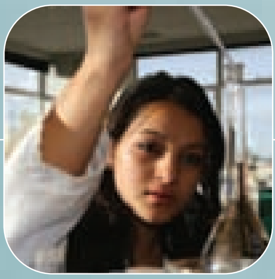
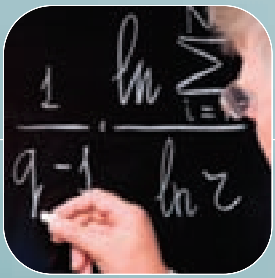
A Field Guide
to Student Success in Mathematics and Science

A Sourcebook for Washington State Educators





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This document was made possible by a grant by the Microsoft Corporation.

The Microsoft Corporation and the American Institutes for Research (AIR) are pleased to have partnered in the development of this *Field Guide to Student Success in Mathematics and Science*. Our two organizations are deeply committed to assisting schools and districts in transforming themselves to better prepare students to meet the great challenges and the great opportunities of the 21st century. We share a common concern regarding the critical need for dramatic improvement in our K–12 school systems, particularly in the area of mathematics and science education.

Microsoft, as a major player in the global software industry, is acutely aware of the increasingly important role that advanced mathematics and science skills play in today's global, digital economy. Our company has a long history of supporting educational initiatives in Washington State, throughout America, and around the world. Microsoft's support for this *Field Guide* reflects its deep concern for the growing gap between the demands of the increasingly technical workplace and the ability of the American K–12 school system to produce students with high levels of mathematics and science skills.

AIR, as one of America's leading educational research, evaluation, and consulting organizations, has been a long-time advocate for increasing academic rigor in America's K–12 school systems. AIR sees dramatic improvement in student performance in mathematics and science as being a critical component of America's nationwide strategy for educational reform. Our organization hopes that this *Field Guide* will assist educators, both in Washington State and across the country, in mobilizing broad-based efforts to reform their instructional practices in mathematics and science so as to drive gains in student achievement.

We developed this *Field Guide* as part of a major initiative to improve mathematics and science education in a group of school districts in the Puget Sound area of Washington State. With the strong support and leadership of the Puget Sound Educational Service District (PSESD), eight school districts—Bellevue, Highline, Issaquah, Kent, Lake Washington, Northshore, Renton and Seattle—have come together and committed to an aggressive agenda of improving mathematics and science education, particularly in their middle schools.

This *Field Guide* is the second major document created over the last year as part of Microsoft's philanthropic strategy for K–12 education in the Puget Sound area. The first document, *The Gateway to Student Success in Mathematics and Science*, summarizes the existing research in mathematics and science education and proposes a framework for school districts in developing an educational reform strategy. This *Field Guide* is a companion piece to the first document, and its central purpose is to serve as a research-based sourcebook for school and district leaders as they lead instructional change in their school communities. While the primary audience for this *Field Guide* is Puget Sound educators, we realize that its contents can also have significant value and applicability in the larger educational community throughout the country.

Microsoft and AIR hope this *Field Guide* supports significant and fundamental improvements in mathematics and science education in the middle grades. Our intent is that it serves as a platform and catalyst for the development of dynamic strategies for improving mathematics and science outcomes for all students. We look forward to a strong and productive relationship with the PSESD and the eight participating school districts.

To fully participate as citizens of the 21st century, today's generation of young people will need significantly higher levels of academic skills than prior generations. Today's technology-driven workplace assigns a high premium to the analytic competencies of mathematics and science that are central to our global, digital economy. Unfortunately, the current K–12 education systems in Washington State and across the country are proving to be inadequate for producing the required high levels of student achievement in mathematics and science. The increasing number of students with diverse linguistic, cultural, and learning needs are particularly vulnerable in these school systems where their performance continues to lag behind their classmates. This weakness in student academic performance is quickly emerging as a serious threat to America's long-term economic security and vitality.

A previous publication from Microsoft and AIR, *The Gateway to Student Success in Mathematics and Science* (2006) (*Gateway*), summarized the existing research on student learning in mathematics and science. Several key themes emerged from this review that should inform education leaders as they strive to dramatically improve student performance in mathematics and science:

- The mathematics and science performance of U.S. students in the K–12 system lags substantially behind their international peers. This weakness in U.S. student performance exists across all student groups, even among our highest performing students.
- Algebra is the key "gatekeeper" for student access to the upper-level high school courses in mathematics and science that are drivers of high school graduation, college readiness, and college completion.
- Providing all students with rigorous mathematics and science coursework in middle school and early in high school will help to close the achievement gap among students from differing ethnic and socioeconomic groups.
- Student performance in Washington State in mathematics and science parallels the weak performance seen nationally. While the state is above the national average in student performance, it lags in the quality of its standards, the rigor of its graduation requirements, and the college-readiness of its high school graduates.

These research findings suggest a number of powerful implications for educators as they consider ways of improving student performance in mathematics and science. However, more than any other, the most powerful implication is this:

If we want to dramatically increase the proportion of students graduating from high school with high level, globally competitive skills,

then we must dramatically increase the number of students who achieve proficiency in algebra in their middle school or early high school years.

This algebra proficiency will serve as a gateway to the advanced high school courses which are drivers of high school graduation, college readiness, and post-secondary completion rates.

Utilization of this Field Guide

This publication should be viewed as a companion piece to the earlier *Gateway* report. That is, given the findings of the *Gateway* report, this *Field Guide* takes the next step by identifying key strategies and practices that educators can utilize to drive instructional change in their schools and school districts. Ultimately, the intent of this *Field Guide* is to be a resource for educators as they lead reform of middle school mathematics and science in their school communities. It provides superintendents, administrators, principals, and teacher leaders with ideas and recommendations for leading instructional improvements in their schools that are based on research and best practice.

This *Field Guide* should be used by schools and districts to assist them in developing well-articulated and widely shared plans for creating middle schools where all students succeed. This *Field Guide* is organized to provide easy navigation to ideas and recommendations in a number of key areas. In particular, it provides detailed resources and recommendations in two major areas:

- **Creating a shared vision of teaching and learning:** Any strategy designed to improve student performance in mathematics and science must be grounded in a clear and shared vision of teaching and learning. This section of the *Field Guide* describes the key elements of an instructional vision that are based on research and best practice and that are critical to the ultimate success of any school or district reform initiative. These elements are imperatives that school leaders must put in place to ensure the success of their instructional reform program.
- **Core components of successful mathematics and science programs:** This section provides detailed recommendations in five areas that are the core components of successful mathematics and science programs in schools and districts. The materials associated with each of these components are included under a separate tab in order to provide ready access to the resources of each component. The five components are:
  - › Curriculum expectations and implementation
  - › Professional development and professional culture
  - › Assessment
  - › Data driven decision-making
  - › Community and stakeholder support

This *Field Guide* is not intended to be read at one sitting from cover to cover and then put away on a shelf; instead, readers are encouraged to turn to this report on a regular basis to inform their work in leading instructional change. Accordingly, it offers a wide variety of ideas, resources, and recommendations that can be tools for educators working to significantly improve middle school mathematics and science programs.

Any strategy designed to improve student performance in mathematics and science must be grounded in a clear and shared vision of teaching and learning. Curriculum, professional development, assessment, data-driven decision-making, and community support are all necessary components of a high-quality educational program. However, these components will have little lasting impact on student achievement unless they are effectively realized in classrooms in which high-quality teaching and learning thrive.

The Key Elements of an Instructional Vision

Effective and productive teaching is not magic and it does not happen by accident. Instead, successful classroom teaching is thoughtfully planned and rooted in a very clear understanding of the teaching and learning process. A vision for great classroom teaching in mathematics and science needs to be built on a powerful set of key elements:

- **Effective instruction begins with a clear understanding of specific learning expectations for all students.** Effective instruction must be built on a clear picture of exactly what skills, concepts, big ideas, and understandings the lesson or unit is designed to develop. This means identifying the tasks, problems, and activities that will be used to support the specific learning expectations; clearly delineating the key questions and explanations that support the tasks, problems, and activities; utilizing techniques to help struggling students master the new lesson; and attending to the likely errors and misconceptions that undermine effective learning.
- **The heart of effective mathematics and science instruction is problem-solving, reasoning, and inquiry.** Effective instruction must consistently include opportunities for students to formulate questions and problems, make hypotheses and conjectures, gather and analyze data, and draw and justify conclusions. Students in effective classrooms regularly encounter questions like “Why?”, “How do you know?”, and “Can you explain that?” Nearly every survey of business and industry identifies the critical need for workers who are able to reason, question, quantify real-world situations, and solve problems. Thus, problem-solving as the heart of mathematics and inquiry as the heart of science are both societal and educational imperatives.
- **Effective instruction uses contexts, connections, and technology to engage students and increase the relevance of what is being learned.** Teachers have a choice: rely on abstractions and rules that are rarely connected to realistic situations and common contexts, or embed these abstractions in realistic contexts

and problem situations that bring mathematics and science to life. Technology, when integrated into the curriculum, can greatly enhance learning: calculators, computers, and scientific kits and instruments are important tools for supporting learning and making instruction more relevant. Graphing calculators that link symbolic, tabular, and graphical representations of functions help students to develop critical understandings of algebra. Scientific simulation software enables students to create scientific environments and to analyze the impact of changes in selected conditions.

