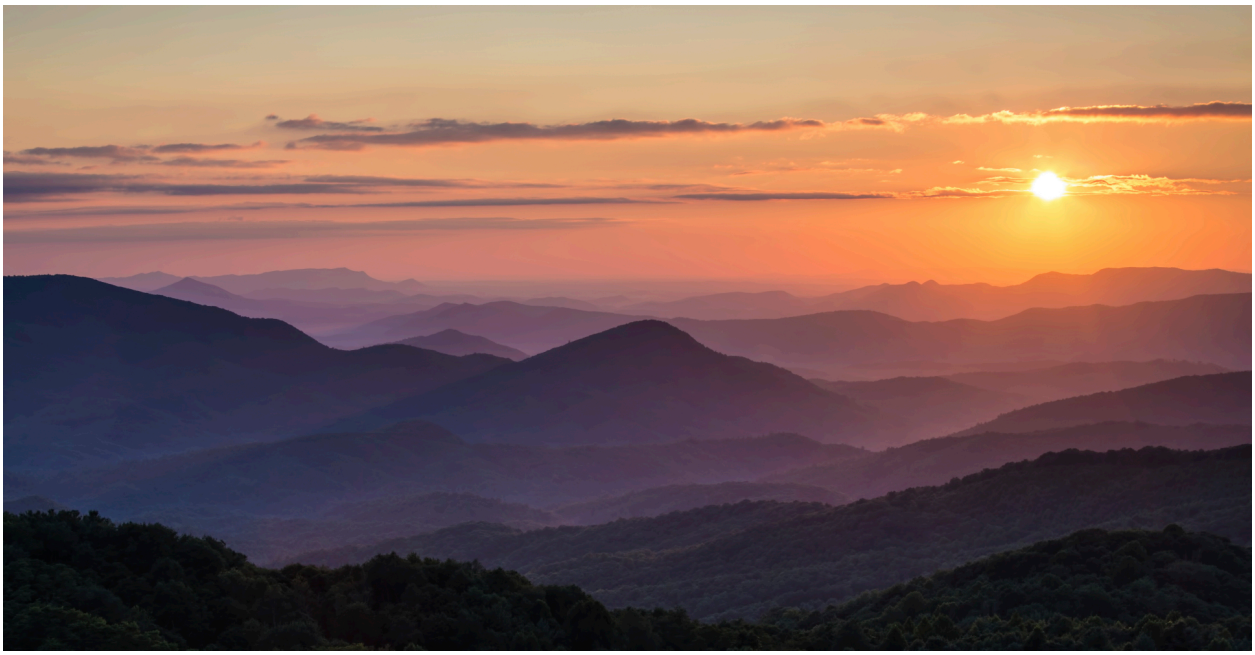
Voices of the AMSP



The Appalachian Mathematics and Science Partnership

Conference Monograph

Inverness Research
September 2012

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and Science Partnership

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The Appalachian Mathematics and Science Partnership (AMSP) was a five-year project (beginning in 2002), funded by the National Science Foundation (NSF) grant number DUE-0227028. The conference, *Voices of the AMSP*, brought together educators and researchers involved in the AMSP effort to share the stories and lessons learned from this project.

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INTRODUCTION

On December 3rd and 4th of 2010, a two-day reflective conference was held in Lexington, Kentucky. The conference was organized by the Appalachian Math Science Partnership (AMSP),[1] a project funded by the National Science Foundation (NSF) in 2002, and one of the first and largest of the "comprehensive" grants awarded under the Math Science Partnership (MSP) program.[2] The conference, *Voices of the AMSP*, brought together educators and researchers involved in the AMSP effort to share the stories and lessons learned from this ambitious project. Over the course of two days, over 40 participants shared the countless ways in which the AMSP project has influenced their work in improving STEM education in the region.

Inverness Research has served as the external evaluator to the AMSP project since its inception,[3] and attended the conference as documenters. In this monograph, we utilize some of the many experiences recounted at the conference to tell the story of the AMSP as an improvement community.[4] This monograph is not meant to be a comprehensive recounting of the AMSP project in detail. Rather, this monograph uses the concrete and very real examples that emerged from the conference to illuminate the ways in which the AMSP project, as part of a cumulative investment that built on other STEM education initiatives in the region, has contributed to the educational improvement capital in Appalachia.

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[1] For more information on the AMSP, see http://www.ms.uky.edu/~chair/outreach/amsp_public.html.
[2] For more on the MSP program within NSF, see http://www.nsf.gov/ehr/MSP.
[3] Inverness Research served as the external evaluator for the AMSP. For more information on Inverness Research and our evaluation of the AMSP, see http://www.inverness-research.org.
[4] The concept of an "improvement infrastructure" was invented by Douglas Engelbart. Engelbart is interested in ways to improve the collective knowledge and information-gathering operations of individuals and institutions. For more about Engelbart, see http://dougengelbart.org.

BACKGROUND

The Educational Context of Appalachia

The AMSP project has worked in a challenging context. AMSP focused its work on some of the poorest counties in the nation: of the 77 counties classified by the Appalachian Regional Commission (ARC)[5] as "distressed", 32 are in eastern Kentucky and 25 are designated AMSP counties. In these areas, poverty rates are double the national average, with income rates ranging from 62-81% of the national average and one-third of children living below the poverty level. A recent article reporting on areas of persistently high child poverty noted, "There are large and enduring concentrations of child poverty in Appalachia..." (Mattingly and Johnson, 2011).

