

PROPOSAL NUMBER: 0227028

Lead Institution: University of Kentucky

Lead PI: Paul M. Eakin

Project Title: Appalachian Mathematics and Science Partnership

As previously discussed, NSF is following up with proposers as part of the merit review process of proposals submitted in response to the *Math and Science Partnership* program solicitation (NSF 02-061).

Reviewers of your proposal have raised a series of issues and concerns about the proposed activities. Consequently, we are requesting that you prepare a concise written response to the items below. **It is VERY important that you engage your entire partnership in crafting the response.** Your response should not exceed thirteen pages in standard 12-point type and must be forwarded to me by e-mail by **Friday, August 2, 2002.**

Please be advised that having reached this step in the review process is no assurance of funding.

Major Questions/Concerns:

1. **SHARED GOALS, SHARED RESPONSIBILITIES and SHARED ACCOUNTABILITY—** Please describe more fully how the core partners, that is the 52 Partner School Districts, the 10 Institutions of Higher Education (IHE), the Kentucky Science and Technology Corporation, and delineated regional agencies will participate as full Partners in shared design, implementation, and accountability of the four major components of the *AMSP* proposal, that is, Preservice Education, Professional Development and Leadership Training, Student Mathematics and Science Learning Opportunities, and Research Component.
2. **Engagement of Science, Mathematics, and Engineering Faculty—**For the above four major components of the *AMSP* proposal, (a) describe how scientists and mathematicians (and engineers if appropriate) will be substantively involved; (b) explain the institutional (10 IHEs) commitments to this involvement; and (c) in addition to mathematicians and scientists from the University of Kentucky, provide more information regarding scientists and other mathematicians who are committed to substantive involvement in *AMSP* from the other 9 Partner institutions.
3. **Governance and Leadership—**Give specifics as to how PreK-12 District personnel will participate fully in the leadership and governance of *AMSP*, beyond advice, feedback, and implementation.
4. **Institutional Change and Sustainability—**The proposal indicates two profound structural changes at one of the Partner IHEs, the two new tenured positions in mathematics and science related to Outreach and Public Service and the establishment of the “Partnership Institute for Mathematics and Science Reform,” both at the University of Kentucky. The proposal goes on to indicate a number of important outcomes (page 8) related to implementation of preservice programs, rigorous high school coursework policies and curricula, increased numbers of highly qualified instructional and leadership MST personnel, increased collaborations among partner entities, and additional IHE personnel for “outreach.” Give specifics as to the institutional changes that each partner (other 9 IHEs, 52 School Districts, the Kentucky Science and Technology Corporation, and delineated regional agencies) anticipate as a result of five years of support for the *AMSP*.

5. Going to Scale—*AMSP* proposes that each Partner District will identify one *AMSP* School to serve as a “baseline improvement site.” Please describe the mechanism and timeline for moving from the initial involvement of 52-baseline-improvement-site-schools to engaging all schools in the Partner Districts so that “No child is left behind.”
6. Incentives for Participation— How many teachers, principals, and counselors do you intend to engage in the various *AMSP* activities and what will compel them to participate? For example, the proposal indicates that currently in the Appalachian states, teachers are required to earn a Masters degree or equivalent within ten years of initial certification, however, “only a small fraction of teachers have earned this degree in their content area or have a strong content emphasis.” Further, some of the proposed certifications are not recognized by the states for enhanced financial reward, licensure, or teaching assignment.
7. Reasonable and Appropriate Benchmarks—Elaborate further on specific outcome numbers against baseline data for **each of the 4 components** and give a rationale for the reasonableness of these in terms of impact in addressing substantive needs within the *AMSP* region. For example, the proposal indicates that within the Partner Districts, 38% of the mathematics teachers and 37% of science teachers are teaching with a minor or less in their disciplinary teaching assignments. An *AMSP* proposed benchmark is to double the current number of students graduating with majors in mathematics, science, or science/mathematics education from 51 to 102 over the five years. How will this goal of 102 graduates impact the teacher quality/number (38%/37%) issue presented, particularly given that some of these majors in mathematics and science will choose careers in SMT other than teaching? Further, this graduation of 102 baccalaureate students represents a 25% graduation rate of the total proposed pool (30% increase of baseline 319 = 415). Is that an effective rate of production? Similarly, related to student enrollment in higher level science and mathematics courses, the proposed goal after five years is 64% and 44% of students enrolled in higher level mathematics and science respectively. No information is provided related to current success rate in these courses or proposed goal of course completion.
8. Recruitment, Induction, and Retention—Please describe further specifics regarding recruitment, induction, and retention strategies related to your proposed efforts to increase the number, quality and diversity of PreK-12 teachers of mathematics and science.
9. Quality of Prior Work—ARSI Lessons Learned—In regards to the seven years of effort in ARSI, give an indication of specific goals which were pursued but not fully realized, what the perceived barriers to achieving those goals were, and what strategies in the proposed *AMSP* are designed to ameliorate those issues. Further, on page 3 the proposal states “The model employed by ARSI has been successful in closing the gap in student achievement.....However, much remains to be done.” Please provide data related to progress in closing of the achievement gap over the past seven years.