- **Effective instruction relies on alternative approaches and multiple representations.** Many students do not process the content being taught in the same way that the teacher processes the content. For example, the teacher visualizes "three-quarters" as three out of four slices of a small pizza; but one student may "see" three quarters or 75 cents, another student may "see" three red balloons out of a total of four, and still another student may "see" three quarters of an inch on a ruler. Effective instruction recognizes that students conceptualize mathematical and scientific concepts in different but often equally appropriate ways. It includes deliberate attention to such multiple representations and to alternative approaches to accommodate the diversity of learning styles within every class.

- **Effective teaching and learning build on the unique linguistic and cultural strengths of each student.** Increasingly, classrooms are comprised of students who come from a wide

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variety of racial, ethnic, cultural, and linguistic backgrounds. Effective instructional approaches build on these personal attributes as value-added assets in the learning process, not as deficits to be overcome. Instruction that is respectful of and integrates the cultural and linguistic backgrounds of the students improves the acquisition and retention of new information.

- **Effective instruction incorporates ongoing cumulative review.** Very few people master something new after one or two lessons or homework assignments. One of the most effective strategies for fostering mastery and retention of critical skills is daily cumulative review. Teachers can do this as part of a daily warm-up, as "bell work" that focuses on recent instruction, or as a daily "mini-quiz" that contains four to six problems that keep skills sharp, review vocabulary, and reinforce conceptual understanding.

- **Effective teachers reflect on their teaching and make revisions to enhance student learning.** Effective teachers replay their instruction; reflect on what appeared to work and what was more problematic; and examine student responses/work as part of an ongoing cycle of plan, teach, reflect, refine, and plan all over again.

- **Effective teachers work collaboratively with colleagues.** Rather than perpetuate the isolation commonplace for most teachers, a collaborative, mutually supportive environment must be put in place for teachers and other school staff. Reaching out to colleagues with a question, a concern, or an idea and benefiting from the shared wisdom of the group yields far more effective teaching.

Schools and districts must undergo substantial change to create classrooms that reflect this vision of teaching and learning. This change is neither easy nor quick. It requires the deep, sustained commitment of educators in schools throughout Washington State to improve their practices relative to this instructional vision.

We know that this instructional vision will not get implemented by exhortation alone; we also know that teachers will not do what they cannot envision and cannot do what they do not understand. However, once a compelling instructional vision is broadly shared in a school community, schools and districts have a common platform upon which to organize and structure the specific improvement strategies described in this *Field Guide*.

Leadership for Learning

Creating dramatically different environments for the teaching and learning of mathematics and science in middle school classrooms is a daunting task. Meaningful improvements in mathematics and science programs can occur only on a broad scale as the result of a thoughtful and sustained commitment of energy, attention, and resources from a wide array of key players in a school system—including teachers, principals, administrators, and the superintendent.

The fundamental starting point for dramatic reform in mathematics and science instruction lies with a strong commitment by educators to lead their school communities toward sustained and long-lasting change. Without committed and inspired leadership, even the best-laid school and district plans will eventually wither and die. Leadership energy should focus on dramatic improvements in the quality of the instructional relationship between teachers and students. The key attributes of the leadership required to drive improvements in mathematics and science instruction are:

- **Leaders must catalyze the creation and development of a coherent vision of change for the future.** Schools and districts need a clear vision of the future that will serve as their central guidepost for instructional change. This vision needs to be clear and compelling so that a wide variety of participants—teachers, parents, principals, administrators, and the community at large—can embrace it and put it into practice on a day-to-day basis.
- **Leaders must create the belief that the change is accomplishable.** A vision and plan that is beautiful on paper but cannot be implemented is ultimately a failure. Leaders must develop thoughtful and clearly defined plans that are designed to meet the real-world challenges of the implementation reality. Then, they must ensure that the necessary human, intellectual, and financial resources are available to support the change process through its entire implementation.

- **Leaders must generate a sense of urgency about the change process.** Leaders must be relentless in advocating for improvements in mathematics and science education: *What can we accomplish this school year? What can we accomplish this month? What can we accomplish today?* Leaders must challenge the status quo to accomplish the changes described in this *Field Guide* while constantly assuring the community that this effort is not just another educational fad.
- **Leaders must embrace their community's diversity and use it as an asset in their vision for change.** Leaders must recognize that their instructional vision can be enhanced by the cultural diversity of their school community's students, parents, teachers, and staff. School leaders must embrace the community's diverse stakeholders and see them as being central to their plan for success.
- **Leaders must publicly and personally model the change they strive to effect.** School leaders must demonstrate their personal commitment to mathematics and science education in everyday actions. They must use evidence to formulate their plans and to support mid-course corrections that may be needed. *How can I use mathematics and science skills to do my job better? What professional development do I need to improve my personal understanding of mathematics and science concepts? Can I explain myself better using charts and graphs rather than just words?*

Alignment for Success

Even when a school or district has dynamic leadership with a compelling vision for instructional improvement in mathematics and science, enormous barriers must be overcome to create lasting gains in student achievement. Most importantly, leaders must take on the very difficult task of aligning all of the components of the school or district's educational program in accord with their overarching instructional vision.

We know that teachers regularly receive mixed and conflicting messages about what should be taught, how it should be taught, and how it will be assessed. This is why alignment—the creation of deliberate coherence across all components of mathematics and science programs—is so critical to ensuring that teachers are absolutely clear and confident in their instructional approach with students.

The need for and the importance of alignment is not a new idea. For example, the Deep Alignment Training Math Pre-Institute in Washington State calls for a match between curriculum (what is taught), instruction (how it is taught), and assessment (what is measured). We know that aligning these three components—curriculum, instruction, and assessment—with the same learning goals, standards, and educational philosophy results in higher student achievement.

This *Field Guide* describes a wide variety of specific strategies that can be utilized by school communities to improve their mathematics and science programs. However, these strategies should not be viewed as discrete and independent ideas. Instead, leaders need to weave a series of these actions into a coherent framework to support an instructional vision for their entire school or district. That is, teacher professional development activities are aligned with the curriculum, which is aligned with the assessments, which are aligned with the curricular materials, which are aligned with the principal training program, which is aligned with the budget. Key attributes of an alignment strategy are:

- **No decision is seen as discrete and independent, but viewed instead as being part of the larger instructional vision.** Every component of an instructional program is connected in some way to every other component. Ignoring this interconnectedness easily dooms many reform strategies. For example, a change in the curriculum will necessitate changes in professional development, instructional materials, and assessments. Changing a classroom focus toward open-ended problem-solving and inquiry-based labs must be accompanied by commensurate changes in instructional time allocations, professional development, and communication with parents.
- **Each component of a mathematics or science program supports and amplifies other components.** Each component of a school or district program—curriculum, professional development, assessment, data-driven

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learning

decision-making, and community support—needs to be structured in ways that collectively support the implementation of the larger instructional vision. With this broad-based alignment, the collective impact of each component will be amplified and enhanced.

- **Leaders should routinely base decisions on their alignment with the instructional vision.** Every decision that a leader makes must be connected to the larger instructional vision of improving teaching and learning. Moreover, leaders should explain and communicate their decisions through the lens and the language of the instructional vision. Two common planning questions should be asked: *How is this decision connected to our instructional vision?* and *If we make this decision, what else will need to be changed to keep everything aligned with our instructional vision?*

The combination of a compelling instructional vision, dynamic leadership and an aligned plan for implementation creates a powerful platform for school communities to drive dramatic improvements in student achievement. With these elements in hand, the next section of this *Field Guide* will provide detailed recommendations in five areas that are the core components of creating successful mathematics and science programs in schools and districts.

curriculum expectations AND implementation

curriculum expectations AND implementation

A critical starting point for schools and districts in developing strong mathematics and science programs is to identify the key knowledge and skills that students must master as they progress from grade to grade. The development of a coherent and articulated set of curricular expectations is a fundamental cornerstone of any school or district effort to improve student performance in mathematics and science.

On first glance, the identification of a clear district-wide and school-wide curriculum appears to be a straightforward proposition—easily accomplishable by virtually every school and district. In practice, however, curriculum development has proven to be a difficult and contentious process in a wide variety of school communities across the country. These difficulties have been particularly pronounced in the areas of mathematics and science due the sharply conflicting viewpoints that exist in some communities regarding these subject areas.

The curriculum development process demands that leaders address a series of important questions that are critical to the development process:

- What are the state and district curriculum and assessment expectations?
- Are the expectations clearly and widely understood by all stakeholders?
- How do the expectations accommodate the diverse linguistic, cultural, and learning needs of all students?
- What texts and supplementary materials are being used?
- How closely do teachers follow these materials?
- What state, district, school, or collegial guidance is available to teachers about curriculum choices?
- How closely do similar courses in the same school or district track against one another?
- What is the coherence of content from grade to grade?

