DOCUMENT RESUME

ED 436 334		RC 022 182
TITLE	Student Achievement in Math and Science: Putting Community Members into the Equation. The ARSI Community Engagement Implementation Manual.	
INSTITUTION	Appalachian Regional Commission, Washington, DC.; Appalachia Educational Lab., Charleston, WV.; Kentucky Science and Technical Council, Inc., Lexington.	
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.; National Science Foundation, Arlington, VA.	
PUB DATE	1998-11-00	
NOTE	73p.	
CONTRACT	RJ96006001	
PUB TYPE	Guides - Non-Classroom (055)	
EDRS PRICE	MF01/PC03 Plus Postage.	
DESCRIPTORS	Academic Standards; *Community Involvement; Educational Quality; Elementary Secondary Education; *Improvement Programs; *Mathematics Education; Program Development; Rural Education; *School Community Relationship; *Science Education	
IDENTIFIERS	*Appalachia	

ABSTRACT

The Appalachian Rural Systemic Initiative (ARSI) aims to stimulate sustainable systemic improvements that enhance student performance in mathematics, science, and technology in 66 Appalachian counties characterized by persistent poverty. To support this aim, a major ARSI goal involves development of partnerships among families, communities, and schools. This manual was designed to help school and community facilitators build community involvement in the education process. Sections 1 and 2 describe ARSI and discuss community engagement as a form of stewardship and as a positive influence on student achievement. Section 3 outlines the ARSI community engagement process, developed with input from agencies and practitioners working in rural Appalachia. The process entails 12 steps: establish a team, define the community being served, select school and community co-facilitators, develop a descriptive profile and submit it to appropriate district and ARSI personnel, complete a community engagement self-assessment, understand the school's vision for improved mathematics and science learning, develop a community engagement action plan, implement the plan, monitor progress, report and use collected data, celebrate success, and renew commitments and action plans. Sections 4 and 5 describe critical elements in high-quality science and math programs and professional development experiences and discuss what quality math and science education means for students in Appalachia. Section 6 contains 9 references and 44 additional resources. Appendices present overviews of national science and mathematics standards. (Contains sample work sheets.) (SV)

ARC

Student Achievement in Math and Science:

AEL

Putting Community Members into the Equation

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The ARSI Community Engagement Implementation Manual

ARC
Appalachian Regional Commission

AEL
Appalachia Educational Laboratory

ARSI
Appalachian Rural Systemic Initiative

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AEL
Appalachia Educational Laboratory

ARSI
Appalachian Rural Systemic Initiative

AEL's mission is to link the knowledge from research with the wisdom from practice to improve teaching and learning. AEL serves as the Regional Educational Laboratory for Kentucky, Tennessee, Virginia, and West Virginia. For these same four states, it operates both a Regional Technology in Education Consortium and the Eisenhower Regional Consortium for Mathematics and Science Education. In addition, it serves as the Region IV Comprehensive Center and operates the ERIC Clearinghouse on Rural Education and Small Schools.

Information about AEL projects, programs, and services is available by writing or calling AEL.

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November 1998

This publication is based on work sponsored wholly or in part by the Office of Educational Research and Improvement, U. S. Department of Education, under contract number RJ96006001. Its contents do not necessarily reflect the views of OERI, the Department, or any other agency of the U. S. Government.

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Acknowledgments

Public education in the Appalachian region is confronting the realities of providing students with the best possible educational opportunities in changing—and challenging—times. One challenge is to better engage parents and other community members in meaningful ways to improve opportunities and student performance in mathematics and science. Appalachia Educational Laboratory (AEL) appreciates the opportunity to collaborate with the Appalachian Rural Systemic Initiative (ARSI) and the Appalachian Regional Commission (ARC) to produce the *ARSI Community Engagement Implementation Manual.* This work further advances AEL's mission of linking the knowledge from research with the wisdom from practice to improve teaching and learning.

This manual illustrates how the research and development done by the regional educational laboratory at AEL can assist school improvement efforts in the region's rural schools. ARSI, a five-year initiative funded by the National Science Foundation and conducted by the Kentucky Science and Technology Council, provided the collaborative opportunity for the laboratory to assist in designing and piloting the community engagement process described in this manual. ARC provided funding to support selected activities of the community engagement teams.

Special thanks go to members of the community engagement teams, particularly team facilitators at ARSI catalyst schools, who suggested improvements to the process and the manual. These voices will continue to influence modifications in the process as the ARSI project continues to explore ways to improve and sustain community involvement in mathematics and science education.

AEL also acknowledges the Appalachian Regional Commission and Wemberley Royster and Keith Smith of the Appalachian Rural Systemic Initiative for their continued willingness to make this collaborative venture possible. This manual reflects their advice and suggestions, as well as the critical review of ARSI Resource Collaborative directors who work daily with ARSI catalyst schools, teachers, and administrators. Their use of the manual will further the work of bringing local knowledge and wisdom into the rural schools of Appalachia.

Many others contributed to the manual, including Pam Buckley and staff at the Regional Eisenhower Consortium for Mathematics and Science Education at AEL and members of the ARSI Management Team and Advisory Council, who provided critical information.

Lastly, few quality products are produced without the expert assistance of writers, editors, and office professionals. To these folks, particularly Doug Fleming, Stan Bumgardner, and Penny Sebok, we extend our sincere thanks.

Introduction

As the new millennium approaches, our society faces many challenges—as does the education system. The situation is summed up by these words:

> Family . . . Community . . . Schools . . . are the three "pillars" of education. From them, public schooling draws its strength, received its mission, and developed its unique character as an institution in our society. The three have formed a collaborative partnership over the years, resembling at its best moments a reciprocal giving-getting compact. Schools prepare our children to assume their place within communities as productive workers and responsible, able citizens. Historically, schools have transmitted the cultural values that undergird our family structure and unify our society. In turn, families and communities have supplied the financial, moral, and practical support our schools rely upon to fulfill their mission.
>
> As we approach the end of the 20th Century, a series of crises is besetting industrialized society which has weakened public schools. Distinct but related social, economic, and cultural upheavals have changed the face of our communities, undermined the structure of our families, and unraveled the fabric of our society. In their wake the schools have been left struggling to carry out a mission whose methods and goals are no longer clear, and whose feasibility is in question. With the weakening of the traditional partners in public education, the compact among schools, community, and family must be rebuilt. (Decker & Decker, 1994, p. 1)

The challenge is how to rebuild the educational partnership so that families and communities can reassert their legitimate interests in schools and become constructively involved in the education process. The *Appalachian Rural Systemic Initiative (ARSI) Community Engagement Implementation Manual* was designed to help concerned community members meet this challenge.

Section One: What Is ARSI?

The Appalachian Rural Systemic Initiative (ARSI), a National Science Foundation-funded project, is a collaborative effort among six states in Central Appalachia—Kentucky, North Carolina, Ohio, Tennessee, Virginia, and West Virginia—to stimulate sustainable systemic improvements in mathematics, science, and technology education for K-14 students. Its target region within the six states encompasses 66 Appalachian counties characterized by significant and persistent poverty. The principal goal of the initiative is to enhance performance in science, mathematics, and technology for all students in its target counties.

To overcome the persistent barriers to achieving this long-range outcome, the ARSI project has three strategic goals: (1) to develop among teachers the necessary knowledge and skills to create effective learning environments in which all students learn mathematics and science and use technology; (2) to develop the school and school district leadership, regional partnerships, community involvement, and stakeholder support necessary to sustain long-term educational improvements; and (3) to develop a sustainable system that provides students and teachers timely, coordinated access to educational resources and services that support hands-on, standards-based teaching and learning.

Major ARSI interventions and strategies, which focus on the interactions that impact change at the school level, include developing teacher partners and catalyst schools, reviewing programs and planning program improvement activities, engaging community members, and creating resource collaboratives and partnerships.

Teacher Partners and Catalyst Schools: Impacting School-Classroom Interactions

The *catalyst school*, as the name implies, is a central component of ARSI's strategy to effect change throughout a school district. The catalyst school provides the laboratory in which ARSI first works to build local vision and leadership, enhance school-based capacity, influence classroom instruction, and link local reform to regional resources. Intervention activities that work in a catalyst school can be "scaled up"—implemented at additional schools.

Each catalyst school has a teacher designated as the *teacher partner*. The teacher partner serves as a school-based instructional leader and resource person who provides mentoring, resource awareness, and other assistance to classroom teachers working to change their instructional practices. Teacher partners are released half-time from regular classroom teaching duties. ARSI convenes monthly meetings of the teacher partners to develop leadership and professional skills and to provide networking opportunities. An annual, weeklong summer institute provides in-depth experiences with inquiry-based instruction, appropriate assessment, and issues affecting the implementation of standards-based mathematics and science programs.

Program Improvement Review and Planning: Impacting District-School Interactions and Scale-up

Perhaps the program improvement review and planning process is the most consequential of the intervention strategies used by ARSI. This process has enormous potential for promoting and institutionalizing high-quality, standards-based mathematics and science programs at the district level. By reviewing mathematics and science programs and using the information acquired from the reviews, schools and districts are helped to effectively structure the mathematics and science components into their program consolidation or school improvement plans. As a result, mathematics and science are placed high on the priority list of district improvements, the resources allocated for mathematics and science are elevated, and the impact of ARSI is extended beyond the end of project funding.

Community Engagement: Impacting School-Community Interactions

ARSI's community engagement model focuses on building the knowledge, commitment, and involvement of local communities in support of mathematics and science reform in their schools. The team that will accomplish this work should consist of local parents, business persons, teachers, students (when appropriate), and others who represent community interests. Two team members selected as community engagement facilitators lead the team as it investigates the status of the mathematics and science programs, assesses needs, identifies local resources, and develops an action plan. The result is a core group of persons who understand and support quality programs and who assist the school in developing meaningful ways to engage community members as partners in mathematics and science reform.

ARSI Resource Collaboratives and Partnerships: Creating a Regional Support System

Regional resource collaboratives lie at the heart of ARSI's operation. A resource collaborative is a customer-driven network of partners whose mission is to empower local educators and communities through coordinated access to physical, human, and organizational resources. Partners include universities and community colleges, state and intermediate service agencies, National Science Foundation projects, and community development organizations. Currently, five resource collaboratives are strategically located throughout the ARSI region. Resource collaboratives perform the following functions:

- Provide ongoing leadership, professional growth experiences, and support for teacher partners.
- Coordinate technical assistance to catalyst schools, district-level personnel, and ARSI community engagement teams.
- Broker professional development and other services to ARSI schools and districts through partner agencies and organizations.
- Provide access to standards-based instructional resources.
- Facilitate networks of professionals in similar or related roles (i.e., teacher partners, technology coordinators, and community engagement facilitators), and use the Internet extensively to provide local individuals timely access to information, resources, and exchange of ideas.

This model of change is a way to implement systemic reform. It is a slow and challenging process, but its strength lies in the premise that local change is best accomplished by local people, who know the community's strengths and hopes. Such an effort takes time. But it also builds the capacity of local people to solve other problems within their own community.

For more information about ARSI, call 606-255-3511 or e-mail jrendall@arsi.org.

Section Two: Why Is Community Engagement Important?

A U.S. Department of Education research publication, *Strong Families, Strong Schools* (1994), points out that in our "rapidly changing society, few areas are as essential to a successful future as education, both as a means of learning basic and advanced skills and as a process for helping to develop responsible, compassionate citizens who are ready to make valuable contributions to their family, community, state, and nation" (p. 1).

Community Engagement is a Form of Stewardship

In this era of declining resources and rising expectations, public schools find themselves competing for allocations from a shrinking pool of resources. Constituencies have become more and more reluctant to tax themselves for schools that the public sometimes perceives to be remote and removed from day-to-day living. When only 30 percent of the adult population in a typical community have school-age children, 70 percent of the potential voters may question cost-benefit ratios at tax time and frequently refuse to bear an additional financial burden for the schools (Schmitt & Tracy, 1996).