AMSP Responses to Major Questions/Concerns

Response to Question 1: Shared Goals, Shared Responsibilities, and Shared Accountability

Throughout the proposal development process, partners from school districts and IHEs collaborated in putting forth ideas that represented their particular entities. In response

to the Major Questions/Concerns, partners convened again at two regional meetings to address these questions. The Morgan County meeting was co-hosted by Joe Dan Gold, Superintendent of Morgan County Schools and Gerald DeMoss, Morehead State University. The Whitley County meeting was hosted by the Whitley County School District. The partners reaffirmed their commitments (details of which are included in Appendix 13 of the original proposal) and provided additional input. The envisioned continuum of teaching and learning experiences is one focus of sharing. It promotes and requires the active and critical involvement of partners (teachers, administrators, students, MST faculty) at all levels. The following additional examples illustrate the reaffirmed shared goals, responsibilities, and accountability.

The administrative structure of the AMSP provides an effective mechanism for implementing the program, through representation of the partners in various groups and at different levels. Key components of this structure include: the AMSP management team, with the PI, Co-PIs, and representatives from AMSP Partners to reflect diverse institutional perspectives; the Initiative Advisory Councils, comprised of representatives of school districts and IHE partners; and District Science and Mathematics Leadership Teams, responsible for district-level and partner planning. The annual AMSP meetings will bring all AMSP partners together for review and assessment of progress in each initiative. Partners decided to elect representatives from district personnel who would serve on a rotating basis to attend these annual meetings.

The Lead Organization concept, as detailed in Appendix 12B of the original proposal, requires different IHEs to assume a leadership role in pre-service and in-service activities according to their experience and accomplishments. The mentored implementation process is a shared activity that is absolutely fundamental to AMSP. In it, teachers, IHE faculty (content and methods), principals, district administrators, and often parents collectively design, implement, and evaluate the new instructional activities through which the new ideas, methods, and tools actually come to bear on student learning.

The project design is built on the principle of shared responsibilities. The objectives, goals, and project activities laid out in the proposal provide the overall structure, while being general enough to allow for partner input across all components and across specific activities. Management teams and the representative structure provide the means for attaining this input. Further, all partners share in the development of courses, in-service training, and pre-service field experiences. At the recent regional meetings, for example, district partners reaffirmed their willingness to serve as pre-service mentors, to actively engage in restructuring pre-service training at the university level, and to team with university faculty to create professional development opportunities for math and science teachers. Participating school districts agreed to create a common in-service day calendar to enhance cooperative regional professional development experiences (Tennessee districts do not have that flexibility). Also IHE Partners agreed to work through the AMSP to coordinate and staff summer math and science camps for high school students.

Communication (technical and social) is key to achieving and sustaining the shared planning and implementation efforts. The AMSP communications infrastructure will provide the basis for collaboration, distance learning, materials, and information sharing in the AMSP. The District Science and Mathematics Leadership Teams serve as a conduit for communication among IHEs, district faculty, counselors, and administrators. Finally, the existing ARSI Resource Collaboratives at various IHE sites will be an additional means of communication.

Technology will also underlie the comprehensive on-line data collection system. Providing the data is a critical element of shared accountability, for which all partners have responsibility. The data collected by each individual district and partner IHE will form the basis for research outcomes on rural math and science education and the resulting foundation for future efforts. All partners will have an equal responsibility to communicate with each other on all initiatives.

Response to Question 2: Engagement of Science, Mathematics, and Engineering Faculty

In addition to the University of Kentucky faculty, each of the participating IHEs has at least four committed science and mathematics faculty who will be substantively involved in all four project components. Specific collaborative activities focus on development of courses that address the problem of inadequate teacher preparation. For instance, currently teacher certification is granted for science survey courses although they do not sufficiently prepare teachers for the content material they subsequently teach. Partners at all levels agree that more comprehensive course content must be made a part of the teacher certification path. To this end, faculty will engage in course development, implementation, and assessment. Many of the specific AMSP initiatives will be adapted from existing successful small-scale implementations at IHE partner institutions. For example, faculty at the partner institutions have agreed to teach and assess a local version of courses acquired through this Adaptation and Implementation (A&I) initiative. In this way, IHE partners collaborate to provide future model instructions offerings on a comprehensive scale.

Additionally, scientists and mathematicians will play key roles in developing and offering institutes for pre-service education, professional development and leadership training, and summer programs for high school students; expanding and coordinating dual credit courses, and increasing the quality and quantity of distance-learning courses. AMSP envisions teacher engagement in university labs and classrooms as well as university visits to district sites. This science and mathematics faculty engagement will incorporate training for K-12 counselors on improving student learning opportunities and career knowledge in science and mathematics and thus cross links to the student learning opportunities component as well. They will be active contributors to the other project initiatives, including the recruitment of science and mathematics teachers, the implementation of standards-based science and mathematics in pre K-12 classrooms, and research into the evaluation of the effectiveness of the initiatives.