Fortunately, a consensus is emerging nationally on what constitutes an excellent mathematics and science curriculum,[2] focusing on problem-solving, reasoning, and inquiry, with balanced attention to skills,

knowledge, and application. It has been a hard-fought battle to arrive at this consensus, complicated by the uneven implementation of various curricula within and across schools.

Unfortunately, a common criticism that is leveled at many existing district curriculum expectations is that they can be characterized as being "a mile wide and an inch deep".[3] For example, using data collected in 1992–93 as part of the Third International Mathematics and Science Study (TIMSS) and summarized in Figure 1 and Figure 2 (see "A Mile Wide and an Inch Deep" sidebar), it appears that U.S. curriculum, regardless of the particular textbook utilized, has valued breadth over depth and quantity over quality.[4]

The result has been curriculum guides that barely allow teachers time to skim through the topics. Mastery and deep understanding were out of the question if coverage was the goal. The result was textbooks that were too heavy to carry, too expensive to buy, and too filled with topics for a teacher to teach in depth.

Compounding the problem are state assessments that are required under the No Child Left Behind (NCLB) legislation. Teachers find themselves torn between preparing their students for these tests, providing adequate time for remediation and exploration, covering district and state content requirements, acknowledging comprehensive national content standards, and nurturing young minds.

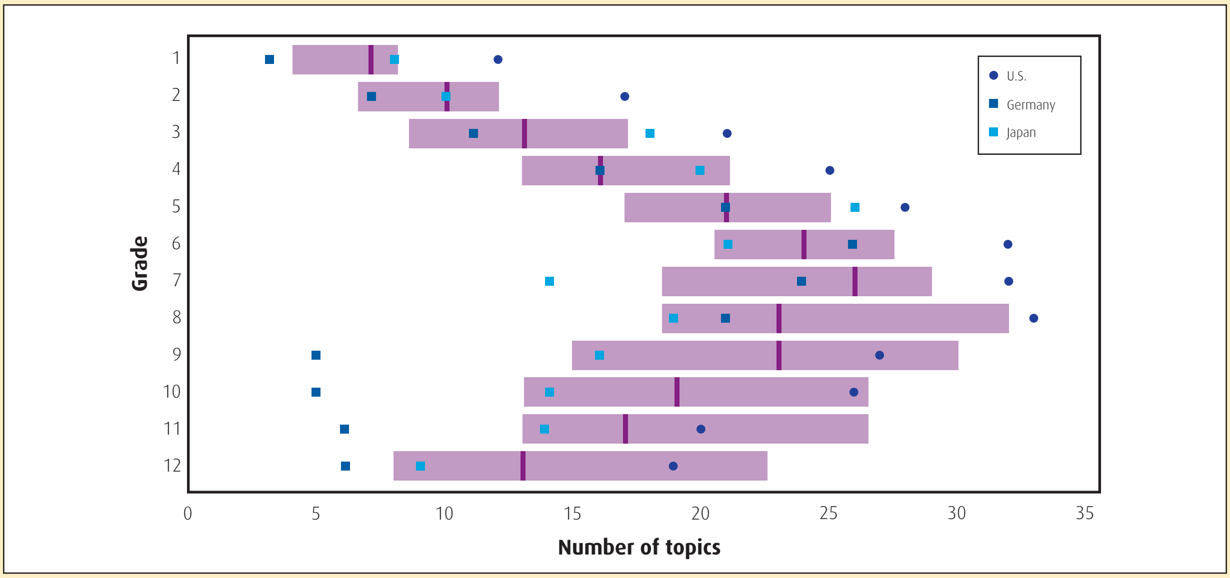
In Washington State, the specific learning standards in science for students in grades K–10, called the Grade Level Expectations (GLEs), articulate the scientific concepts and skills students are expected to know and be able to do.[7] (Washington State's GLEs for mathematics are currently being revised.)[8] This effort to describe a reasonable number of topics for each year of schooling mirrors a movement nationwide. For example, the National Council of Teachers of Mathematics recently released a report that "focuses on a small number of significant mathematical 'targets' for each grade level . . . [as] a way of thinking about what is important in school mathematics that is different from commonly accepted notions of goals, standards, objectives, or learning expectations."[9] Regardless of whether one accepts this particular set of targets, the message is clear: an appropriate number of concepts should be studied each year in

"A Mile Wide and an Inch Deep"

TIMSS analysis of 491 curriculum guides and 628 textbooks from around the world offered a snapshot of the curriculum taught in the United States versus other industrialized countries by tabulating the mathematics or science topics that were to be covered at each grade level. The national mathematics standards were only 3 years old (the national science standards were still in development), but even in such infancy, the data yielded a discouraging picture. This was especially troubling in light of the mediocre performance by U.S. students compared with their international cohort.[5]

As found in the study—and depicted in the Figure 1 and Figure 2—American mathematics curricula sought to cover significantly more topics than curricula in other countries, especially in grades 1 through 8. Science was not as "ambitious" but it too exceeded the 50th percentile of the number of topics introduced internationally at every grade but the 10th. Despite the introduction of new topics, the core content has remained the same. As a result, the U.S. curriculum has widened in its offerings and thinned in its depth.[6]

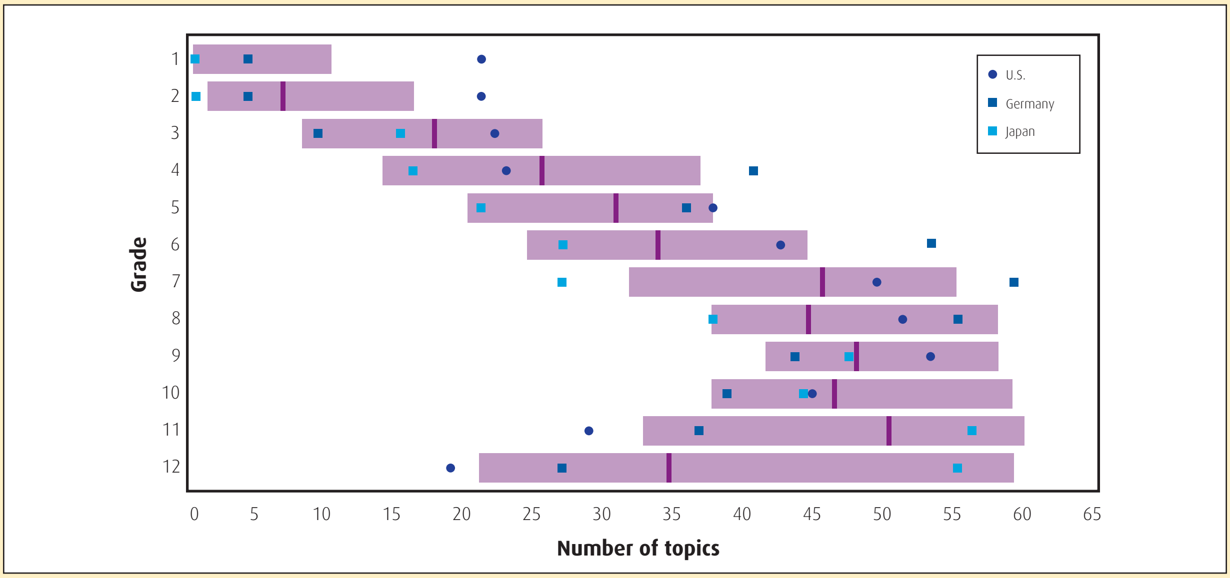
Figure 1: Number of Mathematics Topics Intended to Be Covered in 36 Countries



Note: The light purple bars show how many mathematics topics were intended to be covered at each grade in the TIMSS countries. The bars extend from the 25th percentile to the 75th percentile among countries. The purple line indicates the median number of topics at each grade.

Source: William H. Schmidt, Curtis C. McKnight, and Senta A. Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education,* Third International Mathematics and Science Study, 1992–93.

Figure 2: Number of Science Topics Intended to Be Covered in 35 Countries

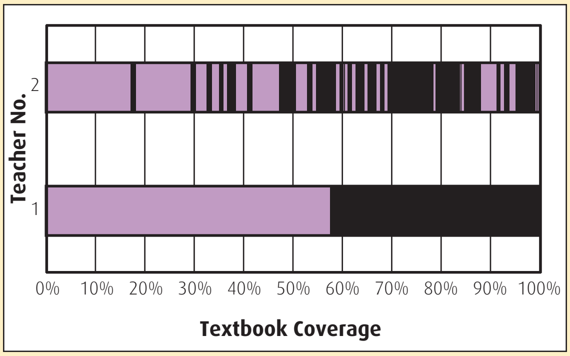


Note: The light purple bars show how many science topics were intended to be covered at each grade in the TIMSS countries. The bars extend from the 25th percentile to the 75th percentile among countries. The purple line indicates the median number of topics at each grade.

Source: William H. Schmidt, Curtis C. McKnight, and Senta A. Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education,* Third International Mathematics and Science Study, 1992–93.

"The development of a coherent and articulated set of curricular expectations is a fundamental cornerstone of any school or district effort to improve student performance in mathematics and science."