In an article called "School Reform Versus Reality," Harold Hodgkinson concludes that the question of how schools should be restructured is in reality a two-part question: "What can educators do that they are not already doing . . . to get [children] achieving well in a school setting? And how can educators collaborate more closely with other service providers so that we all work together toward the urgent goal of providing services to the same client?" (p. 16).

The key to answering these questions lies in how society members define "we." As Guthrie and Guthrie (1991) point out, the challenge is not to divide up responsibilities, but to reconceptualize the role of the school and relationships among the school, the family, the community, and the larger society.

An African proverb eloquently sums up the *what* and *why* of collaboration: "It takes a whole village to raise a child." The job of supporting children to achieve in school and in life is too big a task for families, schools, or community institutions to tackle alone. The whole village has to come together to fulfill its collective obligation to nurture and teach its youngest members.

Together, individuals and groups can make a big difference in children's lives. But these are difficult times. Families spend far less time together, and most face an ongoing struggle to balance the demands of personal life with their jobs (U.S. Department of Education, 1994). It is ironic that today's families, while under a great deal of stress to provide "things," seem less likely than ever to have the one "thing" children need most: time. Long work hours, long commutes, and daily chores leave families little time—or energy—to participate in local schools. At the same time, there is a great need for that involvement.

Lack of parental involvement is one of the biggest concerns in education today. This concern, along with a multitude of others, will be resolved only when adults join forces. Parents and teachers want to do more but are having difficulties arranging the time. For example, two-thirds of employed parents with children under the age of 18 say they do not have enough time for their children (U.S. Department of Education, 1994, p. iv). Many parents say they are willing to spend more time on activities with their children but need more guidance from teachers. Teachers also need more guidance, as very few college and school systems provide new or experienced teachers with coursework in working with families (U.S. Department of Education, 1994, p. iv).

Community Engagement Positively Affects Student Achievement

Research confirms that, regardless of economic, racial, or cultural background, when families are involved as partners in their children's education, the results include improved student achievement, better school attendance, reduced drop-out rates, and decreased delinquency (U.S. Department of Education, 1994).

Thirty years of research confirms that family involvement is a powerful influence on children's achievement in school. When families are involved in education, their children

- earn higher grades,
- receive higher scores on tests,
- attend school more regularly,
- complete more homework,
- demonstrate more positive attitudes and behavior,
- graduate from high school at higher rates,
- are more likely to enroll in higher education than students with less family involvement (U.S. Department of Education, 1994, p. 5).

Listed below are six practical considerations, based on research, for planning and managing community engagement strategies:

1. Thirty-five studies found that the form of parent or community involvement does not seem to be critical, so long as it is reasonably well planned, comprehensive, and long lasting (Henderson and Berla, 1994).
2. Partnerships tend to decline unless schools and teachers work to develop and implement appropriate partnership practices at each grade level.
3. Almost all teachers and administrators would like to involve families, but many do not know how to go about building positive and productive programs and are consequently fearful of trying (Epstein, 1995).
4. Through policies and actions, schools can reach out to parents to help them become involved in the education of their children.
5. While all forms of parent involvement are desirable, home-based parent involvement (doing home-learning activities coordinated with children's class work and providing enrichment activities) appears to be the most valuable in regard to student achievement.
6. Socioeconomic status and lack of education have no effect on the willingness of parents to help their own children (Chrispeels, Fernandez, and Preston, 1991).

Achieving high levels of public participation, approval, and support is not easy. Key strategies appear to involve bringing together representatives from all segments of the community, developing action plans and team projects that improve the life of the local community, and building broad consensus about what makes for strong science and mathematics programs.

ARSI recognizes five specific goals for community engagement in mathematics and science learning:

1. Establish high expectations for scientific and mathematical competency for all students.
2. Advocate practices that allow students to learn science and mathematics through real-life roles and situations, preferably drawing upon community resources.
3. Develop or select curriculum that emphasizes reasoning, problem solving, and understanding over simply memorizing facts, terms, and formulas.

4. Employ greater use of calculators, computers, and communications technologies as tools for collecting, organizing, displaying, exchanging, and analyzing data.
5. Recruit and support teachers who have a deep understanding of both the subject matter and the learning processes that actively engage students.

Thomas Hatch (1998) writes that "beyond changes in curriculum or improvements in self-esteem, meaningful community engagement sets in motion a chain of events that transforms the culture of the school and, often, the community that the school serves" (p. 16). Writing about patterns among school experiences in 32 communities, Hatch reports some important common ingredients contributing to improved test scores:

- Community engagement in improving the physical conditions, resources, and participation of constituent groups around learning
- Community engagement in clarifying and strengthening positive attitudes and expectations among parents, teachers, and students
- Community engagement in expanding the depth and quality of learning experiences in which parents, teachers, and students participate

Section Three: Steps in the ARSI Community Engagement Process

ARSI's strategic plan for developing a community engagement process included working with practitioners to identify successful strategies already being used in communities. Three regional meetings were conducted with invited representatives from various organizations, agencies, and entities working in rural Appalachia. A review of literature related to community involvement with academic achievement in mathematics and science was also conducted. ARSI developed its community engagement implementation process based on these research activities. The process, which was field-tested and refined at ARSI school sites, entails 12 steps: (1) establish a team, (2) define the community being served, (3) select cofacilitators, (4) develop a descriptive profile and submit it to the resource collaboration director and the ARSI community engagement contact person, (5) complete a self-assessment, (6) understand the school's vision for mathematics and science, (7) develop an action plan, (8) implement the action plan, (9) monitor progress, (10) report and use collected data, (11) celebrate success, and (12) renew commitments and action plans.

Step One: Establish the Community Engagement Team for Mathematics and Science

A community engagement team should be organized to take the following actions:

- Gain the superintendent's and board members' support for participation in this program.
- Identify a district liaison to represent the community.
- Seek agreement and support of the school principal to participate in the project.
- Establish guidelines for team operation (goals, expectations, logistics).

ARSI finds the following characteristics essential for effective community engagement teams:

- *Leadership:* One school leader and one community leader share team facilitator responsibilities.
- *Full participation:* Everyone has something to do and to contribute.
- *Shared purpose:* Everyone owns the work and agrees on the work to be done.
- *Open communication:* Information is shared with everyone.
- *A focus toward the future:* The team determines where it wants to be in five years.
- *Innovation:* Change is brought about through creative solutions.
- *A results-centered orientation:* Efforts are directed toward students and communities.
- *Availability of coaching and assistance:* Resource collaboratives and their partner organizations make technical assistance available.
- *Adequate endowment:* The team has the time, authority, and resources necessary to do the job.
- *School Commitment:* Teachers serve on the team, and the principal actively supports team activities.

Guidelines for selecting community engagement team members. The selection of community engagement team members is designed to build a grassroots approach within the community. It is recommended that a team consist of teachers, two parents, one business person, one person from a civic organization, one current high school senior (or other student, when appropriate), one leader from the religious community, and one senior citizen. There may be additional persons who should be included, depending on individual community resources and attitudes. The team should have two facilitators, one representing the school and the other representing the community.

Committee members should be selected by the school principal, with the exception of the teachers, who must be mathematics or science teachers selected by the school's other mathematics and science teachers. The number of teachers on a team will vary depending on the configuration of the school. For example, a K-12 school would include three teachers on the team, one each from the high school, the middle school, and the elementary school. A high school or middle school would include one mathematics teacher and one science teacher. An elementary school would include two teachers from any grade level. A combined middle school/high school might include three teachers—one mathematics and/or science middle school teacher, one high school mathematics teacher, and one high school science teacher.

Each site participating in the ARSI project may already have some type of team in place. It could be a school improvement team, a site-based management team, the school transition team, PTA/PTO, or other teams operating within the school and community. This team could be part of, or could establish, a team to work with mathematics and science improvement. *It is not ARSI's objective to create another team if one already exists that can assume the role of working with math and science.* This is the school's option and the team selected may find it advantageous to utilize the ARSI process and procedure.

Once a team is identified, use the Community Engagement Team Roster included in this section of the manual to record vital contact information for all team members. Make sure each member gets a copy of the completed roster so that it's easy for team members to contact one another.

Community Engagement Team Roster

Team Facilitator (School)

Name:____________________
Home Address:____________________
____
Home Phone:____________________
Work Address:____________________
____
Work Phone:____________________
Fax:____________________
E-mail:____________________
Representing: o parent o teacher o business
o civic org. o student o religious leader
o senior citizen o other ____________________

Team Facilitator (Community)

Name:____________________
Home Address:____________________
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Home Phone:____________________
Work Address:____________________
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Work Phone:____________________
Fax:____________________
E-mail:____________________
Representing: o parent o teacher o business
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Representing: o parent o teacher o business
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Step Two: Define the Community Being Served

The community engagement team should define the persons, areas, and interests being served by identifying the school or feeder schools, collecting demographic information, and preparing a brief description of the community being served. For example, is the community defined as the school district, the county, a relevant geographic area, or by another type of boundary?

Step Three:
Select the Community Engagement Cofacilitators

Two persons will be selected from among the community engagement team—one from the school and one from the community. Cofacilitators may find the Community Engagement Team Planning Sheet (located at the end of this section of the manual) helpful. Cofacilitators have six responsibilities:

1. Plan, prepare for, and facilitate community engagement team meetings, including distributing a meeting agenda and a summary of meeting discussions and decisions.
2. Inform community engagement team members about ARSI goals and resources, upcoming meetings, and training opportunities.
3. Communicate, coordinate, and collaborate with school teacher partners and building administrators.
4. Keep notes, records, and documents to assess team progress over time.
5. Serve as a link between the ARSI project and the resource collaborative director by managing telephone contacts, fax messages, electronic mail, and preparation of reports and forms.
6. Maintain a community engagement activity log.

The community engagement team, and particularly the cofacilitators, can collaborate with the technology coordinator and/or the teacher partner in the following ways:

- Advocate, educate, and initiate for continuous improvement in learning resources, conditions, and support for mathematics and science learning.
- Provide feedback to the teacher partner about community concerns and interest.
- Locate support and materials for technology advancement of the team's action plan priorities.
- Help identify needs of mathematics and science programs.
- Help secure funds needed to outfit laboratories and purchase equipment.
- Link with business leaders via e-mail to exchange information about mathematics/science requirements at job sites.
- Develop resource documents listing businesses and how each uses mathematics and science.
- Share information obtained through ARSI resource collaboratives.
- Involve the technology coordinator and teacher partner in working with community members at special events and functions.
- Communicate the school's needs and achievements (progress toward goals) to the community.

The following 10 principles indicate what community engagement teams can do:

1. Provide training opportunities for teachers, community members, parents, students, and concerned citizens.
2. Join with PTA and other school-based committees, work-based initiatives, and Eisenhower consortium groups to write proposals for additional funding.

3. Work with parents to encourage and support student learning in mathematics and science.

4. Participate in understanding the school's vision for science and mathematics learning and determine how curriculum standards will be developed, implemented, and assessed.

5. Support and promote exemplary mathematics and science practices—opportunities where mathematics and science come alive and teachers and students discover community resources (people, places, policies) that draw upon math and science every day.

6. Improve and expand communication about mathematics and science learning among teachers, students, parents, community members, and businesses and distribute newsletters, brochures, and fact sheets.

7. Convene public meetings to conduct conversations about the importance of science, mathematics, and technological literacy.

8. Leverage additional resources for science and mathematics learning through collaboration with civic and business organizations, coalitions, alliances, and networks.

9. Form dynamic, purposeful partnerships that "get things done." Partnerships can plan and carry out educational projects that meet local school needs. For example, it might decide to assemble learning kits, coordinate field trips, establish homework clubs, locate tutors, or set up Internet access.

10. Advise and support efforts of school leadership, school district administrators, and school board members to set and act on policies that encourage parent and community involvement in the mathematics and science education of all students.