Another area of challenge for the project has been in navigating an Appalachian value system that has been shaped by geographic isolation. The mountainous geography of the region creates pockets of communities and rural school systems that are small and separated from one another (Marcum, 2008). In a 2004 article from the *Journal of Research in Rural Education*, "In many areas of Appalachia, generations of physical isolation have resulted in an ethic of self-reliance and independence, an ethic that is often manifested in resistance to mandates from governmental and social services agencies. For these reasons, and because poor rural areas have historically received little attention from the federal government, many Appalachians continue to have limited access to, and participation in, education...." (Woodrum, 2004).

In this region, as Alan DeYoung, Lee Todd, Jr., and several other conference presenters indicated, education is viewed with some skepticism, as it is perceived as opening up distant opportunities and therefore luring young people away from their relationships and homes, where work needs to be done. Often, higher education is seen as the exporter of the best and brightest, which is undesirable for communities that are already poorly resourced and have little support. Thus, students in poor rural areas are typically low achieving and have limited aspirations for themselves, not imagining college as a place where they can be or want to be successful (St. John and Allen, 2008). "Real work" is often seen as physical work by those in the region—boys often

[5] See http://www.arc.gov.

plan to be truck drivers or miners like their fathers, and girls often plan to be mothers, secretaries, or nurses—all of which are important but limiting ambitions.

There is also a tendency for people within cultures of poverty to have a traditional, estranged, and hierarchical view of education, where the teachers' and superintendent's authority is quite strong, and the positions are often filled by people who are outsiders to the community, or "elites" viewed as the "professional class" (Woodrum, 2004). Attracting and maintaining a stable teacher workforce is a formidable challenge, and particularly impacts the areas of math and science: rural schools have a more difficult time attracting and retaining qualified teachers, and thus, offer fewer advanced math and science courses (Boyer, 2006).

Investment in Education in the Appalachian Region

Over the past several decades, NSF has invested in multiple systemic improvement efforts in science, technology, engineering, and mathematics (STEM) education in Appalachia. This NSF-funded portfolio of complementary, cumulative investment—totaling some $67 million dollars over multiple initiatives across six states—seeks to strengthen math and science education in the Appalachian region.[6] Originally, the AMSP was funded at $22.4 million over five years through the Math Science Partnership (MSP) program at NSF, and with three small supplement grants (bringing the total over ten years to $25 million), it has sustained itself for ten years. In total, it has involved 56 school districts and nine institutions of higher education (IHEs) in Kentucky, Tennessee, Virginia, and West Virginia. The MSPs are a series of multi-year, math- and science-focused, educational improvement grants first awarded by the National Science Foundation in 2002. By design, the NSF's MSP programs have funded innovative, collaborative, and targeted partnerships among K-12 institutions, IHEs, and community organizations aimed at achieving common educational goals. Typically, MSP programs involve both research and development to improve the achievement levels of all K-12 students and reduce achievement gaps in STEM among diverse student populations.

[6] For more on NSF's investment in the region, see Appendix A in Inverness Research's report on the AMSP from January 2008: http://www.inverness-research.org/reports/2008-01-Rpt-AMSP-UmbrellaFINAL.pdf

From the outset, the AMSP was designed to build on the previous investments NSF had made in the region, enhancing and extending the work that had been done to date, through uniting teachers, administrators, guidance counselors, and parents in local schools with leaders and faculty at regional colleges and universities. With the goal to eliminate the achievement gap in science and mathematics in Central Appalachia, AMSP sought to build an integrated elementary, secondary, and higher education system in this underserved region.[7]

THE CONTRIBUTIONS OF AMSP TO EDUCATIONAL CAPITAL IN THE REGION

AMSP made a simultaneous investment in people, and in tools and structures that empowered these people, to improve STEM education in Appalachia. AMSP has made a systematic and critical contribution to the educational capital in the region. Educational capital refers to working assets that support the ongoing, steady work of educational improvement. AMSP has generated multiple forms of educational capital; in this monograph, we focus on exploring the forms that seem most relevant to the unique Appalachian context—human, social, knowledge, financial/political, and cultural capital. We illustrate the development of these forms of capital with quotes from conference sessions and a writing exercise that was part of the conference, and with longer vignettes. The vignettes, in particular, are highly individual stories that are illustrative of many similar stories throughout the region.

Human Capital

Generally, human capital is defined as the attributes gained by a participant or set of participants, through education and experience: the stock of competencies, knowledge, and personality attributes embodied in the ability to do work, so as to produce value (economic, political, educational, etc.). Economists regard expenditures on education, training, medical care and so on as an investment in human capital—referred to as such because people cannot be separated from their knowledge, skills, health, or values in the way they can be separated from their

[7] AMSP project leaders had to be strategic in ensuring that their efforts would build on (and not duplicate) the cumulative efforts of other projects, envisioning the project as a mechanism for extending NSF's longstanding investments and catalyzing additional efforts in the region.

financial and physical assets. Any improvement effort is stronger when there are individuals (human capital) who have the capacity not only to work in their field but also contribute to its improvement.

In the case of the AMSP, human capital refers to *local* assets, including but not limited to: leading administrators, teachers and faculty who are skilled in strategy, curriculum, professional development, assessment, research and equity issues; collectively, these are indigenous leaders who have acquired additional knowledge and skills to guide STEM improvement in the region.

This human capital, along with social capital, which is discussed in the next section, is a particularly important form of capital in Appalachia. The AMSP, and many of the previous investments in STEM education improvement in the region, have helped to grow an impressive corps of people at all levels of the K-16 system in the region that are skilled and well positioned to sustain and evolve improvement efforts into the future.