Figure 3: Percentage of Coverage of the Seventh Grade Mathematics Textbook in the Same District



Source: Chávez, O., Chval, K., Reys, B., & Tarr, J. (in press). Considerations and limitations related to conceptualizing and measuring textbook integrity. In *Teachers' use of mathematics curriculum materials: Research perspectives on relationships between teachers and curriculum.*

mathematics and science so that all students acquire a deep conceptual understanding of the curriculum as well as mastery of skills associated with that curriculum.

Reaction against breadth is also grounded in recently emerging data suggesting that teachers in the same school or district may make different curricular choices. Figure 3, for example, depicts in purple topics taught, and in black, topics omitted by two seventh grade teachers using the same mathematics textbook in the same district. Although both covered 58% of the textbook, students had two very different educational experiences.[10]

Each school and district must clarify learning objectives in middle school mathematics and science to ensure that all students master the essential concepts they will need for rigorous study in high school. Additionally, teachers must be equipped with high-quality tools and training—textbooks, supplemental books, curriculum guides, alignment between textbooks and expectations, and professional development—that enable them to help their students achieve the learning objectives.

district-level STRATEGIES

Clarify curriculum expectations for each grade or course.

- Identify the "big ideas" that students should understand and the skills necessary to demonstrate their understanding.[11] (See "What Is a Big Idea?" sidebar.)
- Limit curriculum expectations to topics that directly build conceptual understanding of those big ideas.
- Cut or de-emphasize other topics from existing courses or topics in adopted instructional materials.[12] Some likely candidates that can be deleted from specific courses are:
  - Extensive re-teaching of previously taught and mastered material, which becomes redundant when GLEs are clear.
  - Topics that do not result in student understanding or topics better suited to a higher grade.
  - Unnecessarily technical vocabulary and facts that do not develop a foundation for important concepts.
- Pursue interdisciplinary study in mathematics and science that mutually reinforces student understanding in both disciplines, particularly in the areas of measurement, proportional reasoning, and using formulas.
- Articulate specific content expectations for each middle school mathematics or science course, which define milestones for coverage of content and enable timely comparison of student learning via common end-of-unit assessments.

Ensure that the instructional materials in use match the curriculum expectations.

- When selecting curricular materials, apply the best current knowledge of how students learn the subject, and use reviewers from the cadre of best informed master teachers.[13] For more information, see "Selecting Powerful Instructional Materials" sidebar.
- Analyze student achievement data to highlight areas of curriculum most in need of improvement, and select new materials that address those needs.
- Examine evidence that the materials have improved student learning in other school districts.
- Provide all instructional materials in ready-to-use form. In mathematics and science, learning requires hands-on materials, manipulatives, and technology (computer software, probe-ware, calculators, etc.). A staffed centralized center is often useful in refurbishing materials, buying consumables at bulk rates, and storing and distributing materials.[14]
- Ensure that materials address and engage the diverse cultural, linguistic, and learning needs of all students.

Selecting Powerful Instructional Materials

The tools of an effective mathematics or science teacher must include high-quality textbooks, supplemental print materials, laboratory manuals and materials, measuring devices, three-dimensional models, blocks and snap cubes, activity kits, software, CDs, videos, and other multimedia. Teachers should use instructional materials to make student learning more concrete, engaging, and exploratory, thereby meeting the diverse cultural, linguistic, and learning needs of all students. Having the right instructional materials readily available is central to meeting high expectations for student learning.

A set of basic principles should drive the selection of instructional materials in mathematics and science, such as:

1. Alignment with the district's learning goals requires that classroom teachers determine the concepts students are expected to master that would most benefit from the use of instructional materials.
2. Instructional materials must support all students' ability to transfer and apply knowledge to various contexts and make connections among concepts.
3. A significant barrier to supplying high-quality instructional materials involves financial resources and the timing of adoption cycles in states.
   - Budgets need to be "amortized" over several years for big purchases (e.g. textbooks, hardware, software). Consumable resources have to be replenished annually, so line items must be included.
   - Textbooks alone are thought to be inadequate instructional materials. For example, the National Science Teachers Association (NSTA) recommends that middle school teachers engage students in laboratory experiences for a minimum of 80% of the science instruction time.
   - Identifying evidence of effectiveness before purchase and implementation of instructional materials is key. Although the demand for such evidence may eclipse its availability, each developer should be able to answer queries about field testing in various settings and subsequent revisions.

Set realistic goals for implementation of new materials.

- Different designs for staged implementation have proved effective: grade-by-grade, or one new unit for everyone each semester.
- Professional development should be different for each stage of implementation and take into account that not all teachers move through the stages at the same pace. (See "Concerns-Based Adoption Model" sidebar.)
- Support differentiated instruction to meet the diverse cultural, linguistic, and learning needs of all students.
- Expect an "implementation dip," during which student learning may suffer temporarily while teachers become more proficient in new practices.
- Set annual and long-term implementation goals, accompanied by measurable indicators of success. Communicate these goals to school leadership teams and regularly monitor progress.

Communicate to all stakeholders the features and implications of the new curriculum.

For example, messages might include:

- Algebra concepts will be included in every middle school mathematics course, culminating with all students ready for a rigorous, college-preparatory high school program. To accomplish this, the critical aspects of algebra need to be defined in ways that allow them to be reached by all students.
- Laboratory activities in science will challenge students to develop their own valid methods of organizing and analyzing data.
- All students will encounter a more rigorous curriculum in science and mathematics, and teachers will be supported and challenged to master techniques to meet the cognitive needs of diverse students in the context of course expectations.[15]

» notes

school-level STRATEGIES

Align the taught curriculum with district expectations.

- Gather information on the current curriculum—what teachers are actually teaching or planning to teach. Align this with the current district curriculum expectations to identify gaps or departures, as well as solid matches.[16]
- Consider mathematics and science interdisciplinary work to enhance student learning and collaboration among staff.
- Define long-term goals and incremental steps to achieve full curriculum implementation within the timeframe set by the district.
- Assign responsibilities to specific members of the school leadership team to initiate and monitor progress toward meeting the goals.
- Use the school plan to set department meeting agendas, inform instructional coaches, guide teacher evaluations, and set priorities for personal professional development plans.[17]

Make certain that each teacher understands the student learning goals at each grade/course and implements them.

- Teachers must be able to identify the "big ideas" in science or mathematics for their grade and course, stated in specific terms what students will know or be able to do.[18] (See "What Is a Big Idea?" sidebar).
- Teachers must be able to construct a "bridge" between the district's GLEs and the level of detail needed to plan instruction and assessments.
- Teachers must meet as a department to review the entire curriculum to ensure that each teacher is aware of the content of each grade and course as well as how to meet the diverse cultural, linguistic, and learning needs of all students (with particular attention to coaching new teachers on such topics).
- Teachers must find solutions to breadth versus depth conflicts and resolve any gaps or overlaps in content by completing a course mapping.
- Teachers must use specific content expectations for each middle school mathematics and science course, which define milestones for coverage of content and enable timely evaluation of student learning via common end-of-unit assessments.

- Teachers must be supported as they give up current practices and "tried-and-true" units by:
  - Developing new lesson plans collaboratively.
  - Sharing experiences in mastering new instructional strategies, assessing student understanding, or assisting diverse student learning styles.
  - Helping each another understand the rationale and benefits in changing classroom practices.
  - Celebrating successes large and small.

Ensure that teachers have the instructional materials necessary to implement the curriculum.

- Technology tools (computers, hand-held computers, calculators, probes, database software, graphic programs for geometry, etc.) must be available in sufficient number and in good repair.
- Hands-on materials (such as science kits, mathematics manipulatives, teacher demonstration materials) must be in good repair and ready for classroom use when needed. Consumable or damaged materials must be replaced promptly. A staffed, carefully inventoried and maintained materials center is often needed (sometimes provided at the district level).[19]
- Supplementary materials are needed to enhance the content with an alternative approach to meet the diverse needs of students (e.g., bilingual materials, high-interest/low-reading level books). Such materials may be particularly appropriate when student achievement levels are consistently low.

» notes

What Is a Big Idea?

Translating Standards and Grade Level Expectations Into Effective Lessons

1. Become familiar with the content and format of Washington State's standards. For complementary information, read national standards documents.
2. Study the GLEs for the grade or course.
3. Choose a student learning goal that is at the concept or principle level (not a fact or skill) and that addresses multiple GLEs. Take into consideration the following:
   - Questions, situations, or issues likely to grab the attention of students (local, timely, thought-provoking, personal).
   - How students learn and approach problem-solving at their age.
4. Write down the "big idea" students should come to understand about the concept.
   - Be specific in describing what they should know or do.
   - A big idea is not a topic; it's more like the "answer."
   - If a student assessment could be designed around the content of your statement, you are on the right track.
5. Sketch out which assessments will reveal student understanding of the big idea and subtopics that go into understanding the big idea.
   - Include a method (test, discussion, activity) to assess student's prior knowledge.
6. Choose from among the activities in instructional materials those that will build student understanding of the big idea.
   - Include a variety of instructional strategies: direct instruction on vocabulary and skills, inquiry and problem-solving activities from teacher-guided to open-ended, practice applying knowledge to new contexts, practice applying skills and processes.
   - Discard any content in textbooks or previous units of study that does not directly build student understanding of the big idea.
   - Use and teach only the vocabulary necessary to understand the big idea, discarding or de-emphasizing unnecessarily technical terms.
7. Plan the sequence of activities.
8. Identify when assessments are essential to guide instruction.
   - When must students have prerequisite knowledge before continuing?
   - When can an instructional activity reveal student thinking, assess developing understanding, or reveal possible misconceptions?
   - When will teacher feedback be most helpful?
9. Discuss your goals with students and assist them in personalizing as appropriate.
10. As you teach, take notes to help you remember how to revise this unit of study.