Step Four:
Submit a Descriptive Profile to Your Resource Collaborative Director and to the ARSI Community Engagement Person

Community profiles help identify local assets, resources, conditions, and activities and reveal gaps, barriers, or needs. To generate such a profile, the team will need to do the following:

- Collect current information on school mathematics and science programs.
- Identify existing community activities that support math and science learning.
- Review the school improvement plan.
- Prepare a profile of school and community relations.
- Map community resource agencies working with the school.

Here are some suggestions that might help you define existing school and community characteristics related to mathematics and science:

- Describe mathematics and science programs in your school, using available test scores, grade distributions, course selection booklets, and class enrollments to make your points.
- Describe the kinds of community activities that already support mathematics and science learning in your school.
- Define how community engagement might strengthen your existing school improvement plan.
- Describe the nature of school-community relations in your school.
- Show the community which resource agencies are working with the school.

Step Five:
Complete a Self-Assessment Profile

The Community Engagement Self-Assessment Profile helps the team to set benchmarks and can be used to continually gauge progress and results. Individual team members may complete the self-assessment profile on their own, but the team's final profile should represent a composite rating that reflects a consensus of opinion based on thorough discussion of each item. The profiling process may not compile all of the information a community engagement team wants for their community, but provides some direction and assistance in developing an action plan. For this reason it is important for the team to accurately rate the degree to which each community engagement indicator is present in its community.

The form is divided into three sections: Community Demographic Information, Community Support for Science, and Community Support for Mathematics. The community demographic information can be assembled from school system data, county development authority data, public service agencies, churches, businesses, and other community agencies. Census data can also be used. (Some census data can be found on the Internet at http://govinfo.kerr.orst.edu/usaco-stateis.html.

The Community Support for Science section has 11 community engagement indicators that can be rated on a low-to-high scale. Each team is asked to rate the indicator statements. The number on the scale should be the result of a consensus of the group after discussion of each indicator, rather than having each team member rate each statement and averaging the scores. The team should summarize its reasons for the rating in the space provided under the rating scale. The reasons give important directions for the team in considering what actions are needed to improve the rating if it is lower than desired. A statement should be made to support the reason for the rating. If the rating for a particular indicator statement is low, the team may want to consider addressing the issue when the action plan is developed.

The Community Support for Mathematics section is completed in the same manner as the science section. The ARSI Community Engagement Self-Assessment Profile form, which begins on the following page, may also be downloaded from the Internet at http://www.arsinet.org.

Each indicator can be rated in this manner, and a reason for the answer can be written in the "rating justification" area. Three blank continuums are included at the end so that teams can develop and include indicators specific to their communities. If you have questions or comments about the self-assessment profile, please contact your ARSI resource collaborative director or Ben Dickens, the ARSI contact for community engagement, at 1-800-624-9120, or e-mail dickensb@ael.org.

Community Engagement Self-Assessment Profile

Sample Response—Part Two, Item 1

1. Students have access to a high quality, standards-based science curriculum

Low 0 1 2 3 4 5 6 X 8 9 10 High

Rating justification: The science curriculum at the school is based on national and state standards.

Community Engagement Self-Assessment Profile

Part One: Community Demographic Information

Population__________

Household Type and Presence and Age of Children__________

School Enrollment and Type of School__________

Educational Attainment__________

Industries__________

Occupations__________

Median Household Income__________

Business Types__________

Civic Organizations__________

Churches/Religious Organizations__________

Education-Related Organizations__________

Social Service Agencies__________

Technology Usage in the Community__________

Other__________

Define your community__________

Part Two: Community Support for Science

1. Students have access to a high-quality, standards-based science curriculum.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

2. Community leaders recognize the need for student achievement in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

3. Community members assist students in academic achievement in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

4. Civic organizations recognize students who excel in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

5. The community is used as a learning laboratory for science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

6. Local media (TV, radio, the press, etc.) recognize the success of students in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

7. Community members value the need for students to achieve in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

8. School board policies encourage a high-quality, standards-based science program.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

9. Local community financial resources are sufficient and leveraged to support a high-quality, standards-based science program.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

10. Data are collected and used in improving science opportunities for students.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

11. The community supports continuous professional development of teachers in science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

Part Three: Community Support for Mathematics

12. Students have access to a high-quality, standards-based math curriculum.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

13. Community leaders recognize the need for student achievement in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

14. Community members assist students in academic achievement in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

15. Civic organizations recognize students who excel in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

16. The community is used as a learning laboratory for mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

17. Local media (TV, radio, the press, etc.) recognize success of students in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

18. Community members value the need for students to achieve in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

19. School board policies encourage a high-quality, standards-based mathematics program.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

20. Local community financial resources are sufficient and leveraged to support a high-quality, standards-based mathematics program.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

21. Data are collected and used in improving mathematics opportunities for students.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

22. The community supports continuous professional development of teachers in mathematics.
Low 0 1 2 3 4 5 6 7 8 9 10 High
Rating Justification:

23. All students achieve acceptable levels of performance.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

24. The school has an active community engagement team that is successful in improving student performance.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

Other

25. The community encourages teachers to seek recognition for teaching effectiveness.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

26. Parents are well informed about their school's mathematics and science curricula.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

27. Teachers communicate with parents concerning the achievement level of their child/children in mathematics and science.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

Use the following three continuums to develop indicators specific to your community:

28. ____.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

29. ____.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

30. ____.

Low 0 1 2 3 4 5 6 7 8 9 10 High

Rating Justification:

Step Six:
Understand the School's Vision for Mathematics and Science

Each state has different structures and processes for reaching consensus on learning standards in science and mathematics. Community engagement teams may invite additional teachers, administrators, or specialists to present and help explain the school's vision for improved mathematics and science learning. Here are some discussion questions that can facilitate an understanding of the school's vision:

- How does each school's improvement plan specifically address improving student achievement in mathematics and science?
- How does the school's improvement plan address the involvement of parents and community members in increasing student achievement in mathematics and science?
- How does the school's improvement plan address the use of technology for increasing student achievement in mathematics and science?

Step Seven: Develop a Plan of Action

A plan of action for implementing the community engagement team's vision involves taking these steps:

- Set priorities for action based on indicator ratings and community support potential.
- Choose the top three areas in need of further attention by your school and community.
- Identify resources, talents, and interests on your team that relate to the action areas you have selected.
- Complete the ARSI Action Plan Work Sheet to show the specific steps you will take to expand community engagement from your current rating (benchmark) to a desired rating level.
- Consider initiating team projects likely to focus team action and community involvement on results.

The ARSI Action Plan Work Sheet and the ARSI Action Plan Checklist that follow are helpful guides to formulating a plan based on these factors.

Sample Entry: ARSI Action Plan Work Sheet

Action Plan						
Indicator	**Current Rating**	**Projected Rating**	**Person(s) Responsible**	**Time Line**	**Expected Results (Impact)**	**Required Actions**
Civic organizations recognize students who excel in science	2	5	Jim Brown Mary James	May/June	List of civic organizations to approach and have as a resource	Identify civic organizations in the community

Action Plan

Indicator	Current Rating	Projected Rating	Person(s) Responsible	Time Line	Expected Results (Impact)	Required Actions
32						33

Action Plan Checklist

- o Our action plan identifies specific goals we expect to achieve through collaboration in the ARSI project.
- o Our action plan includes a schedule of essential tasks, actions, projects, and events that will lead to the results we have identified as desirable.
- o Our action plan identifies who is responsible for carrying out activities necessary to complete each task, action, project, or event.
- o Our action plan includes a budget to support and sustain our efforts and identifies other community resources we will visit, consult, or use in achieving our goals.
- o Our action plan addresses school policy issues as well as programs and practices that improve learning in science and mathematics. Here are some examples of these policy issues:
  - time for professional development
  - expanded course offerings
  - equity in access and opportunity
  - community involvement and participation
  - incorporation of appropriate technology

Step Eight: Implement the Plan of Action

While there is no "one right way" to bring about meaningful community engagement, there are some practices that seem to work effectively in many settings. Here are some ideas for your community engagement team to consider:

Carry out a team project. Some teams find it useful to select a team project to strengthen communication, improve capacity for coordination, and take better advantage of community resources and personal interests. A popular project theme is environmental education. Examples of possible team projects in this area include collecting data on topics such as storm water runoff, waste water treatment, stream erosion and sedimentation, water quality, nature trails, outdoor learning laboratories, and wildlife sanctuaries. Both the community and the school may benefit from such investigations and from constructions and improvements that may result.

Other partnerships can also put the community in the center of the curriculum. In the Young Eagles program, professional aviators provide instruction in flying. Students apply mathematics and science principles while developing an appreciation for and understanding of local resources and economics.

Set short-, mid-, and long-range goals. Your short-range targets should be completed within a few months. A mid-range goal might take six months to a year. A long-range goal might take from one to three years to realize.

Use ARSI resources in carrying out your community engagement initiatives. Resources for community engagement teams are available on the ARSI Web page at http://www.arsinet.org. The ARSI listserv is an electronic discussion list for membership by community engagement team facilitators. To join the list, send an e-mail message to listserv@listserv.appstate.edu; leave the subject line blank. In the body of your message, type *subscribe CE*; you will receive a message confirming your membership and further instructions for posting messages or unsubscribing from the list.

Through the ARSI resource collaborative serving your community engagement team, you will be able to learn more about the implementation aims of ARSI, make connections between your school needs and other resource partners, learn about training opportunities for community engagement team members, get help finding resource persons and workshop leaders, learn more about curriculum development, and get advice on building your local action plan. The ARSI resource collaborative can assist you with auditing your team effectiveness or facilitating a meeting for community engagement teams and facilitators. It can also help you connect to other service providers in and beyond your service region. The community engagement facilitators should call their resource collaborative director and ask for information, materials, and sources of assistance. Resource collaboratives are located at the following institutions:

Marshall University
Research & Development Center
1050 4th Avenue
Huntington, WV 25755
Ph: 888-262-3006 or 304-696-6373
Fax: 304-696-6248

University of Kentucky
Breckenridge Hall, Room 413
Lexington, KY 40506-0056
Ph: 888-257-4836 or 606-257-4915
Fax: 606-257-5640

Clinch Valley College
1 College Avenue
Wise, VA 24293-0016
Ph: 800-560-4298 or 540-328-0319
Fax: 540-328-0233

Ohio University
129 McCracken Hall
Athens, OH 45701
Ph: 888-258-0118 or 740-593-0118
Fax: 740-593-9698

University of Tennessee
UT—Knoxville Conference Center
600 Henley, Suite 312
Knoxville, TN 37996
Ph: 888-459-4620 or 423-974-4001
Fax: 423-974-6436

Step Nine: Monitor Progress Toward Results

Part of keeping your community engagement program on track is monitoring progress. Here are some ways you can do this.

Review goals regularly. Are they still the right goals to be working on? Have you discovered other needs that are more pressing or that must be addressed before you can take action on your initial goal?

Identify milestones for achievement up front. For example, if Family Math or Family Science nights are important start-up goals for your community engagement effort, when should they be held and how many people should be involved in them? You can't hit a target you can't see. Identifying numbers of anticipated attendees, numbers of anticipated sessions, and types of cosponsoring organizations may help you determine that your goals have been partially or fully reached.

Say it with a picture. Chart your progress using time lines or a flow chart so you and your team members will know at a glance where you started, where you are right now, and where you expect to be six months or a year from now.

Assess the impact. Are team actions creating an increase in the rating awarded for the indicator the team is trying to impact?

Step Ten: Report and Use Collected Data

Use both interim and end-of-year reports to keep your local school board, superintendent, principal, area coordinators, business partners, and other agency partners aware of and informed about your goals and the progress you are making toward them. Be sure to send a copy to your ARSI resource collaborative director and the ARSI community engagement contact person. These reports do not have to be long documents—just a few pages and a cover is enough. They should summarize for the reader

- what community engagement indicators and ratings you sought to improve and why they are important,
- what actions you took to improve the performance in the selected indicator areas,
- what results you got (support your assertion with numbers and statistics whenever possible),
- who was involved, and
- how you will use the experience to recommend further action steps.