They will serve as directors for undergraduate teaching assistants, teach and coordinate courses which employ MathExcel student facilitators, and run summer orientation programs for rising undergraduate TAs and student MathExcel facilitators. They also will serve as mentors for student Teaching Explorers (i.e., students who are exploring their interest in teaching careers). Appendices 12A and 12B list activities that will require the work of faculty at the different IHEs. These activities involve a very high level of collaboration and the direct involvement of numerous faculty members at multiple institutions.

Key administrators at each institution have provided letters of support and confirmed at the recent regional meetings that they are currently developing faculty incentives to expand science and mathematics faculty involvement at their institutions. Two of the partners (Eastern Kentucky University and Morehead State University) have developed and employed formal mechanisms for developing faculty buy-in in other projects and are prepared to share details of those programs. Partner administrators stressed the importance of institutional recognition of work on projects such as AMSP.

Faculty from the nine IHEs have participated in earlier planning meetings and attended the recent regional meeting. The AMSP committed faculty list includes individuals at the participating schools many of whom have a long history of involvement with curriculum reform and professional collaboration with other IHE faculty and pre K-12 schools. Their expertise and experiences are diverse. They have a common interest in the training and support of teachers and share an awareness that a systemic, regional approach will be more effective than a competing institutions approach.

Response to Question 3: Governance and Leadership

The specific needs articulated by school districts in the target service area played a major role in developing the AMSP project initiatives. The project is built on the relationship established by ARSI and includes the active participation of K-12 school district partners at individual and group meetings. The AMSP Management Plan includes a Management Team with representatives from the PreK-12 districts as well as IHE partners. Further, Initiative Advisory Councils in Mathematics and Science include project participants from both school districts and IHEs. These Councils identify specific needs regarding new developments and initiatives and recommend changes in on-going activities.

School districts will determine the PreK-12 representation on these Councils. These districts have committed to identifying a District Mathematics and Science Leadership Team that will participate in both district and partnership planning activities. The leader of the team will be the liaison with the Initiative Advisory Councils in their planning and development activities. The districts have also committed to providing support for representative teachers and/or administrators to serve on planning and implementation teams. This concept of leadership teams has worked very effectively in the ARSI project and is expected to be equally effective in the AMSP project.

The PreK-12 districts have agreed to meet at least once a year. They will elect representatives to the Management Team and Initiative Advisory groups. They will be directly involved in the planned utilization of mentored pre-service teachers in the districts, in addressing the gap in state core content and university college freshman expectations, in distance learning and ways in which institutions could make course delivery more user friendly, and in the design and expansion of dual credit courses and AP courses. They will also assist in the development of incentives and programs that increase the content training of teachers leading to master's degrees or mathematics or science specialists.

Response to Question 4: Institutional Change and Sustainability

Through the response meetings, emails, phone calls, and conversations IHE district partners provided a wide variety of expected, lasting outcomes from AMSP. These fall roughly into curriculum and instruction, and human resources.

Curriculum and Instruction: Both IHE and district leaders cite the establishment of modern standards-based curricula in math and science with greatly expanded employment of inquiry and collaborative learning. In the IHEs the reference was primarily to the pre-service teacher curriculum while in the districts it is K-12. The districts expect better K-12 articulation of math and science programs within and among districts while the IHEs expect far better coordination and alignment of pre-service curricula among the institutions. Both expect the introduction of advanced technical tools for instruction and for enhanced communication and collaboration. Both expect greatly improved placement of students in college courses as a result of curriculum alignment and tools such as the KEMTP.

Human Resources: Both IHEs and districts expect growth and overall improvement in school student learning in math and science and for this to be reflected in the standard test scores. Both groups expect the emergence of a strong, active learning community of partner IHE and district faculty, students, and community. Both groups expect a marked increase in the quality and number of pre-service teachers graduating from the partner IHEs – the districts expect this to be reflected in an increasing pool of highly qualified MST teachers from which they can recruit, both groups expect much higher levels of collaboration among district and IHE MST faculty and teachers, the IHEs expect a significant increase in the number of senior MST faculty engaged in outreach and pre-service teacher programs. Both groups expect a significant increase in the number of students from the partner schools taking advanced MST classes.

Beyond the collection of specific changes the AMSP will have created a regional community and given it mechanisms for identifying common concerns and crafting and implementing common, systematic, sustained approaches to their resolution. The entity which will maintain this capacity and sustain and build on the AMSP relationships (which are themselves structural changes) is the “Partnership Institute for Mathematics and Science Reform.” The Institute will begin as the ARSI component of AMSP and move to a permanent home at the

University of Kentucky, housed under the new office of Vice President for Outreach, along with the various coordinating councils (which the AMSP partners agree to maintain).