Individual Improvement Across the K-16 System

During the *Voices of the AMSP* conference, we heard many stories of individuals at all levels of the system—from local teachers, to district administrators, to university faculty—who have been empowered by their participation in the AMSP project to grow personally and professionally, and to take on leadership roles in the region. As the former co-PI of the AMSP project reported:

> *Educators at all levels of the system have been empowered—teachers, school administrators, district supervisors, administrators, parents and students. Improvement is no longer a function of "leadership," since leadership has been expanded to include all who have an investment in the program.*

What is most compelling about these accounts is how much the growth of student interest in, understanding of, and success in STEM is actually driving the work of the leaders at all levels of the system. Through their participation in the AMSP and their work with colleagues, teachers and other school leaders have developed the skills and expertise to respond appropriately to students' needs. As two participating teachers recalled:

> *I have been teaching 19 years, four of those at the college level. I always felt comfortable with my*

> *teaching, doing what I was supposed to do as a teacher and I was blessed to join this program. It opened my eyes. It is so important to collaborate with other teachers and discuss how differently children learn. Before, I was teaching according to my own learning style. The tools and resources we got in AMSP, we implement in our schools, and we see major results.*
>
> *I have been to so many wonderful conferences. I was so much of a traditional teacher before I was allowed to participate in this program. I think more and plan differently now, and think about different learning styles of kids. I'm a more thoughtful teacher. I have to brag about our school. On the CATS assessment, we've had an 11-point jump, and on the ACT, a 1.5-point improvement. I do attribute a lot of that to this program. We meet and share and talk about this. I can't be more thankful than I am today.*

And as a Superintendent of Schools noted:

> *I'm going to say we had good teachers. We had good principals. But where we needed to be was at the great level and we were not there. I want to quote from one of these teachers: "I had a broken pedagogy but I didn't know it. I thought I was one of the best until I went to the AMSP summer institute and learned about inquiry. I had a 2-3% increase in grades from year to year. After I went to this science program, I could see 25% better grades." Both of those teachers who participated in the AMSP summer institute went on to become master or mentor teachers. Their classrooms improved. AMSP projected us from grass-roots level to the outer area of student achievement.*

The previous statements are illustrative of specific ways in which human capital has been developed through the AMSP. They are indicative of teachers engaging in new student-centered pedagogical approaches and displaying more sensitivity to student learning, rather than simply continuing their past practice. These reports also show how open AMSP participants have been to change; for example, these teachers were open to building their own capacity as educators.

K-12 Teachers and Leadership

Teachers have been empowered through the AMSP in many ways, from changes they have made in their classrooms, to collaborating on equal footing with university faculty, to leadership positions in their districts and region that extend their work out to others. The development of human capital in local communities for improving STEM education has been a vital outcome of the AMSP and its predecessor projects. Beginning with the Appalachian Rural Systemic Initiative (ARSI) and its work with teacher partners and with the lead teachers who worked in local communities, AMSP has taken a flexible and responsive approach to serving districts at very different points in their development. Teacher leadership is now being developed through the derivative Master Teacher program[8] developed in later years by the AMSP. One Instructional Supervisor and Teacher Partner described the cumulative growth in teacher leadership in Appalachia that has been as a result of persistent efforts:

> *Over the years, many of our teachers have been participants in the many ARSI/AMSP initiatives. These folks have grown into both school and district leaders whose newly-gained insights and knowledge have been shared with colleagues.*

One administrator from a district that has been a highly active participant in the AMSP described how transformative the project has been, in terms of everyone's perceptions of teacher leadership. Her comment exemplifies how teacher leadership can catalyze future improvements and contribute to additional investments:

> *AMSP has been an inspiration for me to aspire to lead. I see that "My" ideas are worth talking about and doing and sharing. These ideas promoted by AMSP inspired teachers to take leadership positions, to write for additional grant funding, to take college courses, to advocate for whatever they felt like they need.*

Many, if not most, of the AMSP project's key elements and structures have contributed to the development of teachers in the region. The Master Teacher program was one project element

[8] For more on the Master Teacher program, see http://www.uky.edu/P12MathScience/Grant_funded/MT.html.

highlighted in multiple teachers' accounts as empowering, and contributing to the ongoing development of human capital in the region:

> *I used to be discouraged that the good work of the AMSP would end when the money ended, but now I'm confident that some powerful seeds have been planted in terms of the capacity for growth developed in the ATPs (Appalachian Teacher Partners or Master Teachers).*

> *As a result of the current Master Teacher program, investment was made in one teacher (myself) and the rest of the department is now joining me in implementing standards-based curriculum, assessment for learning (formative assessments) and differentiation based on need and learning styles. This is so true to the extent that the other teachers are now collaborating on this work in my (the "Master Teacher") absence.*

One teacher at the *Voices of the AMSP* conference eloquently explained her evolution from examining and changing her individual teaching, to her department-wide work improving math and science education in her school, to her leadership work that extends throughout the region:

> *Being involved with AMSP made me start focusing on what students were learning. Before that, we spent a lot of time focusing on what we were teaching. AMSP laid the foundation for the math and science departments at my high school to be leaders in the improvement of student learning.*

The following teacher's story also illustrates the cumulative capacity-building of multiple projects over time:

> *I started to get interested in science education when I participated in the PIMSER[9] project as a young teacher. Prior to that, I had little background in science content and was wary of teaching. As a result of learning through inquiry and about inquiry as a*

[9] PIMSER is the Partnership Institute for Math and Science Education Reform at the University of Kentucky, established by AMSP to sustain its influence in the region. For more on PIMSER, see www.uky.edu/pimser/about/mission.php.