The document you create could include, where possible, photographs, drawings, or other graphics to convey important ideas. Be sure to include a team success story that can be placed on the ARSI Web page so other schools can learn from your efforts. A report for key policymakers, decision makers, and partners can serve additional duty as a newspaper release, a Web page "blurb," or a meeting handout to inform and attract additional team members. The important thing is to share results with others.

Defining *systemic reform* in mathematics and science education. *Systemic reform* involves working to align all parts of the system rather than just focusing effort on one or two isolated pieces. Systems thinking requires an eye for the whole chessboard and concentrates on the relationships between the parts as well as the parts themselves. Practical considerations may require the need to proceed incrementally—but within a grand design. Key elements in the systemic reform of science and mathematics include

- cultivating high expectations for successful learning in science and mathematics for all students;
- clearly defining standards for mathematics and science proficiency;
- providing access to basic resources—books, equipment, supplies, and laboratory facilities;
- encouraging greater parental and community involvement in supporting learning in mathematics and science;
- forging closer links between formal and informal learning experiences;
- expanding opportunities in professional development;
- making greater use of technology available in school or community library/media centers;
- initiating partnerships with businesses and community agencies;
- developing or selecting challenging curricula that incorporate the community as a resource;
- implementing instructional practices that require active student processing of ideas and information;
- using multiple assessment measures to gauge student understanding, reasoning, and problem solving; and
- creating resource specialists to build capacity for change.

Step Eleven: Celebrate Success

Neither the community engagement team nor its leaders will get far on an empty stomach or empty spirits. There are a number of things the team can do to promote teamwork, unity, and sense of purpose and progress. One is to serve some kind of light refreshment at every team meeting. Another is to hold a celebratory breakfast, lunch, or dinner after the achievement of a program milestone. Here are some ways to say thanks to those whose patience, planning, and performance has paid off.

- Hold a special dinner or banquet to recognize faculty and students who are fulfilling the team's vision for math and science performance.
- Hold a special orientation meeting to recruit new members. This gets existing team members in the habit of speaking positively about team membership.
- Assemble a team manual containing goals and action plans, with short biographical sketches on each team member.
- Invite special guests to attend celebration meetings. These guests may include community members who have not participated in your events . . . yet.
- Complete a press-release form that lists the persons from your community who attend an ARSI leadership academy. Send it to your local paper.
- Call a team member (after hours, on the weekend) just to say thanks for their efforts.
- Recognize team and community members who participate in training sessions offered by technical assistance partners of your ARSI resource collaborative.

How to know that you have succeeded. A clear vision for improved science and mathematics learning is vital to effective community engagement. It's important to recognize and celebrate milestones that tell you you're making progress. Don't let such achievements as these go unnoticed.

- Standards for strong mathematics and science programs are widely understood and supported in the district.
- School and community leaders engage in frequent networking and information-sharing meetings.
- Teachers have ongoing instructional support; both teachers and students are using new technologies to enhance science and mathematics learning.
- More resources for science and mathematics learning have been generated through increased communication, coordination, and collaboration.
- Relationships among curriculum, instruction, and assessment have become more aligned and less separate.

Step Twelve: Renew Commitments and Action Plans

The final step in the community engagement implementation process is for the team to review action plans and accomplishments, renew its commitment to team purposes and goals, and decide how to further act on what it has learned. Facilitators should direct the team to do the following:

- Go back to the original indicator list.
- Think more about what you already know you can do well and expand on it.
- Choose one indicator area that will be a stretch goal (requiring the development of new knowledge or skill) for your team.
- Choose one indicator area where you might "scale-up" or go from just one school to a districtwide focus.

Community Engagement Team Planning Sheet

Use this form to document actions and progress toward goals.

Data Collection	**Date**
1. Obtain and review community engagement section of the school's improvement (transformation) plan.	
2. Review current information on achievement of students at the school in mathematics and science.	
3. Identify current community activities supporting student achievement in math and science.	
4. Develop a profile of additional community activities that support student achievement in math or science at school.	
5. Identify resource partners (agencies) working with (in) the school.	
Development of Action Plan	
1. Complete Community Self-Assessment Profile and Benchmarking.	
2. Develop action plan based on profile.	
3. Prioritize action plan.	

4. Identify community resources available to implement action plan.	
5. Identify role and responsibility of community engagement team members.	
6. Develop time lines for action plan implementation.	
7. Attend ARSI regional community engagement workshop(s).	
Implementation of Action Plan 1. Access community resources.	
2. Connect with the Resource Collaborative and technical assistance partners.	
3. Involve all team members in planning implementation.	
4. Solicit broad-based community participation.	
5. Conduct periodic self-assessment to measure progress and achievements.	

Section Four
Characteristics of Quality Mathematics and Science Programs

This section of the manual can help facilitators understand key concepts in science and mathematics learning. The next few pages discuss critical elements, standards, and practices for high-quality mathematics and science programs; name barriers to creating such programs; and identify hallmarks of good professional development programs for teachers. Facilitators may want to share this information with team members so that they can build a shared vocabulary and a set of understandings based on current thinking in mathematics and science reform. Facilitators should also help team members become familiar with the national science and math standards summarized, respectively, in Appendix A and Appendix B. Teams can use this knowledge to guide the development of projects and initiatives that will have a lasting impact on science and mathematics programs and the students for which they are designed.

Critical Elements of School Science Programs

High-quality science programs challenge both teachers and students to continually increase their knowledge and use of scientific concepts and subject matter. Support from the school administration and from the community allows teachers to take advantage of local knowledge and to provide enrichment opportunities for students. Schools with quality school science programs are distinguished by the following elements.

Hands-on approach. Science is the active investigation of objects, ideas, and natural events. In strong school science programs, students have opportunities to *do* science, not just hear about it, read about it, or recite facts and principles from memory. This includes opportunities to *do* the following:

- Observe: Pay close attention; look at something in detail.
- Question: Decide what you would like to know more about.
- Predict: Use what you already know to guess what will happen next.
- Experiment: Set up a plan to find out if your ideas are right; an important part of an experiment is the collection and display of data.
- Make generalizations: Draw conclusions based on repeated experiments and the analysis of trends and patterns in the data.
- Build models: Show the relationships between parts of complex events and systems by using three-dimensional forms, mock-ups, flow charts, or other representations.

Standards-based curriculum units. It is important to relate mathematics and science activities to learning standards. Teachers should ask themselves: Will doing the activities in a self-contained unit help students learn important facts and principles? Will the activities help students practice inquiry skills? Will they help students learn to make and use tools to solve problems and engage students in reflecting on the impact of science and technology on society?

Common materials center. In strong science programs, students have access to equipment and materials that help them actively engage in scientific investigations. A common materials center is one way to avoid costly duplication, pool resources, and maintain access to quality learning materials. Organizing materials into kits or purchasing modular units from supply houses can be an economical way to share resources among several schools, grade levels, or courses.

Ongoing in-service opportunities for teachers. Many teachers may not have in-depth knowledge of the subjects they are teaching. Ongoing opportunities to participate in in-service sessions led by practicing scientists, college or university teachers, consultants, and trainers can help teachers develop stronger foundational knowledge, learn to use new equipment and techniques, and develop a stronger vision for changes needed in local curriculum, instructional strategies, and assessment methods.

Community and administrative support. None of the changes in how students learn science, what science they learn, what materials they work with, or what professional development teachers will receive are likely to occur without involving, including, and informing the community and school administrators. Site facilitators must work especially hard to ensure that the need for good science learning is understood by the community, takes place within the community, and is sanctioned and encouraged by school-level and district administrators.

Challenging concepts and subject matter. Science activities enable students to connect their observations and experiences with prior knowledge and to challenge and clarify their understanding of the way things work.

Learning activities that develop the mental habits of scientific inquiry. These habits include careful observation, curiosity, skepticism, and respect for evidence, including repeated testing and analysis of facts.

Programs accessible to all students. Students from all cultures, ethnic groups, and genders actively participate in classroom activities.

Appropriate use of technology. Technology is used as the tool for collecting, organizing, displaying, exchanging, and analyzing data.

Integration and continuity among various fields of science. Students experience the interconnectedness of life, earth, space, and physical science each year.

Proper assessment. Assessment of student learning is ongoing and based on using multiple measures of student progress.

Raising Learning Standards in Mathematics

It takes more than addition, multiplication, subtraction, division, and carrying over to add up to a strong mathematics program today. Skills in whole number operations are still important, but the types of mathematical thinking required in today's workplace include the following:

- logical reasoning
- analysis of trends and patterns in data
- estimation
- probability
- statistics
- understanding of geometric shapes and proportion

What are some ways to achieve these new standards in our elementary, middle, and high schools? Many educators argue that students learn mathematical rules, skills, and principles best when they are engaged in actions that allow them to

- use hands-on manipulatives (physical objects that can be manipulated to demonstrate proportion and relationships),
- build three-dimensional models to demonstrate and explain principles and relationships,
- relate mathematical concepts to real-world applications,
- actively process or apply what has just been taught through a variety of frequent and readily available opportunities,
- engage in small-group problem solving designed to provide full and simultaneous participation,
- participate in substantive communication using mathematical ideas, and
- explain their thinking by providing both oral and written arguments and evidence.

Barriers to High-Performance Science and Mathematics Programs

The following characteristics are barriers to high-quality mathematics and science programs:

- outdated textbooks
- inadequate undergraduate preparation of teachers
- lack of in-service opportunities
- no laboratory facilities (water, electricity, space)
- shortage of basic instruments and equipment
- fewer minutes of classroom time allotted for instruction
- tests not aligned with curriculum
- assessments limited to factual recall with no demonstration of understanding
- low enrollments of women/minorities in upper-level courses
- no sense of urgency to take action

Common Threads: Weaving Together Strong Practices in Teaching Science and Mathematics

The following summary represents a set of organizing principles for planning science and mathematics programs. In some cases, these eight items represent the challenges and dilemmas that face classroom teachers on a day-to-day basis.

1. Balance the need to provide breadth (coverage of the curriculum) with depth (demonstration or application of skills through a project or investigation).
2. Find ways for students to explain to each other and to the teacher what they know and can do. The learning is in the talk. The person who does the most talking does the most learning. Use peer tutoring, paired problem solving, drill partners, and cooperative logic problems to get students speaking mathematically and scientifically. Student learning is enhanced by student teaching.
3. Let student questions and interests fuel the inquiry. Allow some choice in topics for investigation or formats for reporting.
4. Help students produce new knowledge as well as use existing knowledge. Projects and community investigations can provide opportunities for students to collect, organize, display, and analyze data.
5. Recognize that performances require audiences. Help your students present to an audience beyond the classroom or the school.
6. Use the community as a learning resource. This helps relate class work to everyday applications and may put students in contact with other adults who actually use on the job what they learned in school.
7. Vary both learning activities and assessment strategies. Blur the distinction between learning and assessing. Consider using portfolios, peer reviews, products, performances, and open-ended question responses in your assessment mix.
8. Identify ways to use technology appropriately in the mathematics and science curriculum. Teachers who use a variety of technology tools in mathematics and science learning report that technology increases student motivation (and, therefore, receptivity and engagement), gives students with different talents a chance to excel, encourages teacher-as-coach approaches, and fosters improved oral and written communication.