The improvements in pre-service and in-service teacher education programs made by scientists and mathematicians will continue to influence the quality of teachers in the targeted region long after the five-year project has been completed. The enhanced knowledge IHE faculties acquire will support summer institutes and special courses for teachers far beyond the five-year project. The positive collegial relationships developed during the project between university mathematics and science faculty and other partners will increase the probability of future positive collaborations. In addition to these positive outcomes, the Partnership Institute is expected to continue as an outreach institution with liaisons and active involvement of all partners to provide a supportive network. By maintaining this structure, partners will be encouraged to implement any necessary institutional changes to continue specific activities beyond the duration of the grant. For example, departments of education at the IHEs will make permanent changes in the nature of their pre-service curriculum, high schools will continue to support the dual course partnership with IHEs, school districts will make a commitment to a standards-based, inquiry-driven curriculum, and mathematics and science departments will continue to offer and expand advanced courses in distance-learning formats. It is anticipated that such activity will be further fostered and stimulated by regional meetings of professional societies.

Response to Question 5: **Going to Scale**

Early in the ARSI project, schools in each ARSI district were rated on several factors using the Program Improvement Rating Form. Key indicators, such as the availability of assets that support excellence in teaching science and mathematics, the alignment of the science and mathematics curricula with state and national standards, and the utilization of inquiry strategies, were rated on a five-point scale. The data obtained helped inform the establishment of project priorities. It was reasoned that repeating the completion of the Program Improvement Rating Form well into the project would provide useful formative and summative evaluation data. The AMSP project proposes to use the same rating system. However, utilizing the Program Improvement Rating Form in one baseline improvement site in each of the 52 school districts would be only one of several evaluation mechanisms, and it would not mean resources would be poured into these schools alone before scaling up to other schools. Rather, the baseline improvement sites would provide data that would serve as a proxy for the status of schools across the districts on the variables rated. Student achievement is the bottom-line indicator, but the Program Improvement Rating Form data can provide an indication of the extent to which conditions are in place to support student achievement.

It is expected that several schools from each district will be impacted by the project in Year 1, and the number impacted will increase during each subsequent year. A particular baseline improvement site might or might not be involved in project activities during Year 1 and might not be as heavily impacted as other schools in the district after 2-3 years.

The changes made in pre-service programs will have a modest impact on instruction in K-12 classrooms for the first 2-3 years of the project, but eventually all schools and students in the 52 districts will be significantly affected. The implementation timelines in Appendices 12A and 12B of the proposal show how rapidly pre-service and in-service activities will be increased to impact a large number of teachers and an even larger number of students.

K-12 teachers accomplishing exemplary implementation of standards-based, inquiry instruction will be identified. Following the successful ARSI model, the districts, the project and the ARSI Teacher Resource Centers will provide leadership training and help support these teachers. The teacher leaders will help other teachers within their districts implement more viable instruction. Identification of the first group of potential teacher leaders will occur during the second year of the project, and their training will begin soon after. They will begin engaging in mentored leadership activities during year three. An additional group of teacher leaders will be added in each subsequent year of the project.

The region has a very small minority population and a very high percentage of children from lower socio-economic homes. We are committed to examining data disaggregated on the basis of race and socio-economic status. Equity within groups will be emphasized as an instructional inquiry strategy in classrooms. Resources will be allocated with the goal of assuring that **no child is left behind**.

Response to Question 6: Incentives for Participation

The projections for professional development participation are based on the ARSI project. The ARSI project serves 45 school districts and during the 2001-02 school year provided direct services to approximately 2,485 teachers, and 200 administrators and counselors (non-duplicated count). The AMSP project will serve 52 K-12 school district partners in a three-state region. The counselor and principal components are enlarged in the AMSP, and it is anticipated that approximately 400 counselors and administrators will participate in leadership training programs. Based on a 15% increase in the districts served, it is anticipated that approximately 3,000 teachers will participate in professional development, curriculum and program improvement, and enhanced student learning opportunities.

Teachers in rural areas in the Appalachian region face barriers in earning graduate degrees in the mathematics and science content areas from institutions in their geographic region and at times convenient for them. In addition, area colleges and universities have not marketed such degrees as teachers have generally opted for advancement through supervisory, counseling, or administrative degree programs. With implementation of the Kentucky Education Reform Act and its system of standards and rewards, teachers and administrators are now requesting programs that will allow teachers to earn advanced degrees in their content fields. The higher education institutions partnering with K-12 institutions in the AMSP are committed to providing opportunities for teachers to earn advanced degrees in mathematics and science. The

organizational structure of the AMSP will provide many opportunities for K-12 teachers to work closely with university colleagues to tailor programs to meet the needs of practicing teachers. The AMSP incorporates a number of systems, including both virtual and traditional credit opportunities, to ensure the availability of quality programs in these content areas. One of these systems is the Certificate Program, which is understood not to be “teacher certification.” However, all of the partner districts already have mechanisms for recognizing credentials less formal than academic degrees. Many of these are “15/30” career steps, with the numbers referring to academic hours completed according to an approved plan. An additional incentive for teacher and administrator participation is the unqualified commitment of the superintendents which was reiterated at the partner response meetings.