> *'method' of teaching, I became focused on science education, so much so that I obtained my Ed.D. in science education. My continuation in AMSP projects continued through ARSI and PIMSER, and I am now an ATP. I work for the Kentucky Department of Education as a network facilitator to build capacity in mathematics leadership in the southeastern Kentucky region. I see the roots of Kentucky's network vision in AMSP initiatives and appreciate the opportunity to learn from AMSP's successes and mistakes to develop a statewide plan of action for investments in STEM initiatives.*

The two quotations above demonstrate that the AMSP not only resulted in increased leadership as human capital, but it also involved shifting professional perspective and overall pedagogical purpose as human capital development. Changing from focusing on teaching to focusing on learning is a deep shift in how a teacher conceptualizes her work and role. While human capital is often assumed to be additive—meaning adding new or more skills and roles—in this case, it is really a changed notion of what teaching is all about, as well as adding new roles and skills.

The following vignette illustrates the powerful impact the Master Teacher program had on one veteran math teacher. It represents one of many examples, from every state participating in the AMSP, of the project's impact on teachers.

Teacher Leader Vignette:
The Master Teacher Program as Vehicle for Developing Human Capital
Robert Allen: Martin County, Kentucky

Robert Allen is a veteran K-12 teacher who has taught high school math for the past 16 years in Inez, Kentucky and who joined the Master Teacher program in 2009. He described himself prior to joining the Master Teacher program as being "in a teacher slump."

> *I didn't look forward to teaching or going to school. I had checked into early retirement. Teaching had become 'stand and deliver' and 'hope and pray'. It was routine and boring for me and my kids. I had accepted that 25% of my students would fail, and that it was not my fault.*

When he joined the Master Teacher program, he didn't know anything about AMSP or PIMSER. He was surprised to find himself amongst a group of teachers from across the region who were not complaining or griping, but rather were focused on becoming better teachers. Throughout his involvement with the Master Teacher program, he learned a great deal about formative assessment and standards-based grading, and he thought he could implement these in his high school math class.

> *Such a compelling idea—assess students on learning targets; grade students solely on the learning targets; give students the option of re-studying and re-testing on targets they hadn't learned... It was the first time I thought of my students that it was never too late for them to learn.*

He took the research to his principal, who was skeptical about it at first. So Robert initiated an experiment. The first nine weeks of class, he taught and graded in the traditional way, with the end result of 21 students out of 131 failing. The second nine weeks, Robert implemented standards-based grading, and at the end of that nine weeks, only three students were failing. By the end of the school year, only one student failed.

As part of his work with the Master Teacher program, Robert also started working to implement learning styles from Harvey Silver's Thoughtful Classroom work, which he said has helped to deepen his students' understanding around the learning targets. He has seen major growth in his students' average mathematics scores and an improvement in their ACT scores as well.

Robert took all of this new data to the principal who became convinced and excited, and encouraged Robert to share what he was doing and learning in a meeting with the rest of the staff. Robert has been working with teachers during professional learning community meeting times, talking about formative assessments. He is also now part of the district's leadership team, planning future professional development sessions. Additionally, he is collaborating with a special education teacher to implement these strategies with her students.

The impact on Robert of participating in the Master Teacher program has been profound, not only for him, but for his students and his school.

> *I am excited to teach again. My students love standards-based grading. Their parents are happy. The administration at my school is happy. But the most important thing is that ALL of my students are learning.*

The previous example underscores the value of investing in people as well as in systems; the system is made of people who carry their perspectives and skills into multiple areas of the system.

University Faculty

Multiple stories of the professional development of university faculty—through collaboration with other IHE faculty and with K-12 teachers—emerged at the conference. University faculty continue to drive educational improvement efforts in the region through the improved courses they teach, the preservice teachers they reach, their interactions with K-12 teachers and district administrators in local projects to improve teaching and learning, and the faculty positions established through the project, such as the Outreach Professors program at the University of Kentucky. As one faculty member from UK noted,

> *I <u>am</u> the capital investment for AMSP. I am STEM faculty and had no previous experience with K-12 education. I learned so much. This experience has changed how I teach, the university initiatives in which I participate, and the scholarly activities in which I engage.*

Another IHE faculty member recalled,

> *As a direct consequence of my involvement with AMSP, I have been able to impact the preparation of countless teachers in ways that should produce meaningful and lasting benefits.*

University Faculty Vignette
Involvement of Higher Education Faculty in Multiple, Collaborative Roles Builds Human Capital
Robert Arts: University of Pikeville

Robert Arts is a physics professor at the University of Pikeville. Over the course of five years, Robert was extensively involved in the AMSP project, participating in the development of courses, serving as an instructor at summer institutes, and participating in a Partnership Enhancement Program (PEP) project in Letcher County, Kentucky. In addition, he drew from his AMSP work in his doctoral dissertation research.

Two AMSP experiences were particularly profound for Robert. One was the creation of a pilot course in 2004, Physics 102, which is a required course for elementary and middle school pre-service teachers. The course grew out of the AMSP work, and is all "inquiry-based, no lecture, all hands-on." Robert described it as a "totally learner-centered environment." This course is still being taught at Pikeville College, and helps teachers-to-be in the region to better understand physics, and to learn it in a way that they will hopefully come to teach it in their classrooms as well.

The second experience was Robert's involvement in the PEP project, which included AMSP participants from Floyd, Knott, and Letcher Counties, and faculty from the University of Pikeville and the University of Virginia at Wise. This group of individuals formed a partnership to draw on their AMSP experiences and develop a curriculum resource to help spread effective instructional practices to teachers in these counties who, thus far, had not engaged with the AMSP.

Thus, Robert embodies human capital, which continues to reach pre-service teachers through not only the courses Robert teaches, but through the courses he helped develop that others teach. Additionally, he is human capital that continues to reach out to teachers in the region and partner with them in innovative ways to share effective methods for teaching math and science.