High-Quality Professional Development Experiences

The purpose of professional development is to improve student learning through increased knowledge, skill, and problem-solving capacity among educators and other community stakeholders. High-quality professional development is marked by variety and flexibility in duration, intensity, and frequency, and provides opportunities for participants to do the following:

- Understand both the broad goals and specific objectives of the program.
- Experience or simulate the roles/tasks for which they are being prepared.
- Learn about opportunities for continuing education and networking.
- Use a variety of materials and engage in activities that illustrate key concepts.
- Work in safe, comfortable environments that promote practice of new skills and application of new tools.
- Serve as teachers and resources to each other.
- Build a learning community—a social system based on mutual respect and trust.
- Assess their own learning and reflect on program components.
- Generate new information or commitments that are shared with the whole group.
- Learn where they can acquire additional knowledge, skills, resources, and support.
- Exercise choices in determining individual or team learning needs.
- Develop new insights about themselves, their team, or their organization.
- Create practical products, clearer understandings, and usable plans related to the work back home.
- Achieve a stronger sense of how groups performing different roles can contribute to a common purpose.
- Identify relationships between different system components that have an effect on the implementation of proposed changes or plans.
- Discover where and how to obtain specific materials (handbooks, guides, references, diagnostics, self-assessments, tools, plans, etc.).
- Practice responding to persons who may threaten or attack another role group.
- Receive public recognition (certificate, award, credit, etc.) for attendance and participation.
- Learn even more about the content and skills of their disciplines.

Section Five:
What Does Quality Mathematics and Science Education Mean for Students in Appalachia?

Today demands are placed on citizens to interpret and use complex information to make choices. Quality school mathematics and science programs are needed to meet these demands because they include opportunities for students to do the following:

- learn mathematics and science content
- develop reasoning skills
- think creatively
- make informed decisions
- solve problems

Quality Mathematics Education

Students' mathematics education goes far beyond the pencil-and-paper computation and memorization that much of society has learned in the past. Students today must also be able to apply what they learn.

More than 10 years ago, mathematics teachers from across the country assisted in developing national standards that include the opportunity for all students to master the traditional basic skills, but also supports instruction that allows students to do the following:

- learn to value mathematics—know that mathematics is important
- become confident in one's ability to do mathematics—be capable of mastering mathematical skills
- become mathematical problem solvers—use multiple approaches and identifying which approach offers the most efficient method for solving the problem
- learn to communicate mathematically—know the signs and symbols and be able to read, write, and discuss mathematics
- reason mathematically—gather evidence and make decisions based on a thorough understanding of mathematics principles and practices

Mathematics instruction for students focuses on subject content that includes developing the mathematics skills necessary for advanced study and for competition in today's workforce. These workforce requirements mean that students need to be mathematically literate; they need to know more about mathematics than just arithmetic. They need to have a basic knowledge of algebraic concepts, geometry, and calculus in order to compete in today's technological job market.

For grades K-4, mathematics uses concrete objects (manipulatives) to demonstrate and develop meaning for mathematical concepts and ideas, while in grades 5-8, the focus is more on problem solving and beginning algebra. High school mathematics courses prepare students for both college and the workforce. Experiences are usually offered in many areas of mathematics, with Algebra I and geometry being minimum requirements. Failing to study mathematics closes many doors to both college opportunities and technical-vocational careers—a lesson often learned too late by students in Appalachia.

Quality Science Education

A change is also occurring in today's science classrooms. Today's classrooms don't look like those from a decade ago, when learning biology meant learning a foreign language by memorizing vocabulary words and processes. Science instruction now includes opportunities for students to become more involved in the processes of scientific inquiry—to make hypotheses about what will occur during an experiment, conduct the experiment, and draw conclusions based on the results. Today's science classrooms include the active participation of every student, not just teacher demonstrations.

Science teachers took their lead from the mathematics community and developed national guidelines for what students should know and be able to do in science. These standards advocate learning science through an approach that is not only *hands-on* but also *minds-on*, providing students with opportunities to

- know about and understand the natural world;
- use appropriate scientific processes and principles to make personal decisions;

- engage in discussions and debates about scientific and technological issues; and
- use their knowledge, skills, and understanding of science to increase their ability to be productive in challenging careers of the 21st century.

When asked what they remember most about school science learning experiences, many individuals recall dissecting frogs and chemistry experiments. We remember these specific things because they went beyond what we think of as ordinary science learning and provided hands-on experiences. Science classes still require memorizing basic scientific ideas, but also permit opportunities for students to actively participate in their own learning.

Content standards in science are organized around the major strands of science, which are centered on the notion of science as inquiry, and include physical science, life science, and earth and space science. Science content also includes the relationship of science to technology, the history and nature of science, and science from a personal and social perspective. Teachers facilitate the learning of science by providing students with the big picture of scientific concepts and then allowing students to build on this knowledge.

Quality Classrooms

Quality classrooms involve *doing*. They are places where students are actively investigating, not just reading about, mathematics or science. Students should be actively engaged in productive practices:

- Observation: paying close attention and looking at something in detail
- Questioning: deciding what additional information is needed
- Predicting: using what is already known to guess what will happen next
- Experimenting: set up a plan to find out if the ideas are right and collecting and displaying data
- Generalizing: drawing conclusions based on repeated experiments and analyzing trends and patterns in the data
- Constructing models: using a physical model to show the relationship between parts of complex events and systems. (For example, an open box or rectangular container could be used to experiment and verify that the mathematical formula for calculating the volume of the box is correct.)

Classrooms that use quality mathematics and science instructional practices often use technology to improve student learning. Computers, graphing calculators and probes, and scientific calculators are used to facilitate problem-solving opportunities. These devices are not intended to take the place of computation skills, but to enable students to be successful with more difficult problem-solving situations.

In classrooms where there is quality teaching and learning in mathematics and science, and where both teachers and students are actively engaged in classroom interactions, student performance will increase. Teachers pose questions that require students to think and investigate to arrive at solutions to problems and actively participate in their own learning. Students develop understandings of meaning for mathematics and science that make sense to them and can be applied to other situations.

Where can I find more information about quality mathematics and science education?

For more in-depth information regarding quality mathematics and science teaching and learning, ARSI recommends the following publications:

National Science Education Standards. National Academy Press, 800-624-6242. $15.00

Curriculum and Evaluation Standards for School Mathematics. National Council of Teachers of Mathematics, 703-620-9840. $25.00

Parents in the Know: You Can Help Your Child Succeed at Math and Science. Kentucky Science and Technology Council, 606-233-3502, ext. 228. No cost to Kentucky communities; outside Kentucky must pay shipping only.

EdTalk: What We Know About Mathematics Teaching and Learning. Eisenhower Regional Mathematics and Science Consortium at Appalachia Educational Laboratory, 800-624-9120. $5.00

EdTalk: What We Know About Science Teaching and Learning. Eisenhower Regional Mathematics and Science Consortium at Appalachia Educational Laboratory, 800-624-9120. $5.00

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Web Sites

http://www.fdncenter.org

The Foundation Center is a nonprofit information clearinghouse for information about foundations, corporate giving, and philanthropy. A good first step in researching what funding sources are available to support your community engagement initiatives.

http://www.ed.gov/pubs/Compact

Order a free copy of *A Compact for Learning: An Action Handbook for School-Family-Community Partnerships.*

http://www.aisr.brown.edu

The Annenberg Institute for School Reform maintains a Web site on issues in public engagement, building local capacity, and rethinking issues in accountability. A good source for information about public engagement research.

http://www.ncrel.org/sdrs/areas/issues/envrnment/css/ppt/putting.htm

Putting the Pieces Together: Comprehensive School-Linked Strategies for Children and Families helps local leaders build collaborative partnerships, conduct community assessments, find and develop resources, evaluate their school-linked strategies, and maintain momentum in their collaboration.

Appendix A
National Science Education Standards: An Overview

The National Academy of Sciences, working with hundreds of educators, scientists, and parents, developed *National Science Education Standards*, published in 1996. The Standards, described as "a vision of a scientifically literate populace," outline what students should know, understand, and do to be scientifically literate at different grade levels.

In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. And everyone deserves to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world.

Scientific literacy also is of increasing importance in the workplace. More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science and the processes of science contributes in an essential way to these skills. Other countries are investing heavily to create scientifically and technically literate work forces. To keep pace in global markets, the United States needs to have an equally capable citizenry.

The National Science Education Standards present a vision of a scientifically literate populace. They outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels. They describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. The Standards point toward a future that is challenging but attainable—which is why they are written in the present tense.

The intent of the Standards can be expressed in a single phrase: Science standards for all students. The phrase embodies both excellence and equity. The Standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. Different students will achieve understanding in different ways, and different students will achieve different degrees of depth and breadth of understanding depending on interest, ability, and context. But all students can develop the knowledge and skills described in the Standards, even as some students go well beyond these levels.

By emphasizing both excellence and equity, the Standards also highlight the need to give students the opportunity to learn science. Students cannot achieve high levels of performance without access to skilled professional teachers, adequate classroom time, a rich array of learning materials, accommodating work spaces, and the resources of the communities surrounding their schools. Responsibility for providing this support falls on all those involved with the science education system.

Implementing the Standards will require major changes in much of this country's science education. The Standards rest on the premise that science is an active process. Learning science is something that students do, not something that is done to them. "Hands-on" activities, while essential, are not enough. Students must have "minds-on" experiences as well.

The Standards call for more than "science as a process," in which students learn such skills as observing, inferring, and experimenting. Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills.

The importance of inquiry does not imply that all teachers should pursue a single approach to teaching science. Just as inquiry has many different facets, so teachers need to use many different strategies to develop the understandings and abilities described in the Standards.

Nor should the Standards be seen as requiring a specific curriculum. A curriculum is the way content is organized and presented in the classroom. The content embodied in the Standards can be organized and presented with many different emphases and perspectives in many different curricula.

Instead, the Standards provide criteria that people at the local, state, and national levels can use to judge whether particular actions will serve the vision of a scientifically literate society. They bring coordination, consistency, and coherence to the improvement of science education. If people take risks in the name of improving science education, they know they will be supported by policies and procedures throughout the system. By moving the practices of extraordinary teachers and administrators to the forefront of science education, the Standards take science education beyond the constraints of the present and toward a shared vision of the future.

Hundreds of people cooperated in developing the Standards, including teachers, school administrators, parents, curriculum developers, college faculty and administrators, scientists, engineers, and government officials. These individuals drew heavily upon earlier reform efforts, research into teaching and learning, accounts of exemplary practice, and their own personal experience and insights. In turn, thousands of people reviewed various drafts of the standards. That open, iterative process produced a broad consensus about the elements of science education needed to permit all students to achieve excellence.

Continuing dialogues between those who set and implement standards at the national, state, and local levels will ensure that the Standards evolve to meet the needs of students, educators, and society at large. The National Science Education Standards should be seen as a dynamic understanding that is always open to review and revision.

Organization of the Standards

After an introductory chapter and a chapter giving broad principles and definitions of terms, the National Science Education Standards are presented in six chapters:

- standards for science teaching (Chapter 3)
- standards for professional development for teachers of science (Chapter 4)
- standards for assessment in science education (Chapter 5)
- standards for science content (Chapter 6)
- standards for science education programs (Chapter 7)
- standards for science education systems (Chapter 8)

For the vision of science education described in the Standards to be attained, the standards contained in all six chapters need to be implemented. But the Standards document has been designed so that different people can read the standards in different ways. Teachers, for example, might want to read the teaching, content, and program standards before turning to the professional development, assessment, and systems standards. Policy makers might want to read the system and program standards first, while faculty of higher education might want to read the professional development and teaching standards first, before turning to the remaining standards.

Science Teaching Standards

The science teaching standards describe what teachers of science at all grade levels should know and be able to do. They are divided into six areas:

- the planning of inquiry-based science programs
- the actions taken to guide and facilitate student learning
- the assessments made of teaching and student learning
- the development of environments that enable students to learn science
- the creation of communities of science learners
- the planning and development of the school science program

Effective teaching is at the heart of science education, which is why the science teaching standards are presented first. Good teachers of science create environments in which they and their students work together as active learners. They have continually expanding theoretical and practical knowledge about science, learning, and science teaching. They use assessments of students and of their own teaching to plan and conduct their teaching. They build strong, sustained relationships with students that are grounded in their knowledge of students' similarities and differences. And they are active as members of science-learning communities.