In a pilot workshop of math teachers in eastern Kentucky, a survey of teacher motivation to participate in professional development activities elicited the following responses. All agreed that stipends, materials, and supplies are important “honoraria” that place a value on their time. Beyond these the motivating factors they mentioned (which are all fundamental to AMSP) fall into two categories: (1) motivation as teachers, (2) motivation as professionals. Among the items under (1) are opportunities to: (a) better serve students, (b) provide opportunities for students, (c) better serve the community (economic/work force development), (d) learn new content, (e) learn new methods (particularly technology), and (f) acquire new labor and time conserving tools. Among the topics under (2) were opportunities for: (a) professional advancement (dual credit, master teacher, traditional and alternative approaches to certification, access to convenient college courses), and (b) professional expression (collaborate on and publish research, serve as journal editor or columnist, travel to and present at professional meetings, membership in a professional community, working with new technology and tools at the forefront of the profession, creation and publication of materials to be shared with others).

The participants attending the recent response meetings reaffirmed their commitment to these and added: (a) learning new strategies to develop higher achievement in science and mathematics (improve test scores), and (b) opportunities to develop leadership skills in science and math, and (c) opportunities to strengthen relationships with universities and receive assistance with program improvement. The partner superintendents emphasized that their districts and schools would work with AMSP on this and stated their intention to recognize and reward alternative credentials earned through the AMSP in the context of a district-approved program. They strongly supported the AMSP Certificates Program. In addition, the Kentucky Superintendent of Education, as an AMSP partner, committed to work with AMSP and the state standards board on processes for properly incorporating certificate programs into the “or equivalent” alternative, above.

Response to Question 7: Reasonable and Appropriate Benchmarks

The benchmarks established for the project are realistic expectations for the program based on data collected from the partner higher education institutions, K-12 school

district partners participating in the ARSI initiative, and state agencies serving higher education and K-12 districts in the region.

A primary goal for the AMSP is to increase the number of highly skilled mathematics and science teachers in rural school districts in Appalachia. To significantly impact the teaching profession in the region requires the following: (1) increasing the number of students graduating with teacher certification in mathematics and/or science *who have an interest in teaching in rural schools in Appalachia*; (2) increasing the quality of mathematics and science teacher preparation programs; (3) providing additional opportunities for under-qualified teachers to enroll in science and mathematics courses which will enable them to obtain certification in their teaching field; and (4) providing high quality professional development for teachers who are certified but whose training is outdated or lacks sufficient content breadth and depth.

With these factors in mind, the project has established benchmarks that are interconnected through the four initiatives:

Benchmark #1, related to increasing student achievement, is relatively modest. However it is recognized that fundamental changes related to teacher training, curriculum development, and resource procurement have to be made to see improvements in student achievement. The projected growth is based on the rate of improvement in student achievement that has occurred in ARSI districts that are nearing full implementation of the ARSI model, which has similar components to the AMSP. Data to show how ARSI districts have closed the gap are incorporated into the response to Question # 9. Minority and low SES student data indicate significant needs, and the AMSP will focus additional resources in an effort to eliminate the gap in performance between student groups.

Benchmark #2 is based on course enrollment data provided by the participating school districts and the core data for ARSI school districts. Enrollment figures for both mathematics and science indicate that a significantly reduced number of students enroll in higher level science and mathematics courses across the Appalachian region. For example, in 2001, for the schools reporting, 56.7% of the students enrolled in lower level mathematics courses, whereas only 32% of the student population enrolled in higher-level mathematics courses. Higher level mathematics courses are defined as Algebra II, Calculus or other advanced courses. Similar data was examined for science, and in 2001 approximately 22% of the students were enrolled in higher level science courses including chemistry and physics. Since at the outset of the project, participating school districts will have varying enrollments from which individual targets will be established, an *overall benchmark* to “double the enrollment by the end of the five years” appears to be a reasonable goal. Although some of the AMSP districts may already exceed 50% of their students enrolled in higher level courses and cannot double their enrollment individually, applying this standard across the project, utilizing 2001 baseline data, a minimum of 64% of the students in AMSP schools will be enrolled in higher level mathematics courses and a minimum of 44% of the students will be enrolled in higher level science courses at the end of the five years. Data is also reported regarding the success rate of students in these courses. A chart showing

enrollment patterns and gender success rate (reported as number of students earning a C or better) in ARSI school districts is reported in Appendix #4 of the AMSP proposal. Additional ARSI core data is available to show the individual school enrollment statistics.