Concerns-Based Adoption Model

We are all well aware of how difficult change can be. However, with planning and targeted professional development plans, schools and districts can and should take into consideration the level of concern about such change among staff. Using Table 1, the first and second columns are from the Concerns-Based Adoption Model (CBAM)[20] and describe the typical progression of staff's level of concern when adopting a change. The third column suggests how schools and districts can use high-priority professional development activities to address each stage and make staff more comfortable with the change taking place.

Table 1: Stages and Expressions of Concern and Professional Development Priorities

Stages of Concern About a Change	Expression of Concern	Professional Development Priorities
Non-Use	The user has no interest or is taking no action.	• Written information • Overview demonstrations • Displays • Personal contacts
Orientation	The user is taking the initiative to learn more about the innovation.	• Question and answer sessions • Discussions • Testimonials from experienced teachers
Preparation	The user has definite plans to begin using the innovation.	• Guided overview of instructional materials • Practical advice on classroom management • Modeling and practice with new instructional strategies
Mechanical	The user is making changes to better organize use of the innovation.	• Experiences to deepen content knowledge • Collegial discussion of experiences • Information on student learning, common misconceptions
Routine	The user is making few or no changes and has an established pattern of use.	• Experiences to deepen content knowledge • Examination of student work • Using formative assessments and questioning • Differentiated instruction
Refinement	The user is making changes to increase outcomes.	• Experiences to deepen content knowledge • Examination of student work • Using formative assessments and questioning • Differentiated instruction • Analysis of student achievement data • Lesson study
Integration	The user is making deliberate efforts to coordinate with others in using the innovation.	• Conference presentations • Mentoring • Lesson study
Renewal	The user is seeking more effective alternatives to the established use of the innovation.	• Data analysis • Review of research on effective practices • Participation in field testing of innovative products

Source: Hord, S., Rutherford, W., Huling-Autin, L., & Hall, G. (1987). *Taking charge of change.* Alexandria, VA: Association for Supervision and Curriculum Development.

reflective QUESTIONS

Is my knowledge of the content deep enough to judge whether the curriculum is rigorous? Where my knowledge is weak, what are my best remedies?

Do I know what to look for in classrooms at our current stage of curriculum implementation? What are reasonable expectations?

Are instructional materials being used as expected? Do my observations point to strengths and weaknesses in the materials themselves or in their implementation?

How do I know that the diverse cultural, linguistic, and learning needs of my students are being met in the classroom?

Are we as leaders well aware of teacher concerns about the curriculum? Do the teachers perceive they are being heard?

curriculum expectations and implementation
summary

At the district level, it is critical that:

- Curriculum expectations are clarified for each grade or course.
- Instructional materials match the curriculum expectations.
- Realistic goals are set for implementation of new materials in terms of teacher learning and available resources.
- All stakeholders are able to communicate the features and implications of the new curriculum.

At the school level, it is critical that:

- The taught curriculum is aligned with district expectations.
- Each teacher understands the student learning goals at each grade and course and implements them.
- Teachers have the instructional materials necessary to implement the curriculum.

resources FOR curriculum expectations and implementation

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professional **development** AND professional **culture**

professional **development** AND professional **culture**

The most powerful tool for enhancing student knowledge in mathematics and science is the quality of teaching in every classroom.[21] All good intentions and well-conceived plans are for naught if they are not implemented by enthusiastic, energetic, expert teachers. Without such teachers and teaching, the classroom door keeps out more than noise and cold air; it becomes a barrier to innovation, higher student achievement, and sustained improvement, regardless of the policies and practices that a district or school implements.

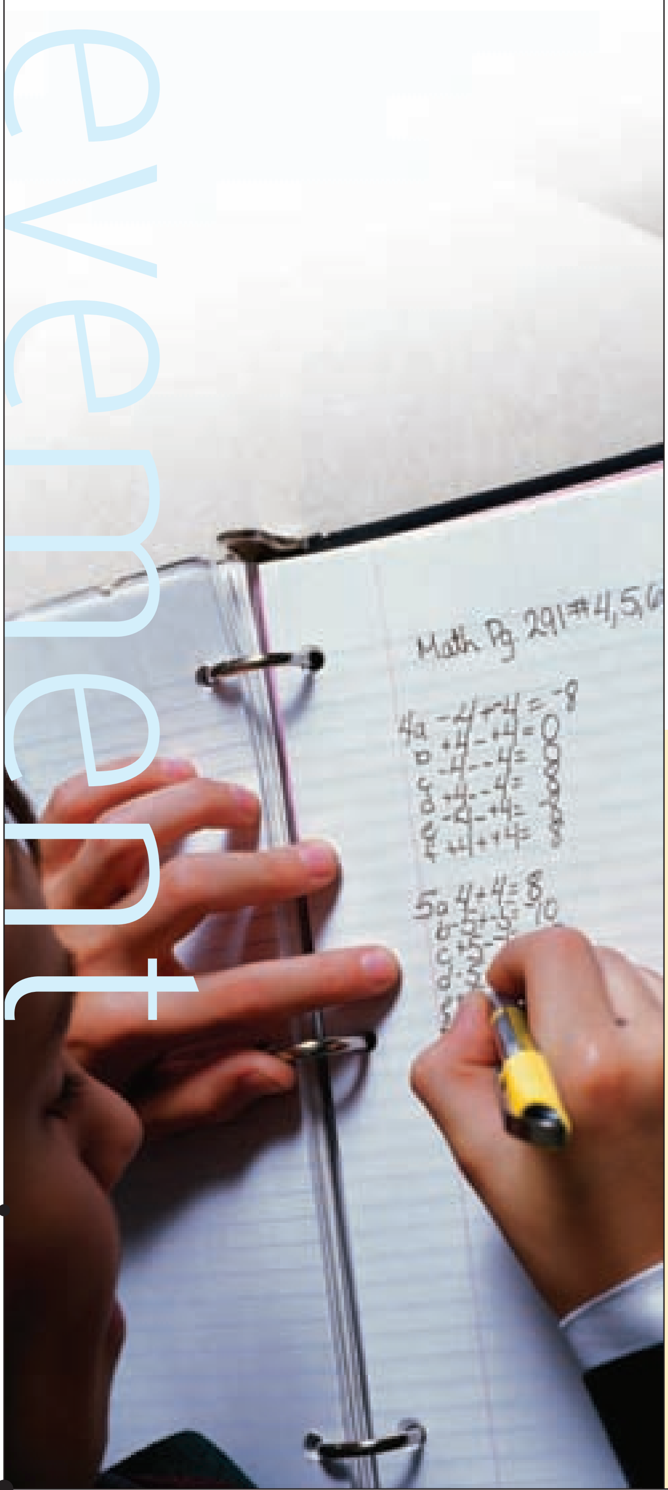
Shepherding high-quality educational change is an enormous responsibility to place on teachers' shoulders, but an appropriate one given their professional stature and their role in society. Make no mistake, however: to bolster student achievement in mathematics and science many current teachers must fundamentally change the way they approach teaching. Many prospective teachers need a fundamentally different set of preparatory experiences. Most importantly, all teachers must have administrative support and *time* to make these adjustments. Such change cannot and will not happen on its own. Further, teachers must be exposed to the best practices that address the cultural, linguistic, and learning needs of the increasingly diverse student body of Washington State schools. The education and political systems cannot hold teachers and students accountable for a lack of progress if their knowledge base and skills are lacking.

Thus, what is required is an ongoing system of professional development in a workplace that supports and values adult learning with the goal of improving instruction. New teachers need sustained high-quality mentoring and supportive induction programs. Seasoned teachers need time to reflect, collaborate, and broaden their knowledge and skills.

Research corroborates common sense: teachers with strong content knowledge who know how to engage students in rigorous learning make a critical difference in student success.[22] Yet, in a nationwide sample, nearly three quarters of middle school mathematics and science teachers reported general education as their major (not mathematics or science education) rather than a content-rich, discipline-based major.[23] Strong content and pedagogical content knowledge in

"What is required, then, is an ongoing system of professional development in a workplace culture supporting and valuing adult learning with the goal of improving instruction."

achievement



mathematics and science are not often found as hallmarks of such teacher preparation programs. However, strong content knowledge is but one hallmark of an effective teacher. Merely increasing content knowledge on the part of teachers is not enough to raise student achievement in mathematics and science, as indicated in "Raising Student Achievement in Mathematics and Science" sidebar.