Robert had this to say about the impact of the AMSP:

> *AMSP changed my life. I've had the opportunity to be out in the schools and be more actively involved with what's happening there. I've had the opportunity to finish my doctorate. I've totally revised my courses and those courses are still in the college catalog.*

Students

The AMSP project had both a direct and indirect impact on the region's students, building the human capital of the young people of Appalachia. Through direct experiences—like the project's College Reality Store program that invited high school students to spend time on college campuses—to the indirect benefit of students having enriched science and mathematics learning experiences in the classrooms of teachers and faculty who participated in AMSP professional development, students' understanding of science and math concepts, their knowledge of what it takes to continue to study math and science in college, and their self-efficacy related to math and science were all enhanced through the project. As the Director of College Admissions at one of the participating AMSP IHE's noted:

> *AMSP was incredibly important in helping students in our region to begin to see themselves in college. I come back to the quote that I use a lot and that is "kids can't want what they don't know" and the AMSP program helped kids in our region to know more about college and to begin to picture themselves on a college campus. In an area where a culture of higher education doesn't exist, AMSP helped as the corner stone in building a culture of higher education in far southwestern Virginia.*

During the conference, numerous examples of the contributions of the project to students were shared by participants, ranging from specific examples of students' ability to reach specific learning targets, to improved performance on state and national exams. For example, state data from Virginia, provided by the AMSP, shows a steady increase among AMSP participating schools in meeting the Standards of Learning in mathematics and science over the past three years.

We also heard several compelling examples of rich science and mathematics experiences for students, facilitated by the AMSP project. The following vignette from Anderson County, Tennessee illustrates the powerful impact of a Partnership Enhancement Project (PEP) grant from the AMSP that created a school yard wetlands, and a whole-school immersion in science.

Human Capital Vignette
Students and Teachers in Anderson County, Tennessee
Restore a Wetland

After two previous and successful PEP grants that involved lesson studies in mathematics and science curriculum development, Anderson County applied for and received a PEP grant to create a school yard wetlands. At the *Voices of the AMSP* conference, John Byrd, a retired teacher of 31 years and current science consultant for Anderson country Schools, shared the story of how AMSP funds helped form a partnership at the Anderson County schools that turned an unused portion of the school grounds into wetlands for students to study:

> *We had a playground and a lot of space being unused that we were spending a lot of money mowing. We also had a lot of water coming off the parking lot that we were just trying to shoot as far away from us as fast as possible. So we used the PEP grant to create a wetland, and that turned into a total school yard landscape design and water management strategy.*

Teachers, engineers and ecologists collaborated on the project, and students have been involved in every stage of the project: from surveying the land and installing the liner, to seeding, to planning the wetland vegetation, and studying the resulting wetland habitat. The result—the Anderson County School Yard Wetlands and Natural Areas project—is a resource that provides "tremendous biodiversity" for the students and teachers to study. As John said,

> *I'm pretty sure that every major biological concept could be taught right there.*

And as Denise Wilburn from Anderson County noted:

> *Our pre-K students can actually do scientific fieldwork. The students are surveying the schoolyard using real tools. Not only are they creating an ecosystem, they are also solving water run-off problems. They are talking to us already as scientists.*

Byrd reported that the project increased students' understanding of the importance of wetland habitats, and rekindled their excitement and appreciation for the biodiversity of Anderson County.

The schoolyard wetlands vignette illuminates the investment of AMSP in the development of human capital in the form of knowledgeable, informed students who experience the power of doing and learning science in an authentic setting, and engaged in real-life problem solving.

Knowledge Capital

Knowledge capital is a form of capital that overlaps with human capital and it exists in two ways: first within the minds of the people who know something useful that will make their work on STEM reform more productive. Second, knowledge capital exists as independent and shareable content. In this sense, content is the formal 'written-down' documented expression of knowledge capital. In general, knowledge capital is a concept that asserts that knowledge has intrinsic value, which can be shared and leveraged within and between individuals and organizations. Knowledge capital has value to the extent that the sharing of significant educational knowledge is a means of empowerment. These ideas and skills include formal conceptual and disciplinary knowledge but also craft knowledge—the know-how that results from the experience of individuals within an organization or group. Possibly the most important sources of knowledge capital are education (Clayton, 2009), research, and practical experience (such as knowing about effective STEM instruction or about the particular needs of a unique community).

Knowledge capital includes ideas, knowledge sharing, and dissemination. The AMSP contributed to a wealth of knowledge about effective instructional practices in STEM, and about the organizational structures needed to develop, evolve, and distribute an educational improvement infrastructure that spans numerous agencies and districts, and a large, complicated geographical area. Importantly, the AMSP has generated and contributed essential and critical knowledge about the unique challenges of rural education in Appalachia and how to improve it.

Other specific examples of the knowledge gained and produced through the AMSP project include how to design and implement in-person and online courses for teachers in inquiry-based methodology, how to effectively mentor teachers, and how to design and implement effective science and math experiences for students. The AMSP has disseminated that knowledge broadly throughout the region through the structures, partnerships, networks, and collaborations the project established.

Knowledge Capital Vignette
Building Knowledge at All Levels of the System –
Anderson County, Tennessee

Denise Wilburn, the Director of Federal Projects for the Anderson County School Board of Education, has described the extensive involvement of Anderson County, Tennessee in the AMSP from 2003 to 2010, and said there were only one or two program elements that they did not participate in. She has also shared a list of positive outcomes of Anderson's participation, including: better conceptual understanding for students and teachers; more instructional time in K-8 mathematics and science; a systemic professional development plan for the county teachers' system-wide mathematics coordinator; a specialized science consultant; the adoption of STC curriculum kits; the adoption of Connected Math in grades 6-8; the development of school yard wetlands in six of nine elementary schools in the county; and stronger University of Tennessee participation through the Anderson County Regional Professional Development Center.