Benchmark #3 for higher education enrollment is based on two indicators: (1) increasing the overall number of students from rural schools majoring in science, mathematics, science education and mathematics education, and (2) increasing the percentage of students *completing* degree programs. In examining state and institutional data, rural Appalachian students make up a significantly lower percentage of the lead university population than students from other regions and have a relatively high dropout rate. Consistent with these data are the relative percentages of students majoring in mathematics, science, science education and mathematics education. All of the rural school districts participating in the AMSP have indicated either a minimum number of qualified candidates or no qualified candidates for mathematics and science teaching positions, resulting in schools reducing programs in these areas. As the number of applicants for mathematics and science teaching positions in rural schools in Appalachia continues to dwindle, it is anticipated that increasing the number of students *from rural areas* enrolling as science or mathematics education majors *and* providing support services to enhance the retention rate, will enhance the pool of certified teachers willing to teach in these types of school settings. Although the increase in the total number of mathematics and science graduates is projected at 102 for the lead institution (UK), similar growth at other participating higher education institutions will provide a significant improvement in the number of available mathematics and science teachers in the region.

Benchmark #4 is based on data collected from participating ARSI districts. Baseline data will be collected at the outset of the AMSP for all participating districts. Although the project will monitor the progress of all participating school units, as discussed in the response to question #5, one school will be identified for longitudinal data collection. These schools will represent elementary, middle, and secondary levels and provide a measure of progress for the project over time. Enhanced instructional practice including the implementation of inquiry and problem-solving based strategies, incorporation of standards-based resources, curriculum development, community engagement, and leadership capacity will all be included in the database.

Benchmark #5 relates to the success of students completing pre-service science and mathematics programs. Atwood and Christopher have experience with pre-service elementary teachers in a physical science course designed to help them learn in a guided-inquiry, collaborative manner. Using a 32-item multiple choice instrument designed to test them on standards-based topics they have found, based on several semesters experience, that these students score on average less than 45% on pretest. However, the average for such students completing the course is typically around 80%.

In addition to the five benchmarks identified, baseline data and additional benchmarks such as the number of students enrolled in advanced and in AP courses, parent involvement, principal and counselor training will be established.

Response to Question 8: Recruitment, Induction, and Retention

The ARSI programs aimed to increase the number of high quality teachers who are equipped with a modern curriculum will proportionately increase both the size of the potential pool of pre-service teachers and in the fraction of that body favorably disposed to a career in teaching. The question then is: in addition to the expected impact of a better trained, more productive group of teaching professionals, and modern school and college curricula, what will AMSP do to fan the spark of student interest in teaching and nurture it to fruition.

First it will expand the effectiveness of the teacher as role model.

Teacher status: AMSP will enhance teacher professional standing. This is important for many reasons but one is the impact of the teacher as a role model. Through AMSP, teachers at all levels will have the opportunities to do such things as: engage in and publish research, develop and disseminate instructional material, serve on professional committees that direct and coordinate the AMSP, travel to and give presentations at professional meetings, and serve as instructors of college courses.

However, beyond interest, there must be the opportunity for students to be involved in a community of equally motivated students and inspiring faculty.

Student involvement with teaching and teachers: The original proposal states, “AMSP envisions a continuum of mathematics, science and technology teaching and learning experiences for students and teachers at all levels.” The vision is one of a well-marked path along this continuum of experience to a teaching career – a path along which a student can embark at any point in his or her academic career. Fundamental to this vision is that these experiences (1) bring the student at one level into substantive, sustained interaction with teachers and students at higher levels, and (2) substantively expose the student to different aspects of teaching.

The proposal (p.10) describes three major categories of experiences: The school Excel program, the college Explorers program (which includes the college Excel program), and the College Undergraduate Teaching Assistant (UTA) program. The school Excel program creates opportunities for advanced students to serve as collaborative teaching facilitators for elementary and middle school students. As such it is an entry point to a prospective teaching career for the advanced students and an advertisement of such opportunities to the younger students. This effort is supplemented at the schools by AMSP promotion of student academic leadership and student-faculty interaction through academic clubs and teams for science/math academic competitions. The college Explorers program is a structured introduction to MST teaching that is formally a weekly seminar run jointly by scientists and mathematicians, science/math education specialists, and partner school teachers. Students in the seminar have faculty mentors with whom they work on MST teaching experiences as a laboratory. The experiences will be varied and will depend on interest and institution. They include structured

college tutoring, working with a local partner school program, assisting school students using distance-learning technology, etc. The college Excel programs will be part of the Explorers program and will provide a natural school-college transition for Excel students. A rich menu of experiences for pre-service teachers is organized under the Undergraduate Teaching Assistantship (UTA) program in which pre-service students are more deeply engaged in teaching. As with the Explorers, the UTAs will have faculty mentors and participate in a seminar with college MST and MST-ED faculty and with partner school teachers. As stated in the narrative the priority for UTA experiences will be involvement that brings the student directly into working contact with district partner students and teachers. When possible, UTAs will travel with faculty to academic year workshops and act under the supervision of master teachers as substitutes for teacher partners taking part in the workshops.