In each of these areas, teachers need support from the rest of the educational system if they are to achieve the objectives embodied in the Standards. Schools, districts, local communities, and states need to provide teachers with the necessary resources—including time, appropriate numbers of students per teacher, materials, and schedules. For teachers to design and implement new ways of teaching and learning science, the practices, policies, and overall culture of most schools must change. Such reforms cannot be accomplished on a piecemeal or ad hoc basis.

Considerations of equity are critical in the science teaching standards. All students are capable of full participation and of making meaningful contributions in science classes. The diversity of students' needs, experiences, and backgrounds requires that teachers and schools support varied, high-quality opportunities for all students to learn science.

Professional Development Standards

The professional development standards present a vision for the development of professional knowledge and skill among teachers. They focus on four areas:

- the learning of science content through inquiry
- the integration of knowledge about science with knowledge about learning, pedagogy, and students
- the development of the understanding and ability for lifelong learning
- the coherence and integration of professional development programs

As envisioned by the Standards, teachers partake in development experiences appropriate to their status as professionals. Beginning with preservice experiences and continuing as an integral part of teachers' professional practice, teachers have opportunities to work with master educators and reflect on teaching practice. They learn how students with diverse interests, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all students. They study and engage in research on science teaching and learning, regularly sharing with colleagues what they have learned. They become students of the discipline of teaching.

Reforming science education requires substantive changes in how science is taught, which requires equally substantive change in professional development practices at all levels. Prospective and practicing teachers need opportunities to become both sources of their own growth and supporters of the growth of others. They should be provided with opportunities to develop theoretical and practical understanding and ability, not just technical proficiencies. Professional development activities need to be clearly and appropriately connected to teachers' work in the context of the school. In this way, teachers gain the knowledge, understanding, and ability to implement the Standards.

Assessment Standards

The assessment standards provide criteria against which to judge the quality of assessment practices. They cover five areas:

- the consistency of assessments with the decisions they are designed to inform
- the assessment of both achievement and opportunity to learn science
- the match between the technical quality of the data collected and the consequences of the actions taken on the basis of those data
- the fairness of assessment practices
- the soundness of inferences made from assessments about student achievement and opportunity to learn

In the vision described by the Standards, assessments are the primary feedback mechanism in the science education system. They provide students with feedback on how well they are meeting expectations, teachers with feedback on how well their students are learning, school districts with feedback on the effectiveness of their teachers and programs, and policy makers with feedback on how well policies are working. This feedback in turn stimulates changes in policy, guides the professional development of teachers, and encourages students to improve their understanding of science.

Ideas about assessments have undergone important changes in recent years. In the new view, assessment and learning are two sides of the same coin. Assessments provide an operational definition of standards, in that they define in measurable terms what teachers should teach and students should learn. When students engage in assessments, they should learn from those assessments.

Furthermore, assessments have become more sophisticated and varied as they have focused on higher-order skills. Rather than simply checking whether students have memorized certain items of information, new assessments probe for students understanding, reasoning, and use of that knowledge—the skills that are developed through inquiry. A particular challenge to teachers is to communicate to parents and policy makers the advantages of new assessment methods.

Assessments can be done in many different ways. Besides conventional paper and pencil tests, assessments might include performances, portfolios, interviews, investigative reports, or written essays. They need to be developmentally appropriate, set in contexts familiar to students, and as free from bias as possible. At the district, state, and national levels, assessments need to involve teachers in their design and administration, have well-thought-out goals, and reach representative groups to avoid sampling bias.

Assessments also need to measure the opportunity of students to learn science. Such assessments might measure teachers' professional knowledge, the time available to teach science, and the resources available to students. Although difficult, such evaluations are a critical part of the Standards.

Science Content Standards

The science content standards outline what students should know, understand, and be able to do in the natural sciences over the course of K-12 education. They are divided into eight categories:

- unifying concepts and processes in science
- science as inquiry
- physical science
- life science
- earth and space science
- science and technology
- science in personal and social perspective
- history and nature of science

The first category is presented for all grade levels, because the understandings and abilities associated with these concepts need to be developed throughout a student's educational experiences. The other seven categories are clustered for grade levels K-4, 5-8, and 9-12.

Each content standard states that as a result of activities provided for all students in those grade levels, the content of the standard is to be understood or certain abilities are to be developed. The standards refer to broad areas of content, such as objects in the sky, the interdependence of organisms, or the nature of scientific knowledge. Following each standard is a discussion of how students can learn that material, but these discussions are illustrative, not proscriptive. Similarly, the discussion of each standard concludes with a guide to the fundamental ideas that underlie that standard, but these ideas are designed to be illustrative of the standard, not part of the standard itself.

Because each content standard subsumes the knowledge and skills of other standards, they are designed to be used as a whole. Although material can be added to the content standards, using only a subset of the standards will leave gaps in the scientific literacy expected of students.

Science Education Program Standards

The science education program standards describe the conditions necessary for quality school science programs. They focus on six areas:

- the consistency of the science program with the other standards and across grade levels
- the inclusion of all content standards in a variety of curricula that are developmentally appropriate, interesting, relevant to student's lives, organized around inquiry, and connected with other school subjects
- the coordination of the science program with mathematics education
- the provision of appropriate and sufficient resources to all students
- the provision of equitable opportunities for all students to learn the standards
- the development of communities that encourage, support, and sustain teachers

Program standards deal with issues at the school and district level that relate to opportunities for students to learn and opportunities for teachers to teach science. The first three standards address individuals and groups responsible for the design, development, selection, and adaptation of science programs—including teachers, curriculum directors, administrators, publishers, and school committees. The last three standards describe the conditions necessary if science programs are to provide appropriate opportunities for all students to learn science.

Each school and district must translate the National Science Education Standards into a program that reflects local contexts and policies. The program standards discuss the planning and actions needed to provide comprehensive and coordinated experiences for all students across all grade levels. This can be done in many ways, because the Standards do not dictate the order, organization, or framework for science programs.

Science Education System Standards

The science education system standards consist of criteria for judging the performance of the overall science education system. They consider seven areas:

- the congruency of policies that influence science education with the teaching, professional development, assessment, content, and program standards
- the coordination of science education policies within and across agencies, institutions, and organizations
- the continuity of science education policies over time
- the provision of resources to support science education policies
- the equity embodied in science education policies
- the possible unanticipated effects of policies on science education
- the responsibility of individuals to achieve the new vision of science education portrayed in the standards

Schools are part of hierarchical systems that include school districts, state school systems, and the national education system. Schools also are part of communities that contain organizations that influence science education, including colleges and universities, nature centers, parks and museums, businesses, laboratories, community organizations, and various media.

Although the school is the central institution for public education, all parts of the extended system have a responsibility for improving science literacy. For example, functions generally decided at the state (but sometimes at the local) level include the content of the school science curriculum, the characteristics of the science program, the nature of science teaching, and assessment practices. These policies need to be consistent with the vision of science education described in the Standards for the vision as a whole to be realized.

Today, different parts of the education system often work at cross purposes, resulting in waste and conflict. Only when most individuals and organizations share a common vision can we expect true excellence in science education to be achieved.

Toward the Future

Implementing the National Science Education Standards is a large and significant process that will extend over many years. But through the combined and continued support of all Americans, it can be achieved. Change will occur locally, and differences in individuals, schools, and communities will produce different pathways to reform, different rates of progress, and different final emphases. Nevertheless, with the common vision of the Standards, we can expect deliberate movement over time, leading to reform that is pervasive and permanent.

No one group can implement the Standards. The challenge extends to everyone within the education system, including teachers, administrators, science teacher educators, curriculum designers, assessment specialists, local school boards, state departments of education, and the federal government. It also extends to all those outside the system who have an influence on science education, including students, parents, scientists, engineers, businesspeople, taxpayers, legislators, and other public officials. All of these individuals have unique and complementary roles to play in improving the education that we provide to our children.

Efforts to achieve the vision of science education set forth in the Standards will be time-consuming, expensive, and sometimes uncomfortable. They also will be exhilarating and deeply rewarding. Above all, the great potential benefit to students requires that we act now. There is no more important task before us as a nation.

Source: National Committee on Science Education Standards and Assessment. (1996). *National Science Education Standards.* Washington, DC: National Research Council.

Appendix B
An Overview of Curriculum and Evaluation Standards for School Mathematics: Background

In 1989, the National Council of Teachers of Mathematics, in conjunction with numerous mathematical and scientific organizations, published *Curriculum and Evaluation Standards for School Mathematics.* The Standards, as they are known, have served as guides for teachers, curriculum developers, supervisors, researchers, and others as they examine their practice and plan new instructional experiences.

Background. These standards are one facet of the mathematics education community's response to the call for reform in the teaching and learning of mathematics. (1) They reflect, and are an extension of, the community's responses to those demands for change. (2) Inherent in this document is a consensus that all students need to learn more, and often different, mathematics and that instruction in mathematics must be significantly revised.

As a function of the National Council of Teachers of Mathematics (NCTM) leadership in current efforts to reform school mathematics, the Commission on Standards for School Mathematics was established by the Board of Directors and charged with two tasks:

1. Create a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields
2. Create a set of standards to guide the revision of the school mathematics curriculum and its associated evaluation toward this vision

The Working Groups of the commission prepared the Standards in response to this charge.

This report is organized into six sections. The Introduction describes the need for standards, discusses the need for new goals, and presents an overview of the standards. The body of the report presents the standards themselves, organized into four distinct sections: K-4, 5-8, 9-

12, and Evaluation. The concluding section outlines the steps necessary to accomplish the needed reform of school mathematics.

Key terms used in the development of this document include these three:

Curriculum. A curriculum is an operational plan for instruction that details what mathematics students need to know, how students are to achieve the identified curricular goals, what teachers are to do to help students develop their mathematical knowledge, and the context in which learning and teaching occur. In this document, the term describes what many would label as the "intended curriculum" or the "plan for a curriculum."

Evaluation. Standards have been articulated for evaluating both student performance and curricular programs, with an emphasis on the role of evaluative measures in gathering information on which teachers can base subsequent instruction. The standards also acknowledge the value of gathering information about student growth and achievement for research and administrative purposes.

Standard. A standard is a statement that can be used to judge the quality of a mathematics curriculum or methods of evaluation. Thus, standards are statements about what is valued.

The Need for Standards for School Mathematics

Historically there have been three reasons for groups to formally adopt a set of standards: (1) to ensure quality, (2) to indicate goals, and (3) to promote change. For NCTM, all three reasons are of equal importance.

First, standards often are used to ensure that the public is protected from shoddy products. For example, a druggist is not allowed to sell a drug unless it meets certain very rigid standards that include both the control of how it was produced and evidence of its effectiveness. Standards in this sense are minimal criteria for quality. They set necessary, but not sufficient, conditions for producing desired results. There is no guarantee that a drug will not be misused or will produce expected results.

Second, standards often are used as a means of expressing expectations about goals. Goals are broad statements of social intent. For example, we can agree that two goals for all tests are that they should be both valid and reliable. The standards for tests developed by the American Psychological Association in 1974 describe the kind of documentation that publishers should provide about the reliability and validity of each test.

Third, standards often are set to lead a group toward some new desired goals. For example, the medical profession has adopted and periodically updates standards for the licensing of specialists based on changes in technology, research, and so on. The intent is to improve or update practices when necessary. In this sense, standards should be seen as "criteria for excellence." They are based on an informed vision of what should be done given current knowledge and experience.

Standards are needed for school mathematics for all three purposes. Schools, teachers, students, and the public at large currently enjoy no protection from shoddy products. It seems reasonable that anyone developing products for use in mathematics classrooms should document how the materials are related to current conceptions of what content is important to teach and should present evidence about their effectiveness. For NCTM the development of standards as statements of criteria for excellence in order to produce change was the focus. Schools, and in particular school mathematics, must reflect the important consequences of the current reform movement if our students are to be adequately prepared to live in the twenty-first century. The standards should be viewed as facilitators of reform.

The Need for New Goals

Our vision of mathematical literacy is based on a reexamination of educational goals. Historically, societies have established schools to—transmit aspects of the culture to the young; direct students toward, and provide them with, an opportunity for self-fulfillment. Thus, the goals all schools try to achieve are both a reflection of the needs of society and the needs of students.