To be most effective, professional development must be tailored to individual needs, just as teaching is tailored to individual student needs. Washington State, like many states, has reported a shortage of teachers in mathematics, physics, and special education.[24] Some teachers, therefore, find themselves teaching "out-of-field"—or outside of their field of expertise. (For a national snapshot of this problem, see Figure 4 in "Out-of-Field Teachers" sidebar). Although the number of such teachers reported in Washington State is small, the number of young minds they have

Raising Student Achievement in Mathematics and Science

To raise student achievement in mathematics and science, all teachers must:

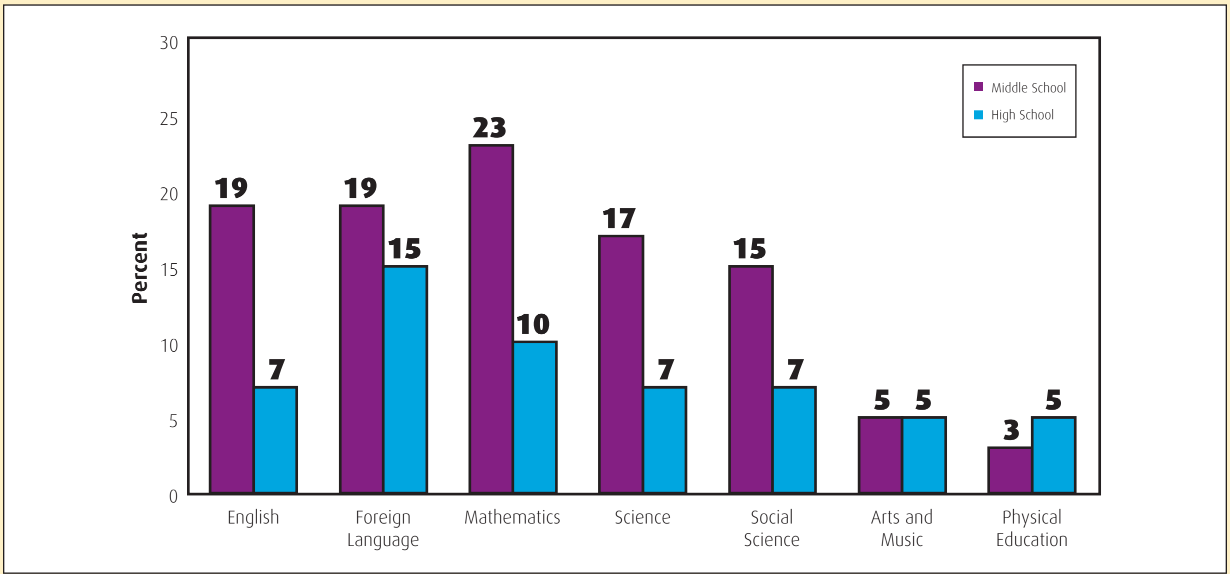
- Deepen their content knowledge.
- Develop pedagogical content knowledge about how students learn specific concepts.
- Connect research-based insights to practice, build communication links and collaborative relationships with others in the same school and district.
- Keep up to date with new professional insights.
- Reflect on what they are learning.
- Make the necessary adjustments as a result of such reflection.

responsibility for is not.[25] Shoring up content knowledge among these teachers will have a real payoff.

In Washington State, middle school teachers can have one of three types of endorsements. These endorsements have differing requirements about the number of quarter credits required in mathematics or science. With course requirements ranging from as few as 3 to as many as 45, certainly the lower end of the range is insufficient background for the rigorous mathematics and science courses that should be taught in middle school. Like out-of-field teachers, even some teachers with endorsement would benefit from professional development that emphasizes the mastery of content and pedagogical content knowledge.

The stability of Washington State's teaching force suggests that high-quality professional development for currently employed teachers will be beneficial compared to the status quo. Figure 5 summarizes teacher retention and mobility in Washington State between 1998 and 2002.[26] Only a quarter of Washington State's teacher workforce leaves the profession within 5 years, considerably less than the national average, which varies between 40% and 50%.[27] Teacher mobility within districts is greater than mobility

Figure 4: Out-of-Field Teachers: Percentage of public school students in middle and high school grades taught by teachers without a major or certification in the field they teach, by subject area, 1999–2000



Note: Major refers only to a teacher's primary field of study for a bachelor's degree.

Source: Seastrom, M. M., Gruber, K. J., Henke, R. R., McGrath, D. J., and Cohen, B. A. (2002). *Qualifications of the public school teacher workforce: Prevalence of out-of-field teaching 1987–88 to 1999–2000* (NCES 2002–603, tables B-8 and B-9). Washington, DC: U.S. Department of Education. Data are from U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS), "Public Teacher Questionnaire," 1999–2000 and "Charter Teacher Questionnaire," 1999–2000.

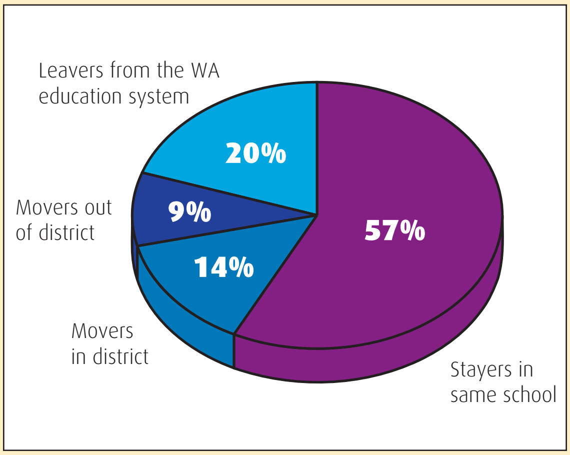
"The learning culture that permeates schools must be extended to include both teachers and administrators, so that instruction can improve along with student achievement.

Teachers with their own "A-ha!" moments internalize the personal power they will want to develop in their students."

between districts, so district-planned professional development is a sound investment. In fact, contrary to many urban districts, Seattle has only a 5% rate of mobility to positions outside the district. Of the 20% of the Washington State teacher workforce who leave the profession, about half are retirees and some leave temporarily for child-rearing responsibilities.[28]

The learning culture that permeates schools must be extended to include both teachers and administrators, so that instruction can improve along with student achievement. Teachers with their own "A-ha!" moments internalize the personal power they will want to develop in their students.[29] For this to happen, school and district leaders must deliberately implement strategic policies that both value teacher knowledge and expertise and provide opportunity for this knowledge and expertise to flourish.

Figure 5: Statewide Teacher Retention and Mobility After Five Years (1998 and 2002).



Source: Ingersoll, R. M. (2003). *Is there really a teacher shortage?* (p. iv). Seattle, WA: University of Washington, Center for the Study of Teaching and Policy and the Consortium for Policy Research in Education.

district-level STRATEGIES

» notes

Professional development must focus on how teachers can increase student understanding of important concepts ("big ideas") in mathematics and science.

- Build teachers' content knowledge through personal experience and access to key resources.
  - › Engage teachers in learning experiences on key concepts. For example, teachers should be able to develop a visual as well as an algebraic solution to a problem, such as using pattern blocks to visualize multiplication of fractions. Or teachers should find a data-based, replicable explanation for a scientific phenomenon, such as causing water vapor to condense.
  - › Provide reference materials for future use by teachers that help them to understand concepts and focus instruction on building students' conceptual understanding.[30]
  - › Encourage teachers to dig deeper into the content by identifying the specific student learning goals for each topic area. Instead of planning a unit on "types of rocks," for example, teachers should first identify what students should understand, such as "Rocks have characteristics that identify how they were formed: from volcanic activity, from applied pressure from underground surroundings, and from built-up layers of sedimentation." Then, instruction should focus on students learning to identify and describe these characteristics in rock samples.
  - › Support teachers in assessing the cognitive demand of tasks within their lessons. (For more information, see "Depth of Knowledge" sidebar.) This requires that they understand the content well enough to ensure that students are engaged in learning rigorous content in each learning activity.[31]

- **Address how students learn mathematics and science, including how conceptual understanding develops and typical misconceptions that students possess.**
  - › Cite research and authoritative sources on how students best learn mathematics and science concepts.[32] Students (and teachers) often have their own explanations for scientific phenomena or mathematical processes that are not correct.
  - › Provide and discuss resources that identify common misconceptions or preconceptions for middle school science and mathematics concepts.[33]
- **Model and practice formative assessments that provide information on what students are thinking and how their conceptual understanding is developing.**
  - › Collect and use data on student learning to inform instruction via collaborative study of student work, sharing of various formative assessments and their applications, common summative assessments, and identification of exemplars of student work.[34]
  - › Use student work samples to illustrate common ways of thinking about a concept.
  - › Develop rubrics that help students understand how to improve their own work.
  - › Develop and/or refine teachers' facility at asking questions of students that help challenge misconceptions and foster deeper thinking and understanding.
- **Emphasize the importance of classroom climate in supporting learning for all students by examining all practices for their consequences in supporting student learning. Specifically ensure that:**
  - › Instruction is varied enough to allow students with diverse learning styles to develop understanding.
  - › Instructional time is allocated efficiently and in ways that maximize time on task.
  - › Students are supported by teacher and peers in taking risks, such as offering alternate explanations or asking for help.
  - › Concepts are presented in varying contexts that are engaging and meaningful to all students.
  - › Teachers and students are committed to helping every student learn.
  - › Students participate in setting goals and assessing their own progress.[35]
- **Address the effect of a student's culture and background knowledge on learning mathematics and science.**
  - › Model and provide information on promising alternatives to prevalent instructional practices, particularly cultural competencies and effects of multicultural social interactions on the classroom learning climate.[36]
  - › Use specific remediation that builds background knowledge—for example, creating language-rich classrooms.[37]
  - › Use student work samples to study how students learn differently—especially those from diverse cultural and linguistic backgrounds—and assess the effectiveness of varied instructional strategies.
  - › Structure grading practices that are supportive of learning so that students struggling in the learning process can still be recognized for effort and achievement.