Additional Recruitment Strategies: Our partners suggested several recruitment ideas during our collaborative meetings. Some school district partners suggested the establishment of future teacher clubs in high schools; these clubs would be collaboratively sponsored by high school teachers and IHE mathematicians and scientists.

Community colleges in the region are potential sources of future middle and high school mathematics and science teachers. Many capable students attend community colleges to save money and to live at home. The teaching profession provides relatively good compensation and job security in many Appalachian communities. Interested, qualified community college students will be recruited to pursue careers as science or mathematics teachers at a partner IHE near them. At least one NSF-sponsored initiative is already underway to bring geometry and statistics courses for future middle school teachers to the community college level.

Morehead State University has recently established a position for a full-time teacher education recruiter. The focus of recruitment will be high-need fields, such as science and mathematics. Early results are encouraging. This is an idea partner IHEs will want to monitor and evaluate.

Partner IHEs already employ students to serve as tutors for mathematics and science courses, and the practice will be increased through AMSP. Tutors who are particularly effective and seem to find the work satisfying will be encouraged to consider the option of becoming a mathematics or science teacher.

Different approaches to supporting students who elect to prepare to become science or mathematics teachers will be piloted by the IHE partners, and the results will be shared. Special efforts will be made to recruit female and minority students through all recruiting strategies employed by the partners.

Retention and Support: The NSF-sponsored technology base described in the proposal (Appendix 10) provides the basis for a continuing support system for pre-service teachers as they enter the profession. Students stay within a familiar network of faculty

and colleagues with electronic accounts, materials, relationships, and collaborations intact. Such transitional support is currently in practice among UK math faculty and teacher partners in three partner districts.

Diversity: The issue of diversity is particularly challenging in the AMSP partnership area, as, with the exception of three districts, the minority population is extremely low. AMSP will work to involve every minority partner teacher in the credentials and status-enhancement activities and will work with community and teacher partners, and college minority affairs programs to strongly and personally develop and recruit minority school students into the teacher development program.

Response to Question 9: Quality of Prior Work—ARSI Lessons Learned

ARSI has made significant strides in the past seven years with regard to standards-based curriculum development, policy changes, resource convergence, and student achievement in schools that fully implemented the ARSI model. However, specific goals not fully realized include: implementation of technology into instructional programs across the region; readiness and willingness in all districts to reform mathematics and science education; and the need to utilize data for decision-making. In addition to the size of the region served, a number of factors emerged as barriers to full realization of these goals. The number and isolation of the districts have taxed personnel and financial resources. ARSI districts began at varying stages of development and readiness and have required significantly different approaches and levels of support to forge a regional systemic reform effort. The challenges of working in communities in a region steeped in local traditions and values are ongoing and require an understanding of the rural Appalachian culture by all partners working in the reform initiative.

ARSI now has many assets in place in the region that were non-existent six years ago. There is a network of committed and competent teacher leaders; administrators recognize program improvement needs and are willing to work with other school and district leaders to achieve higher performance in mathematics and science; Resource Collaboratives are now strategically located at universities in the region and have established long-term and productive relationships with the ARSI districts; and, most importantly, the overall capacity for reform in the region has been greatly enhanced through the ARSI project. The AMSP is designed to both support current ARSI participating districts and expand the impact of the ARSI model into a significant number of rural districts not previously involved.

Some of the Lessons Learned in past years that have shaped the development of the AMSP project, include the following:

(1) Understanding and use of data is critical to the success of school improvement efforts. *AMSP participating schools will utilize the results of a comprehensive school review process (Program Improvement Review) to establish needs that will be addressed through the school improvement plan. These data will be used to guide the work of the partnership in individual schools as well as provide the basis for establishing benchmarks for improvement for each school district.*

(2) Support for mathematics and science reform should be based on district readiness, willingness to reform, and current level of performance. *School districts participating in the AMSP have committed to participate in pre-service, in-service, and student development activities that will result in improved student learning opportunities. School and district assessments will determine the level of need and ability of the districts to embrace reform initiatives. Districts will develop individual plans based both on need and capacity to implement the specific strategies available through the AMSP.*

(3) Implementation of technology into the instructional program continues to be an area of need for all rural schools in the Appalachian region. Technology can be successfully integrated in science and mathematics instruction leading to higher level student performance *only if* teachers have a clear understanding of the nature of scientific inquiry and mathematics problem solving and appropriate pedagogy for increasing student learning. *Professional development is a major component of the AMSP. K-12 teachers will work closely with university science, mathematics, and science/mathematics educators to learn inquiry, problem solving and technology skills. In addition, ongoing support for these efforts will be provided through both face-to-face and on-line strategies.*