Calls for reform in school mathematics suggest that new goals are needed. All industrialized countries have experienced a shift from an industrial to an information society, a shift that has transformed both the aspects of mathematics that need to be transmitted to students and the concepts and procedures they must master if they are to be self-fulfilled, productive citizens in the next century.

The Information Society. This social and economic shift can be attributed, at least in part, to the availability of low-cost calculators, computers, and other technology. The use of this technology has dramatically changed the nature of the physical, life, and social sciences; business; industry; and government. The relatively slow mechanical means of communication—the voice and the printed page—have been supplemented by electronic communication, enabling information to be shared almost instantly with persons—or machines—anywhere. Information is the new capital and the new material, and communication is the new means of production. The impact of this technological shift is no longer an intellectual abstraction. It has become an economic reality. Today, the pace of economic change is being accelerated by continued innovation in communications and computer technology.

New Societal Goals. Schools, as now organized, are a product of the industrial age. In most democratic countries, common schools were created to provide most youth the training needed to become workers in fields, factories, and shops. As a result of such schooling, students also were expected to become literate enough to be informed voters. Thus, minimum competencies in reading, writing, and arithmetic were expected of all students, and more advanced academic training was reserved for the select few. These more advantaged students attended the schools that were expected to educate the future cultural, academic, business, and government leaders.

The educational system of the industrial age does not meet the economic needs of today. New social goals for education include (1) mathematically literate workers, (2) lifelong learning, (3) opportunity for all, and (4) an informed electorate. Implicit in these goals is a school system organized to serve as an important resource for all citizens throughout their lives.

Mathematically literate workers. The economic status quo in which factory employees work the same jobs to produce the same goods in the same manner for decades is a throwback to our industrial-age past. Today, economic survival and growth are dependent on new factories established to produce complex products and services with very short market cycles. It is a literal reality that before the first products are sold, new replacements are being designed for an ever-changing market. Concurrently, the research division is at work developing new ideas to feed to the design groups to meet the continuous clamor for new products that are, in turn, channeled into the production arena. Traditional notions of basic mathematical competence have been outstripped by ever-higher expectations of the skills and knowledge of workers; new methods of production demand a technologically competent workforce. The U.S. Congressional Office of Technology Assessment (1988) claims that employees must be prepared to understand the complexities and technologies of communication, to ask questions, to assimilate unfamiliar information, and to work cooperatively in teams. Businesses no longer seek workers with strong backs, clever hands, and "shopkeeper" arithmetic skills. In fact, it is claimed that the "most significant growth in new jobs between now and the year 2000 will be in fields requiring the most education" (Lewis 1988, p. 468). Henry Pollak (1987), a noted industrial mathematician, recently summarized the mathematical expectations for new employees in industry:

- the ability to set up problems with the appropriate operations
- knowledge of a variety of techniques to approach and work on problems
- understanding of the underlying mathematical features of a problem
- the ability to work with others on problems
- the ability to see the applicability of mathematical ideas to common and complex problems
- preparation for open problem situations, since most real problems are not well formulated
- belief in the utility and value of mathematics

Notice the difference between the skills and training inherent in these expectations and those acquired by students working independently to solve explicit sets of drill and practice exercises. Although mathematics is not taught in schools solely so students can get jobs, we are convinced that in-school experiences reflect to some extent those of today's workplace. This is especially true given that the availability of such broadly educated workers will be a major factor in determining how businesses respond to today's changing economic conditions.

Lifelong learning. Employment counselors, cognizant of the rapid changes in technology and employment patterns, are claiming that, on average, workers will change jobs at least four to five times during the next twenty-five years and that each job will require retraining in communication skills. Thus, a flexible workforce capable of lifelong learning is required; this implies that school mathematics must emphasize a dynamic form of literacy. Problem solving—which includes the ways in which problems are represented, the meanings of the language of mathematics, and the ways in which one conjectures and reasons—must be central to schooling so that students can explore, create, accommodate to changed conditions, and actively create new knowledge over the course of their lives.

Opportunity for all. The social injustices of past schooling practices can no longer be tolerated. Current statistics indicate that those who study advanced mathematics are most often white males. Women and most minorities study less mathematics and are seriously under represented in careers using science and technology. Creating a just society in which women and various ethnic groups enjoy equal opportunities and equitable treatment is no longer an issue. Mathematics has become a critical filter for employment and full participation in our society. We cannot afford to have the majority of our population mathematically illiterate: Equity has become an economic necessity.

Informed electorate. In a democratic country in which political and social decisions involve increasingly complex technical issues, an educated, informed electorate is critical. Current issues—such as environmental protection, nuclear energy, defense spending, space exploration, and taxation—involve many interrelated questions. Their thoughtful resolution requires technological knowledge and understanding. In particular, citizens must be able to read and interpret complex, and sometimes conflicting, information.

In summary, today's society expects schools to insure that all students have an opportunity to become mathematically literate, are capable of extending their learning, have an equal opportunity to learn, and become informed citizens capable of understanding issues in a technological society. As society changes, so must its schools.

New Goals for Students

Educational goals for students must reflect the importance of mathematical literacy. Toward this end, the K-12 standards articulate five general goals for all students: (1) that they learn to value mathematics, (2) that they become confident in their ability to do mathematics, (3) that they become mathematical problem solvers, (4) that they learn to communicate mathematically, and (5) that they learn to reason mathematically. These goals imply that students should be exposed to numerous and varied interrelated experiences that encourage them to value the mathematical enterprise, to develop mathematical habits of mind, and to understand and appreciate the role of mathematics in human affairs; that they should be encouraged to explore, to guess, and even to make and correct errors so that they gain confidence in their ability to solve complex problems; that they should read, write, and discuss mathematics; and that they should conjecture, test, and build arguments about a conjecture's validity.

The opportunity for all students to experience these components of mathematical training is at the heart of our vision of a quality mathematics program. The curriculum should be permeated with these goals and experiences so that they become commonplace in the lives of students. We are convinced that if students are exposed to the kinds of experiences outlined in the Standards, they will gain mathematical power. This term denotes an individual's abilities to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve nonroutine problems. This notion is based on the recognition of mathematics as more than a collection of concepts and skills to be mastered; it includes methods of investigating and reasoning, means of communication, and notions of context. In addition, for each individual, mathematical power involves the development of personal self-confidence.

Toward this end, we see classrooms as places where interesting problems are regularly explored using important mathematical ideas. Our premise is that what a student learns depends to a great degree on how he or she has learned it. For example, one could expect to see students recording measurements of real objects, collecting information and describing their properties using statistics, and exploring the properties of a function by examining its graph. This vision sees students studying much of the same mathematics currently taught but with quite a different emphasis; it also sees some mathematics being taught that in the past has received little emphasis in schools.

Learning to value mathematics. Students should have numerous and varied experiences related to the cultural, historical, and scientific evolution of mathematics so that they can appreciate the role of mathematics in the development of our contemporary society and explore relationships among mathematics and the disciplines it serves: the physical and life sciences, the social sciences, and the humanities. Throughout the history of mathematics, practical problems and theoretical pursuits have stimulated one another to such an extent that it is impossible to disentangle them. Even today, as theoretical mathematics has burgeoned in its diversity and deepened in its complexity and abstraction, it has become more concrete and vital to our technologically oriented society. It is the intent of this goal—learning to value mathematics—to focus attention on the need for student awareness of the interaction between mathematics and the historical situations from which it has developed and the impact that interaction has on our culture and our lives.

Becoming confident in one's own ability. As a result of studying mathematics, students need to view themselves as capable of using their growing mathematical power to make sense of new problem situations in the world around them. To some extent, everybody is a mathematician and does mathematics consciously. To buy at the market, to measure a strip of wallpaper, or to decorate a ceramic pot with a regular pattern is doing mathematics. School mathematics must endow all students with a realization that doing mathematics is a common human activity. Having numerous and varied experiences allows students to trust their own mathematical thinking.

Becoming a mathematical problem solver. The development of each student's ability to solve problems is essential if he or she is to be a productive citizen. We strongly endorse the first recommendation of An Agenda for Action (National Council of Teachers of Mathematics 1980): "Problem solving must be the focus of school mathematics" (p. 2). To develop such abilities, students need to work on problems that may take hours, days, and even weeks to solve. Although some may be relatively simple exercises to be accomplished independently, others should involve small groups or an entire class working cooperatively. Some problems also should be open-ended with no right answer, and others need to be formulated.

Learning to communicate mathematically. The development of a student's power to use mathematics involves learning the signs, symbols, and terms of mathematics. This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas in which the use of the language of mathematics becomes natural. As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking.

Learning to reason mathematically. Making conjectures, gathering evidence, and building an argument to support such notions are fundamental to doing mathematics. In fact, a demonstration of good reasoning should be rewarded even more than students' ability to find correct answers.

In summary, the intent of these goals is that students will become mathematically literate. This term denotes an individual's ability to explore, to conjecture, and to reason logically, as well as to use a variety of mathematical methods effectively to solve problems. By becoming literate, their mathematical power should develop.

An Overview of the Curriculum and Evaluation Standards

This document presents fifty-four standards divided among four categories: grades K-4, 5-8, 9-12, and evaluation. The four categories are arbitrary in that they are not intended to reflect school structure; in fact, we encourage readers to consider these as K-12 standards. In addition, we believe that similar standards need to be developed for both preschool programs and those beyond high school.

It was our task to prepare the curriculum and evaluation standards that reflect our vision of how the societal and student goals already articulated here could be met. These standards should be seen as an initial step in the lengthy process of bringing about reform in school mathematics.

Curriculum Standards. When a set of curricular standards is specified for school mathematics, it should be understood that the standards are value judgments based on a broad, coherent vision of schooling derived from several factors: societal goals, student goals, research on teaching and learning, and professional experience. Each standard starts with a statement of what mathematics the curriculum should include. This is followed by a description of the student activities associated with that mathematics and a discussion that includes instructional examples.

Mathematics. The first consideration in preparing each standard was its mathematical content. To decide on what is fundamental in so vast and dynamic a discipline as mathematics is no easy task. John Dewey's (1916) distinction between "knowledge" and the "record of knowledge" may clarify this point. For many, "to know" means to identify the basic concepts and procedures of the discipline. For many nonmathematicians, arithmetic operations, algebraic manipulations, and geometric terms and theorems constitute the elements of the discipline to be taught in grades K-12. This may reflect the mathematics they studied in school or college rather than a clear insight into the discipline itself.

Three features of mathematics are embedded in the Standards. First, "knowing" mathematics is "doing" mathematics. A person gathers, discovers, or creates knowledge in the course of some activity having a purpose. This active process is different from mastering concepts and procedures. We do not assert that informational knowledge has no value, only that its value lies in the extent to which it is useful in the course of some purposeful activity. It is clear that the fundamental concepts and procedures from some branches of mathematics should be known by all students; established concepts and procedures can be relied on as fixed variables in a setting in which other variables may be unknown. But instruction should persistently emphasize "doing" rather than "knowing that."

Second, some aspects of doing mathematics have changed in the last decade. The computer's ability to process large sets of information has made quantification and the logical analysis of information possible in such areas as business, economics, linguistics, biology, medicine, and sociology. Change has been particularly great in the social and life sciences. In fact, quantitative techniques have permeated almost all intellectual disciplines. However, the fundamental mathematical ideas needed in these areas are not necessarily those studied in the traditional algebra-geometry-precalculus-calculus sequence, a sequence designed with engineering and physical science applications in mind. Because mathematics is a foundation discipline for other disciplines and grows in direct proportion to its utility, we believe that the curriculum for all students must provide opportunities to develop an understanding of mathematical models, structures, and simulations applicable to many disciplines.