Depth of Knowledge

Norman Webb created four "depth of knowledge" levels (as depicted in Table 2) to help ensure that the cognitive demands (or thinking skills) required in the state and/or district standards were aligned and consistent with assessment expectations.[38] In identifying standards and assessment items based on one of the four depth of knowledge categories, districts, schools, and teachers can better balance and vary the levels—making certain that all levels are represented and being utilized, especially in the areas of mathematics and science.

Table 2: Depth of Knowledge: Mathematics and Science

MATHEMATICS	
Level 1: Recall	Includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. That is, in mathematics a one-step, well-defined, and straight algorithmic procedure should be included at this lowest level. Key words that signify a Level 1 include "identify," "recall," "recognize," "use," and "measure."
Level 2: Skill/Concept	Includes the engagement of some mental processing beyond a habitual response, including interpreting information from a simple graph. Requires students to make some decisions as to how to approach the problem or activity. Key words include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." These actions imply more than one step.
Level 3: Strategic Thinking	Requires students to use reasoning, planning, and evidence to explain their thinking and make conjectures. The cognitive demands are complex and abstract and require more demanding reasoning. Includes drawing conclusions from observations, citing evidence and developing a logical argument for concepts, explaining phenomena in terms of concepts, and using concepts to solve problems.
Level 4: Extended Thinking	Requires complex reasoning, planning, developing, and thinking most likely over an extended period of time—requiring applying significant conceptual understanding and higher-order thinking, making several connections—such as relating ideas within the content area or among content areas—and having to select one approach among many alternatives for how a situation should be solved. Includes designing and conducting experiments, making connections between a finding and related concepts and phenomena, combining and synthesizing ideas into new concepts, and critiquing experimental designs.
SCIENCE	
Level 1: Recall and Reproduction	Includes recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple science process or procedure. Requires students to demonstrate a rote response, use a well-known formula, follow a set procedure (like a recipe), or perform a clearly defined series of steps. Key words such as "identify," "recall," "recognize," "use," "calculate," and "measure" generally represent cognitive work at the recall and reproduction level.
Level 2: Skill and Concept	Includes the engagement of some mental processing beyond recalling or reproducing a response. Requires students to make some decisions as to how to approach the question or problem. Key words include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." Activities include making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.
Level 3: Strategic Thinking	Requires reasoning, planning, using evidence, and more demanding reasoning that is complex and abstract. Requires students to explain thinking and justify their response. Includes experimental designs with more than one dependent variable, drawing conclusions from observations, citing evidence and developing a logical argument for concepts, explaining phenomena in terms of concepts, and using concepts to solve nonroutine problems.
Level 4: Extended Thinking	Requires high cognitive demands and very complex reasoning, design, and planning, over an extended period of time. Students must make several connections—relate ideas within the content area or among content areas—and have to select or devise one approach among many alternatives on how the situation can be solved, including "develop generalizations of the results obtained and the strategies used and apply them to new problem situations."

Source: Webb, N. L. (2002). *Depth-of-knowledge levels for four content areas.* Madison, WI: Wisconsin Center for Education Research.

» notes

Professional development must be designed and delivered to model best teaching and learning practices.

- Mathematics teachers should work collaboratively on problem-solving, explaining their thinking, using multiple representations, and developing an understanding of concepts.[39, 40]
- Science teachers should design scientific inquiries, communicate their findings, and practice defending conclusions based on data.[41]
- Teachers should promote reflective thinking about lesson planning through journal writing, personal goal-setting, and discussions of concerns and experiences from classroom implementation.

Implement a multiyear plan to build teacher knowledge and skills.

- Start with data on current student achievement, teacher needs, impact of past professional development, and alignment of current practices with goals.
- Plan incremental steps (over 3–5 years) toward meeting goals in curriculum, instruction, assessment, and building shared leadership through professional development. Resources—both time and money—rarely allow for a more ambitious timeline.
- Offer professional development that meets the varied needs of teachers and provides a continuum culminating in mastery of high-quality instruction. This will include:
  - Hands-on orientation to new materials or instructional strategies.
  - Advanced sessions focused on student learning and effective instructional strategies, including questioning, collaborative learning, formative assessment, and differentiation for specific learning challenges.
  - Individualized opportunities provided by trained coaches, mentors, or peers in an ongoing professional learning group.

- Develop a cadre of instructional coaches to guide and support classroom implementation.
  - Plan professional development for coaches that incorporates teacher professional development strategies and adds training and mentoring on coaching,[42] fostering change,[43] and varied leadership roles and strategies.[44]
  - Provide guidance and support for coaches to understand and develop effective instructional practices to meet the diverse cultural, linguistic, and learning needs of students.
  - Continually select, train, and mentor new coaches to deepen the pool.

Link district-level professional development directly to the school and classroom.[45]

- Support ongoing collaboration of small groups of teachers of the same subject or grade level, of similar interests, or at the same school.[46]
- Have instructional coaches present in every school to address the concerns of teachers and help ensure coherent implementation.
- Inform building administrators about the district's long- and short-term goals to guide and support mathematics and science teachers.

Align all resources with the professional development plan.

- Use federal and state funds to complement and support grant-funded initiatives.
- Ensure that mentors, instructional coaches, and building leaders align their work plans with the goals of the mathematics and science program.
- Evaluate all mini-grants, field trip requests, department budgets, etc. for their support of program goals.
- Use data on student learning, teacher needs, and progress toward program goals to guide prioritization of budget items.

school-level STRATEGIES

Develop a personal professional development plan for each teacher.

- Collaborate with teachers to develop a personal plan that will:
  - Encourage reflective thinking.
  - Integrate differentiated instructional strategies to meet the diverse cultural, linguistic, and learning needs of students.
  - Promote the vision and goals of the program.
  - Facilitate coaching opportunities.
  - Communicate opportunities.
  - Undertake a professional development needs assessment, and communicate to the district professional development providers.
- Utilize mentors/coaches to provide job-embedded, practical, and timely assistance for professional development needs. Opportunities to mentor/coach also develop emerging leaders.

Build a robust professional learning community.[47]

- Middle school mathematics or science staff meetings include collaborative, 45–50 minute activities that focus on the content to be taught, the manner in which it should be taught, and/or the student learning outcomes that are expected.
  - Discuss articles on learning, content, or issues involving science or mathematical analysis.
  - Share formative assessment ideas, new instructional strategies, or examples of student work revealing unusual or innovative approaches to understanding content.
  - View videotapes of classroom lessons to identify and discuss promising practices.
  - Collaboratively plan lessons that recognize the diverse learning needs of students.
  - Report individual professional development experiences.
- Ongoing activities for departments or teams should focus on content and pedagogy, such as:
  - Collaboratively planning a lesson (lesson study) and collectively monitoring its implementation while one colleague teaches.[48]
  - Scoring common assessments to widen each teacher's experience with student learning and to reach common understanding of proficiency expectations.
  - Developing, implementing, and discussing specific formative assessment or questioning strategies.
  - Designing studies that focus attention on the learning progress of individuals.

- Encourage teachers to use technology and time differently to make more time for learning. For example:
  - Enable teachers to observe and coach one another, such as combining their classes or hiring one or two roving substitutes for a day.
  - Have teachers regularly videotape lessons and choose clips to share and discuss with peers.
  - Have small groups reclaim the few minutes of contracted time at the end of the day for quick planning and reporting tasks.
  - Suggest teachers in an interest group post e-mails to one another during their planning times.
  - Post scanned samples of student work so they can be viewed online by other teachers.

» notes

reflective QUESTIONS

How will I know a teacher understands the content in his or her subject?

What kind of school climate supports teacher learning—for all teachers? Are any school or district policies or practices getting in the way?

What evidence will I see or hear that the teachers in this school understand the goals of the new science and mathematics program? What do I hope to see the teacher or students doing in the classroom?

What have I learned that will help motivate the teachers with whom I work? How can I engage each teacher in reflective practice?

Do my interactions within the school community foster a learning culture focused on continuous improvement?

How do I ensure that teachers are prepared to meet the diverse cultural, linguistic, and learning needs of students?

professional development summary

At the district level, it is critical that:

- Professional development focuses on how teachers can increase student understanding of important concepts ("big ideas") in mathematics and science.
- Professional development is designed and delivered to model best teaching and learning practices.
- A multiyear plan explains how teacher knowledge and skills will be developed and needed resources provided.
- District-level professional development is directly linked to the school and classroom.
- All resources are aligned with the professional development plan.