(4) It is critical that reform efforts be institutionalized so that the gains that have been made in improving science and mathematics instructional programs can be sustained. Focus on individual teacher improvement is not enough to sustain improvement in rural districts. Reform initiatives must be imbedded into the programs of the universities that currently house the Resource Collaboratives to provide a support system that will sustain the progress made in these rural districts. *The AMSP has included principal, counselor and community engagement initiatives as well as established leadership teams at the district level to insure that reform efforts are not individual teacher dependent. The focus of the initiatives will be increasing district and regional capacity for science and mathematics education even though a significant effort will be made to improve individual teacher and administrator performance. The partnership concept will imbed the initiatives in the partner universities as well as incorporate regional and state agencies, business and industry with local school district school improvement efforts.*

(5) Shared leadership is vital to reforms in rural areas. Districts in which there is a viable leadership team have been able to sustain reform efforts and have shown consistent improvement. School district climate and impetus for systemic growth is extremely fragile. *The AMSP Partnership design provides the mechanism for the long-term support system necessary for implementing and sustaining program improvements in science and mathematics in rural school environments.*

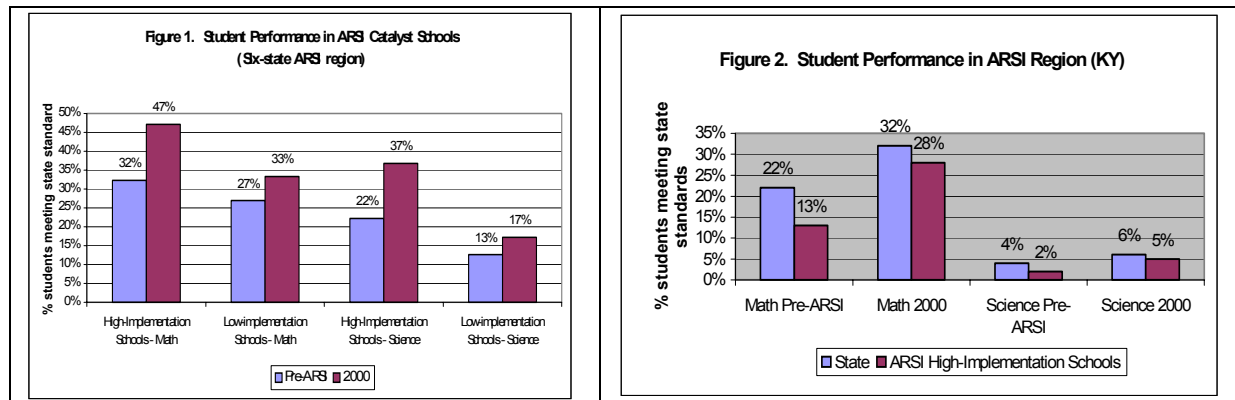
(6) Administrative support is key to the change process. School principals must be brought on board and kept informed if science and/or mathematics education reform is established and continued. *The AMSP includes significant pre-service and in-service principal enhancement components.*

ARSI Regional Assessment Results. Student achievement data for ARSI districts validate the impact of the ARSI model. 91% of all ARSI catalyst schools, as determined through the aggregation of individual state assessment data, show improved student performance in either mathematics or science. 80% of the catalyst schools show improved performance in science whereas 91% of the schools show improved student

achievement in mathematics. The school districts that have fully implemented the ARSI Model exhibit the following characteristics:

- District and school-level leadership and vision to support implementation of standards based mathematics and science;
- Data-driven district and school-level improvement planning for mathematics and science program improvement efforts;
- Mathematics and science curricula aligned to state standards and sequenced across grade levels;
- Teachers utilizing inquiry and/or problem-solving instructional strategies on a regular basis;
- Quality instructional materials aligned with the school’s science and mathematics curricula;
- Professional development and leadership training based on both personal and school program improvement needs.

As can be seen in Figure 1, student achievement, in both science and mathematics, has improved significantly in all catalyst schools during the seven years of the ARSI project. As would be expected, schools that have fully implemented the ARSI model have shown greater improvement in both mathematics and science.



Closing the Gap. To indicate how ARSI school systems have closed the gap, representative data for the largest ARSI participating state have been provided. The data from Kentucky are representative of data from the other states served by the ARSI project, as in every case ARSI school districts have improved at a higher level than their respective state. The student assessment data for Kentucky have been aggregated to compare the performance of K-12 mathematics and science students performing at the proficient and distinguished levels on the Commonwealth Accountability Testing System assessment for ARSI participating schools and the state. The data presented in Figure 2 show that although ARSI schools are still performing below the state average, there has been a significant reduction in the performance gap. Kentucky schools have had a 115% increase in the number of students scoring proficient or higher in mathematics whereas the number of students across the state scoring at this level has increased only 45% during this same period. In science, the overall number of students scoring proficient or higher at the state level increased by 50% whereas the number of

students in ARSI schools scoring at the proficient level or higher has more than doubled (100% increase) since the outset of the project.