All of this contributed to the development of several forms of knowledge capital, including at the school and teacher levels. At the school level, knowledge improved around how to structure instructional time in math and science; how to provide space for teachers to plan and reflect together; how to provide professional development opportunities; how to partner with the University of Tennessee; how to undergo thoughtful curriculum adoption (resulting in STC kits and Connected Math); and how to coordinate K-8 instruction (including a school yard wetlands project in six of nine elementary schools).

Teachers developed a deeper conceptual understanding of the content they were teaching, learned how to better assess their students' understanding, and came to appreciate the possibilities inherent in partnering with each other and with a university partner. This was particularly evident in one teacher's description of how the K-12 teachers' interactions with the university faculty have evolved:

> *Now we learn from each other. We developed a regional professional development center and the University is our partner in that. All incoming elementary teachers will be part of this process so that they understand math and science, they like it, and they know how to really teach it.*

Social Capital

Another important form of capital, particularly in this region, is the development of social capital. Generally speaking, social capital is the value derived from strategic alliances—that is, relationships built around and in support of common work and shared self-interest. It is "the aggregate of the actual or potential resources which are linked to the possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (Bourdieu, 1972). Social capital

can exist at an institutional level and at a personal level, and refers to connections within and between social networks. Social networks contribute to the productivity of individuals and groups. In other words, social capital refers to personal and institutional connections, the internal and external relationships and communities of practice that lead to the creation of an improvement community.

Notably, the AMSP fostered the creation of ongoing social capital through taking the notion of "partnerships" very seriously. The project created communities of collaborators throughout Appalachia, among teachers, IHE administrators, and IHE faculty. These strong relationships and networks remain in place. One university faculty member who served as a panelist during the conference shared an example of the social capital developed among teachers in the region:

> *One interesting thing I thought of for our teachers—they were very isolated and very rarely had an opportunity to share their professional practice before the project. But afterward there are these incredible networks. As I've heard from teachers in ASMP, the way they were able to bring their practice out and share it with others has been very exciting to me.*

Conference participants highlighted other varied forms of social capital as well:

- High school teachers are networking with teachers and faculty of UK and MSU throughout the region.
- Teachers no longer work in isolation; they collaborate with peers and IHE professors.
- Teachers have formed collaborative relationships with colleagues who have since also become friends.

The AMSP also helped to create permanent and strategic structures to enable the work of those empowered through AMSP activities to be of service to the region—through a durable network—for many years to come. One such structure is the creation of the outreach professor position in several of the participating IHEs. The outreach professor is a position that is essentially charged with establishing and maintaining the working relationships that are needed to continue the work of reform in the region. Over time, the AMSP benefited from many different university faculty members doing outreach or serving as

outreach professors from its IHE partners: the University of Kentucky, Morehead State University, the University of Tennessee at Knoxville, Eastern Kentucky University, the University of Virginia at WISE, and the University of Pikeville. Whether or not AMSP leaders and participants referred to these structures as building social capital, they were very intentional about doing so.

Several conference participants noted this as an example of how the AMSP contributed to the development of social capital:

> *At the university level, the creation of the outreach professor positions…once created, the math outreach professor has become a permanent role in the department.*

> *I believe that the primary contribution has been the institutionalization of outreach or engagement. At the beginning of AMSP, there was at UK (at least in Arts and Sciences) no institutional sense of obligation or value to such activity. The AMSP has completely changed this, with outreach/engagement recognized, expected and rewarded.*

The following vignette highlights the work of faculty members from three IHE partners in three different subjects areas who have sustained connections in the region made through their participation in the AMSP.

Social Capital Vignette
Connecting IHE Faculty: Carol Wymer, Morehead State University; Martin Brock, Eastern Kentucky University (EKU); and Jennifer Wilson, University of Virginia's College at Wise (UVA-Wise)

The three professors we are highlighting here have been highly active in the AMSP project, participating in collaborative course development teams with K-12 faculty, providing instruction at summer institutes, and actively participating in PEPs. Carol Wymer is a biology professor at Morehead State University; Martin Brock is a chemistry professor at Eastern Kentucky University; and Jennifer Wilson is a mathematics education professor at UVA-Wise. All three of these professors reported that participating in the AMSP project had a profound impact on their own teaching—the content and activities that made up their courses, their sources of inspiration, and the approaches they used in their teaching (more hands-on). As importantly, all three professors through their work with the AMSP engaged in meaningful collaborations that have continued and evolved over the past ten years. As Martin Brock noted,

> *I have had extensive contact with teachers, schools and other education professionals in Eastern Kentucky. They make up my extended professional learning community.*

Carol Wymer noted that since her participation in AMSP, her scholarly interests have changed to focus on K-12 education, and she continues to partner with area teachers on other NSF-funded projects focused on elementary, middle and high school science education improvements. She noted:

> *I had no previous experience with K-12 education and I learned so much [through the AMSP]. This experience has changed how I teach, the university initiatives in which I participate, and the scholarly activities in which I engage. I feel connected to the region, and to others that can support STEM education improvements in the region.*

Jennifer Wilson has been an active participant in the AMSP summer institutes and in Partnership Enhancement Program (PEP) grants throughout the region, partnering with local school districts—both activities that have directly influenced the development of the Mathematics Concentration for the Bachelor of Arts in Liberal Arts and Sciences (a major designed for students seeking an elementary education endorsement to teach at the PreK-6 level).

As the above vignette highlights, the development of social capital in Appalachia, where individual relationships and connections are key, has been an important lasting contribution of the project.