Third, changes in technology and the broadening of the areas in which mathematics is applied have resulted in growth and changes in the discipline of mathematics itself. Davis and Hersh (1981) claim that we are now in a golden age of mathematical production, with more than half of all mathematics having been invented since World War II. In fact, they argue that "there are two inexhaustible sources of new mathematical questions. One source is the development of science and technology, which make ever new demands on mathematics for assistance. The other source is mathematics itself . . . each new, completed result becomes the potential starting point for several new investigations" (p. 25). The new technology not only has made calculations and graphing easier, it has changed the very nature of the problems important to mathematics and the methods mathematicians use to investigate them. Because technology is changing mathematics and its uses, we believe that—appropriate calculators should be available to all students at all times; a computer should be available in every classroom for demonstration purposes; every student should have access to a computer for individual and group work; students should learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems.

We recognize, however, that access to this technology is no guarantee that any student will become mathematically literate. Calculators and computers for users of mathematics, like word processors for writers, are tools that simplify, but do not accomplish, the work at hand. Thus, our vision of school mathematics is based on the fundamental mathematics students will need, not just on the technological training that will facilitate the use of that mathematics.

Similarly, the availability of calculators does not eliminate the need for students to learn algorithms. Some proficiency with paper-and-pencil computational algorithms is important, but such knowledge should grow out of the problem situations that have given rise to the need for such algorithms. Furthermore, when one needs to calculate to find an answer to a problem, one should be aware of the choices of methods (see Figure 1). When an approximate answer is adequate, one should estimate. If a precise answer is needed, an appropriate procedure must be chosen. Many problems should be solved by mental calculation (multiplying by 10, taking half). Some calculations, if not too complex, should be solved by following standard paper-and-pencil algorithms. For more complex calculations, the calculator should be used (column addition, long division). And finally, if many iterative calculations are required, a computer program should be writ-

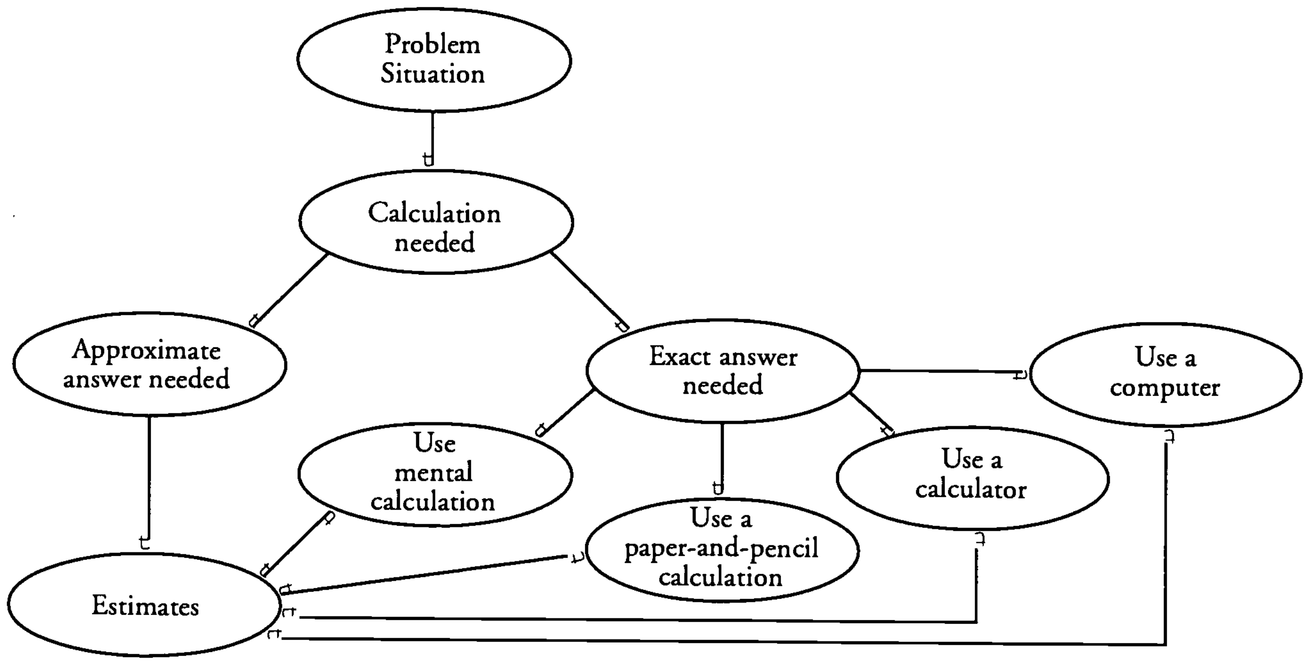

Figure 1. Decisions about calculation procedures in numerical problems

ten or used to find answers (finding a sum of squares). Note in Figure 1 that estimation can, and should, be used in conjunction with procedures yielding exact answers to foreshadow any calculation and to judge the reasonableness of results.

Contrary to the fears of many, the availability of calculators and computers has expanded students' capability of performing calculations. There is no evidence to suggest that the availability of calculators makes students dependent on them for simple calculations. Students should be able to decide when they need to calculate and whether they require an exact or approximate answer. They should be able to select and use the most appropriate tool. Students should have a balanced approach to calculation, be able to choose appropriate procedures, find answers, and judge the validity of those answers.

Finally, in developing the standards, we considered the content appropriate for all students. This, however, does not suggest that we believe all students are alike. We recognize that students exhibit different talents, abilities, achievements, needs, and interests in relationship to mathematics. The mathematical content outlined in the Standards is what we believe all students will need if they are to be productive citizens in the twenty-first century. If all students do not have the opportunity to learn this mathematics, we face the danger of creating an intellectual elite and a polarized society. The image of a society in which a few have the mathematical knowledge needed for the control of economic and scientific development is not consistent either with the values of a just democratic system or with its economic needs.

We believe that all students should have an opportunity to learn the important ideas of mathematics expressed in these standards. On the one hand, prior to grade 9, we have refrained from specifying alternative instructional patterns that would be consistent with our vision. On the other hand, for grades 9-12, the standards have been prepared in light of a core program for all students, with explicit differentiation in terms of depth and breadth of treatment and the nature of applications for college-bound students. At the same time, the mathematics of the core program is sufficiently broad and deep so that students' options for further study would not be limited. Our expectation is that all students must have an opportunity to encounter typical problem situations related to important mathematical topics. However, their experiences may differ in the vocabulary or notations used, the complexity of arguments, and so forth.

Student Activities. The second aspect of each standard specifies the expected student activities associated with doing mathematics. Two general principles have guided our descriptions: first, activities should grow out of problem situations; and second, learning occurs through active as well as passive involvement with mathematics.

Traditional teaching emphases on practice in manipulating expressions and practicing algorithms as a precursor to solving problems ignore the fact that knowledge often emerges from the problems. This suggests that instead of the expectation that skill in computation should precede word problems, experience with problems helps develop the ability to compute. Thus, present strategies for teaching may need to be reversed; knowledge often should emerge from experience with problems. In this way, students may recognize the need to apply a particular concept or procedure and have a strong conceptual basis for reconstructing their knowledge at a later time.

Furthermore, students need to experience genuine problems regularly. A genuine problem is a situation in which, for the individual or group concerned, one or more appropriate solutions have yet to be developed. The situation should be complex enough to offer challenge but not so complex as to be insoluble. In sum, we believe that learning should be guided by the search to answer questions—first at an intuitive, empirical level; then by generalizing; and finally by justifying (proving).

In many classrooms, learning is conceived of as a process in which students passively absorb information, storing it in easily retrievable fragments as a result of repeated practice and reinforcement. Research findings from psychology indicate that learning does not occur by passive absorption alone (Resnick 1987). Instead, in many situations individuals approach a new task with prior knowledge, assimilate new information, and construct their own meanings. For example, before young children are taught addition and subtraction, they can already solve most addition and subtraction problems using such routines as "counting on" and "counting back" (Romberg and Carpenter 1986). As instruction proceeds, children often continue to use these routines in spite of being taught more formal problem-solving procedures. They will accept new ideas only when their old ideas do not work or are inefficient. Furthermore, ideas are not isolated in memory but are organized and associated with the natural language that one uses and the situations one has encountered in the past. This constructive, active view of the learning process must be reflected in the way much of mathematics is taught. Thus, instruction should vary and include opportunities for

- appropriate project work,
- group and individual assignments,
- discussion between teacher and students and among students,
- practice on mathematical methods, and
- exposition by the teacher.

Our ideas about problem situations and learning are reflected in the verbs we use to describe student actions (e.g., to investigate, to formulate, to find, to verify) throughout the Standards.

Focus and Discussion. Finally, our vision sees teachers encouraging students, probing for ideas, and carefully judging the maturity of a student's thoughts and expressions. Hence, each standard is elaborated on in a Focus section followed by a discussion with examples, which is meant to convey the spirit of this vision about both mathematical content and instruction.

Another premise of the standards is that problem situations must keep pace with the maturity—both mathematical and cultural—and experience of the students. For example, the primary grades should emphasize the empirical language of the mathematics of whole numbers, common fractions, and descriptive geometry. In the middle grades, empirical mathematics should be extended to other numbers, and the emphasis should shift to building the abstract language of mathematics needed for algebra and other aspects of mathematics. High school mathematics should emphasize functions, their representations and uses, modeling, and deductive proofs.

The standards specify that instruction should be developed from problem situations. As long as the situations are familiar, conceptions are created from objects, events, and relationships in which operations and strategies are well understood. In this way, students develop a framework of support that can be drawn upon in the future, when rules may well have been forgotten but the structure of the situation remains embedded in the memory as a foundation for reconstruction. Situations should be sufficiently simple to be manageable but sufficiently complex to provide for diversity in approach. They should be amenable to individual, small-group, or large-group instruction, involve a variety of mathematical domains, and be open and flexible as to the methods to be used.

The first three standards in each section are labeled Problem Solving, Communication, and Reasoning, although details vary between levels with respect to what is expected both of students and of instruction. This variation reflects the developmental level of the students, their mathematical background, and the specific mathematical content.

The fourth curriculum standard at each level is titled Mathematical Connections. This label emphasizes our belief that although it is often necessary to teach specific concepts and procedures, mathematics must be approached as a whole. Concepts, procedures, and intellectual processes are interrelated. In a significant sense, "the whole is greater than the sum of its parts." Thus, the curriculum should include deliberate attempts, through specific instructional activities, to connect ideas and procedures both among different mathematical topics and with other content areas. Following the Connections standard, nine or ten specific content standards are stated and discussed. Some have similar titles, which reflects that a content area needs emphasis across the curriculum; however, once again the concepts and processes emphasized vary by level. Others emphasize specific content that needs to be developed at that level.

The Evaluation Standards. The evaluation standards are presented separately, not because evaluation should be separated from the curriculum, but because planning for the gathering of evidence about student and program outcomes is different. The difference is most clearly illustrated in comparing the curriculum standards titled Connections and the evaluation standards titled Mathematical Power. Both deal with connections among concepts, procedures, and intellectual methods, but the curriculum standards are related to the instructional plan whereas the evaluation standards address the ways in which students integrate these connections intellectually so that they develop mathematical power.

We present fourteen evaluation standards that can be viewed in three categories. The first set of three evaluation standards discusses general assessment strategies related to the curriculum standards. The second seven focus on providing information to teachers for instructional purposes. They closely parallel the curriculum standards—problem solving, communication, reasoning, mathematical concepts, and mathematical procedures, in addition to a separate standard on "mathematical disposition." These seven standards are to be used by teachers to make judgments about students and their mathematical progress. The final set of four standards addresses the gathering of evidence with respect to the quality of the mathematics program. These standards are to be used by teachers, administrators, and policy makers to make judgments about the quality of the mathematics program and the effectiveness of instruction.

Challenge

Such are the background, the general focus, and the intent of our efforts. It is now left to each of you concerned with the teaching and learning of mathematics to read the standards, to share them with colleagues, and to reflect on their vision. Consider what needs to be done and what you can do, and collaborate with others to implement the standards for the benefit of our students, as well as for our social and economic future.

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