] The No Child Left Behind Act of 2001 (Public Law 107-110), commonly known as NCLB, is a US federal law signed on January 8, 2002 that reauthorizes a number of federal programs aiming to improve the performance of primary and secondary schools by increasing the standards of accountability for states, school districts and schools; it also provides parents more flexibility in choosing which schools their children will attend. The text of the law can be found on the Department of Education website <http://www.ed.gov/policy/elsec/leg/esea02/index.html>.

is not possible with a grant that only lasts from 3 to 5 years. ARSI is a good indicator of the need for funders to consider longer term investments focused on incremental human capital building, as opposed to short term projects aimed only at producing direct and immediate outcomes.

A long-term, incremental funding perspective is especially pertinent when funders seek to invest in the development of communities that are as depleted as some of the rural Appalachian communities which were targeted by ARSI. In these communities the capacity required to implement improvement efforts is largely lacking. It makes little sense to invest in such communities for a mere three years and to look for immediate "results." By contrast, it makes a great deal of sense to invest in the building of an improvement infrastructure and an improvement community, which can slowly but steadily ameliorate the affects of chronic cultural and economic depletion. The Appalachian Rural Systemic Initiative allowed for well-paced, cumulative growth of the ARSI improvement community over a decade. This community now provides a solid nucleus and a strong foundation for further efforts at improving math and science education in the region.