Another structure that has been key to the development of social capital in the region has been the PEP grants. Created by the AMSP in Year 2 of the initial grant, the PEPs are an excellent example of an AMSP structure that has helped to continually

increase social capital in the region. PEPs are small investments (of a maximum of $30,000) to initiate partnerships among schools, districts, and with IHEs, for improvement across all levels of the educational system, while addressing locally identified needs of the K-12 partner districts. The PEPs were primarily intended not only to have an impact on local students and teaching communities, but also to help foster connections that could outlive the NSF funding period—an important step toward sustainability. The majority of the PEPs were teacher professional development and school improvement programs, although a few included elements of pre-service and research programs.

The following vignette illustrates the development of social capital through a PEP grant in West Virginia around place-based teaching and learning.

Social Capital Vignette
The Power of Place and Connections in West Virginia

The AMSP PEP connected Marshall University and teachers in several counties in West Virginia in a project focused on developing interdisciplinary place-based projects. Steve Beckelhimer and Michael Little from Marshall University presented about how they and the teachers worked together to help students better know places throughout West Virginia utilizing technology. One example they shared was a group of middle school teachers in Cabell County who attended an AMSP professional development session on using Google Earth and other software to integrate the study of math and science with the study of history and social studies related to places. This group of teachers, with the support of Marshall faculty, visited locations around the state to document the history, geology, biology and other content at these locations, and using mathematics, to map them. For each location, they created a place mark that included the latitude and longitude, geology, trees, history, etc., creating an online textbook for the state with hyperlinks for each location that are accessible to all teachers throughout the state. From the Marshall AMSP website, teachers throughout the state can access handouts and materials that help them utilize what other teachers have created, and add to that database through work of their own and their students.

The above vignette demonstrates the social capital created through the AMSP: a connected study of place among teachers and faculty that serves not only the teachers and faculty who helped to create it, but also as a resource to other teachers throughout West Virginia.

Another example of social capital fostered through the AMSP was in the connections made among federally-funded projects. As we

mentioned in the background section of this report, there have been numerous large-scale federal investments in the region aimed at improving math and science teaching and learning, with the AMSP being one of the largest. During the conference, Diane Tomlinson and Barbara Willis presented about the Working to Improve Systemic Education (W.I.S.E.) Council—formed in Virginia after the AMSP had been in place for some time—that connected key stakeholders from schools and universities who had the common goal of improving science and math education. Through working together and creating common goals, they were able to identify overlaps and gaps among programs and focus on key areas of need. As Willis noted during the conference,

> *It was the perfect partnership. We weren't pooling resources, we were pooling people.*

Finally, much of the social capital built through the AMSP relied on another key structure—the position of the Regional Coordinators. The four Regional Coordinators—Kathy Strunk, Debbie Owens, Judy Compton, and Robin McDonald—worked tirelessly throughout the AMSP project to make or leverage existing connections between districts, and between districts and IHEs. The Regional Coordinators knew the needs of the local counties, schools and districts with which they worked quite well, but they also knew well the broader reform landscape of the region, as well as the whole of the AMSP. This allowed them to broker relationships among counties with similar needs, and make connections to the appropriate IHE faculty. Thus, the Regional Coordinators were key in linking counties to a vast network of resources and in shepherding local reform efforts, oftentimes through connections to other teachers, university faculty, and leaders in the broader Appalachian region.

Financial and Political Capital

The AMSP is a prime example of how successful projects build future successful projects. Through this project, the partners built financial and political capital that was leveraged to accrue even more financial and political capital. Financial capital refers to the level and diversity of financial resources that are available to an organization to build its own capacity for doing work. It provides resources for the acquisition or creation of other forms of real capital that are critical to the production of future goods and services—in other words, it also refers to the capacity of a group to garner additional and future financial resources. Political capital refers to the ability to form alliances that gain

power for positive changes or to influence policy. In the case of the AMSP, financial and political capital describes the resources and the *imprimatur* to solidify and build STEM educational improvement efforts in rural Appalachia.

Through the AMSP project and associated projects in the region, those involved were able to cumulatively develop the financial and political capital of Appalachia. Successful projects have led to continued and additional funding opportunities. During the *Voices of the AMSP* conference, James Hamos, NSF's MSP program director, provided his perspective on the origins and history of the MSP program which launched in 2002 as a result of the No Child Left Behind legislation. Due to the continued success of projects such as the AMSP, the MSP program was "strongly reauthorized" as part of the America Competes Act of 2007 and 2010, and was included as part of the American Recovery and Reinvestment Act of 2009. In addition, other presenters provided examples of how corporations such as DuPont and Toyota had sponsored additional work in Appalachia, once they saw the positive outcomes of previous efforts.

Political Capital Vignette
AMSP's Influence on Education Policy in Kentucky – Terry Hibpshman and Steve Clements

In Year Five of the AMSP, project leaders commissioned a study of policy considerations relevant to participation in AMSP by Kentucky schools and districts. Terry Hibpshman (then with the Kentucky Education Professional Standards Board and currently with the University of Kentucky) and Steve Clements (then with the University of Kentucky and now with Asbury University) interviewed staff in AMSP participating districts about the local policy barriers that might prevent greater reach and implementation of AMSP activities. One of the key findings from their study was that one of the greatest barriers was the state policy that ordained local schools and districts to determine their professional development activities. This "laissez faire professional development landscape in Kentucky" resulted in great variation in the types and quality of professional development offered, and great variation as to the extent to which local schools and districts were being thoughtful and intentional in their choice of professional development or not. As Clements and Hibpshman stated in their report:

> *This leads to a tremendous amount of variation in the types and quality of PD for teachers, and a very diffuse market environment. Some teachers seek out easy and available PD, or make choices based on which of their friends will be attending certain sessions. Teachers, schools, and districts will often develop close relationships with specific PD providers. Some schools make very coherent, deliberate, and informed decisions about PD, whereas others allow teachers to choose PD independently. Some districts work closely with cooperatives or KDE, but others do not. The variation here is to us quite stunning, and is the result of state policies that ordain localism in the selection of PD opportunities.*[10]

The variation among the districts was antithetical to what the Kentucky Reform Act of 1990 had intended, and to the type of systemic change the AMSP was attempting to promote through its professional development. AMSP leaders shared this research study report with Kentucky education leaders, which was utilized in addressing the nature of professional development in Kentucky.

Cultural Capital

Appalachia is a region with both unique history and characteristics. We see cultural capital as an intertwining of the human, knowledge, and social capital contextualized within this unique region. AMSP, and other NSF investment in the region, has fostered the development and continued support of indigenous capacity that understands well the nature of Appalachia, and is thus positioned to continue and extend the educational

[10] For the full report, see http://www2.research.uky.edu/amsp/pub/Annual%20Report%20-%20Year%205.pdf

improvement efforts. We see the development of this local capacity, grounded in the context and culture of the region—particularly in the form of indigenous leadership that has both the ability and the commitment to pursue further STEM improvements—as a key contribution of the AMSP and other NSF investments. As one teacher reflected:

> *The concept of building "indigenous capacity" in the participating schools and districts through the development of the teacher partner program is so powerful. Teachers have been recognized as leaders in their respective schools/districts, and the "culture of place" provides the space for them to influence others and change practice to benefit students. Their "culture of place" is not invaded by a "fly in, fly off, fly out" experts who's "not from around here." The power of this aspect of the program transcends everything else.*

And as one university professor noted:

> *When I started my AMSP-funded research in Eastern Kentucky, I met three high school students who were AMSP tutors. They couldn't tell me what or why they were doing the interaction with younger students, but they enjoyed the time out of study hall, and they thought reviewing middle school math was helpful to them in their high school math classes. One hoped it would improve her ACT score from the 16 she had earned. What they didn't notice is that they were talking about math, and teaching math, and learning math to and with someone not from their town in the context of their futures. This is a start—a difference with immeasurable benefits. I think AMSP does and should demonstrate the growth of cultural capital—the shifts in habits of those who choose or are placed in marginal (to the main) communities. Without the shift in cultural capital to appropriate values for STEM learning into local ways of knowing, AMSP or any other project will remain external to the region.*

Recalling the characteristics of the educational context of Appalachia that were described earlier in this report, it is critical that ownership of change and improvement be local, and that investment focuses strategically on developing cultural capital in these regions.

SUMMARY

The *Voices of the AMSP* conference was an important event for many reasons. Typically, participants in large projects such as these don't know the full extent of the work, or the contributions of, the project. Furthermore, the projects themselves don't often know how their work fits within the broader national improvement community. The *Voices of the AMSP* conference allowed participants to share their very personal stories of how the AMSP had impacted their personal and professional lives, and how they have, in turn, touched the lives of others in the region. Together, the five general and 33 concurrent conference sessions told an impressive story of a project that, while large in its scope, had managed to have both highly individual and large-scale impacts on STEM education in rural Appalachia.

As one former Superintendent in Appalachia reflected:

> *Through this process, the greatest reward is seeing teacher leaders teaching the way they should teach and students achieving in the way they should achieve. Because of the work we did with AMSP—and that the folks who evaluated this program helped turn our direction, rather than telling us at the end that we did it wrong—I was a much better superintendent recognizing that I could change things mid-stream. In rural America… Kentucky, Virginia, Tennessee… there are children out there who will excel if you give them the right tools.*

The AMSP built on the work of previous NSF investments in STEM education improvement in the region in important and significant ways. Over the past ten years, significant numbers of teachers, students, pre-service teachers, and IHE faculty have been touched by the project and these people have continued the work.

As we described in this monograph, in many ways the AMSP project built capital and empowered people at all levels of the system, and provided structures within which they could develop and share their work and knowledge with others in the region. As the *Voices of the AMSP* conference presenters illuminated, through complementary, sustained, cumulative initiatives over time, the investments in this region generated local capacity, which, in turn, has generated additional and broader capacity and improvement efforts. The AMSP created a regional networked improvement community (Englebart, 2003). This improvement community,

comprised of people, structures, tools, and resources—the forms of capital we have outlined in this monograph—is aimed at not only improving the teaching and learning experiences of science and math in one geographic region, but also at continuing to get better at improving math and science teaching and learning experiences more broadly.

The notion of networked improvement communities is one that is gaining prominence in discussions about education improvement for several reasons. As past research and development and research-to-practice efforts have had difficulty becoming realized within the varied contexts and situations that comprise the educational landscape, and localized practitioner-based improvement efforts have sometimes had difficulty scaling, the notions of networked improvement communities can be seen as the best of all worlds because the efforts of networked improvement communities are both powerful, and sensitive to context. In a recent Carnegie Perspectives essay, Anthony Bryk states, "We need design which explicitly aims to function in the hands of diverse individuals working in highly varied circumstances. We know all too well from past experiences that such contextual knowledge is not transferred easily across institutional lines to the academic labs or publishing companies where many educational tools and products currently are designed. In contrast, a network organizational approach can surface and test new insights and enable more fluid exchanges across contexts and traditional institutional boundaries—thus holding potential to enhance designing for scale" (Bryk, 2010).

The improvement community AMSP has created in the region is significant in many ways. AMSP has developed and operationalized capacity in the region to address an array of factors critical to the improvement of math and science teaching and learning. Because the foundational capital remains—the people, the knowledge, and the connections—the region is ripe for continued investment. Thus, the project has created an improvement community in Appalachia that is positioned to continue to grow, and continue to build on foundational work laid during the AMSP project and the work of previous investments.

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