At the school level, it is critical that:

- Each mathematics and science teacher has a personal professional development plan.
- Ongoing efforts build a robust professional learning community.
- Mentors/coaches are utilized to provide job-embedded, practical, and timely assistance for professional development needs.

resources FOR professional development and professional culture

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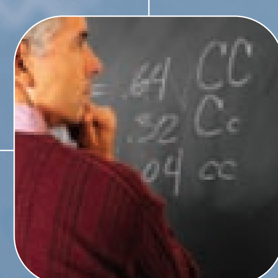
assessment



assessment

Teachers assess their students' progress all the time. There are weekly quizzes and chapter tests, grades given on homework and for class participation, impressions derived from informal classroom observations and quizzical facial expressions, as well as tests administered on behalf of the district or state.

Parents also assess their children's progress. Parents wonder if the evening's homework is complete and pay attention on report card day. Many parents regularly attend teacher conferences to hear first hand about their children's work.

Principals also assess their schools' progress. Impressions about faculty competence are formed during classroom observations, by the number of parent complaints lodged against a teacher, and by the spread of grades given on report cards. Principals also look at student enrollment in honors classes and after-school detention. They analyze dashboard data provided by their district on school indicators.

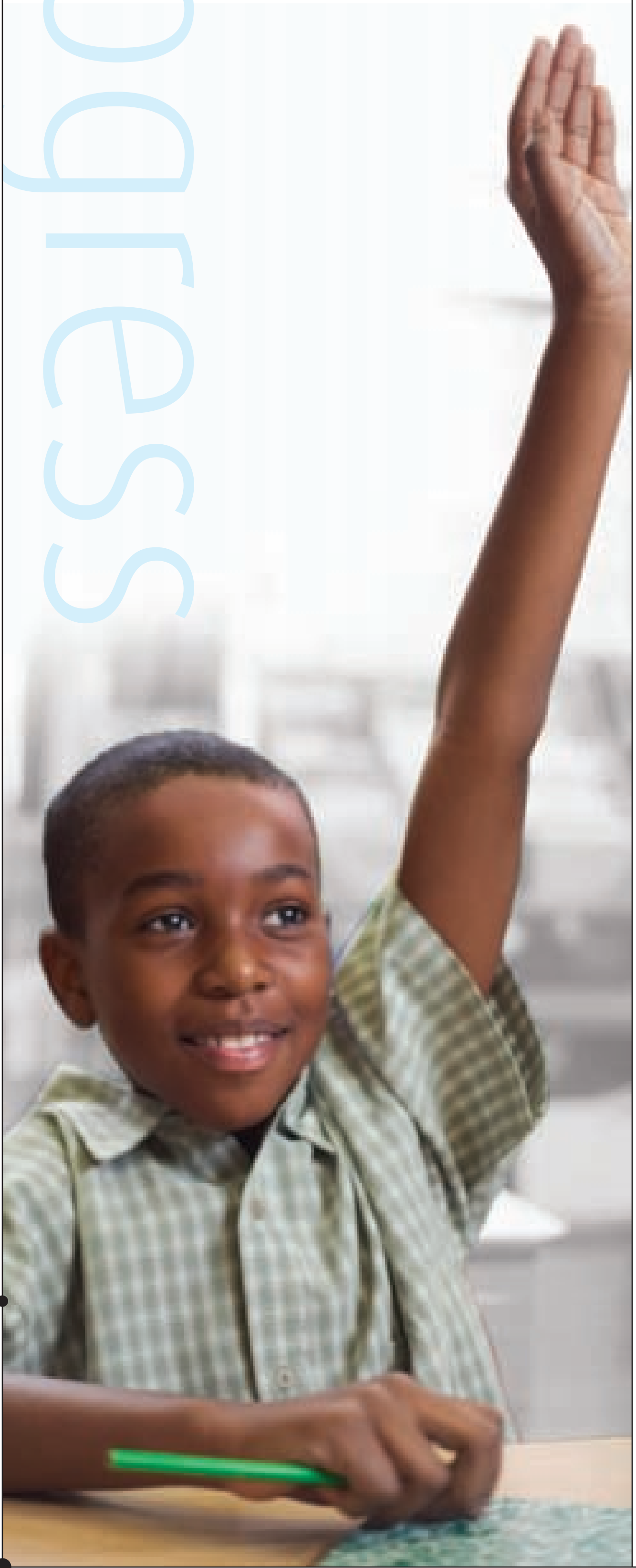
Indeed, the culture of schooling is rife with assessments, formal and informal, as a means to measure the competency of others, specifically measuring what they know and are able to do. This continual attention to assessing is educationally appropriate. When used correctly, assessments mirror the purpose of education; they provide information on students' misconceptions, enabling teachers to adjust their instruction and administrators to modify policies and practices.

Assessments provide data to support a grade earned on a report card. They help to evaluate new curricula or a new program, thus illuminating the effectiveness of public expenditures on education. Assessments help to determine whether an individual is on track to master important skills year by year and eventually to earn a high school diploma. They help to identify struggling teachers who are in need of collegial support. And, through the framework on which assessments are based, they provide a clear statement on the knowledge and skills that are valued for students to master. In other words, assessments are powerful tools to judge whether or not the education enterprise is a success.

"When used correctly, assessments mirror the purpose of education;

they provide information on students' misconceptions, enabling teachers to adjust their instruction and administrators to modify policies and practices."

progress



The power of assessments is constrained by two factors: the quality of the assessments and the integrity with which the results are interpreted and acted upon. Without high-quality assessment instruments or procedures, the information they provide is worthless. But even a high-quality assessment instrument will yield little value if it is used for a purpose other than that for which it was created. If assessment results are not interpreted with care and appropriate caveats, the information is similarly useless.

To help ensure that assessments are high quality, three principles are recommended:[49]

- Content principle: Assessments must reflect the content that is most important for students to learn. For example, educators can assess students' knowledge of how cells function in the body rather than assessing whether students can name all parts of a cell.[50]
- Learning principle: Assessments must enhance learning and support good instructional practice on extended projects, portfolios of mathematical products, models and simulations, and other means used. For example, the College Board developed the Pacesetter™ high school mathematics course to show how assessment can be integrated into instruction.[51]
- Equity principle: Assessments must support each student's opportunity to learn important content. Assessment items must be designed to enable all students, especially those with diverse cultural, linguistic, and learning needs to demonstrate the greatest level of individual understanding. Each student must also have the opportunity to learn the content that will be assessed.

In the current era of accountability, the importance of assessments looms large. Given that reality, it is critical to get assessment right. A starting point in getting it right is ensuring that assessment systems—traditional tests, student projects and portfolios, teacher observation, and performance assessment—are aligned with content standards, that assessments are appropriately administered in a timely fashion, and that the results are used to benefit teaching and learning.

High-quality assessment should focus on important and rigorous content in mathematics and science rather than focusing on discrete, procedural skills. Assessments should be an integral part of the teaching and learning process—integrated into and used throughout the teaching and learning process—rather than the culmination of an instructional unit. Assessments should not be used to close off opportunities for students; instead, assessments should be used to identify strengths and weaknesses in the content knowledge of each student. Students' weaknesses would be addressed with additional mathematics or science instruction. Moreover, without exception, students should have the chance to learn all of the content that ultimately appears on assessments.

The Washington Assessment for Student Learning (WASL)[52] was designed to measure student performance against specific academic standards (a criterion-referenced test) in contrast to measuring student performance to other students in the state or nation (a norm-referenced test). The WASL was also designed to measure students' ability to demonstrate an understanding of concepts rather than their ability to memorize facts. Students are asked to draw conclusions from tables, charts, and graphs for their solutions to mathematical and scientific problems by

"The power of assessments is constrained by two factors:

the quality of the assessments and the integrity with which the results are interpreted and acted upon."

responding to multiple choice questions and developing short answers and essays.

Furthermore, the WASL was designed to align with Essential Academic Learning Requirements (EALRS) in Washington State to give a clear picture of student progress toward mastery of the knowledge and skills that are valued by the state. To facilitate the interpretation of student scores, a state-based standard-setting committee determined the level of performance on the assessment that is expected to show that students are meeting the expectations embedded in the EALRS. Scores can exceed, meet, or fail (on two levels) to meet Washington State's performance standards. These are all characteristics of well-developed assessments.

Educators must carefully ensure that the chosen assessment instrument is designed to inform the educational question under consideration. Standardized tests are one type of assessment; formative assessments—those that are ongoing and often teacher made—occur frequently in classrooms and are characterized as those from which learners have a chance to revisit, revise, and reorient their insights and understandings. Formative assessments can be formal exercises or informal experiences, such as student-generated questions that display confusion or misconceptions to an alert teacher.

Summative assessments, in contrast, come at the end of a unit of study, with little or no chance for students to revise their thinking or learn from their mistakes. In some cases, summative assessments are written by individual teachers for use in their individual classes; in other cases, they are written at the school, district, and occasionally state level for administration in individual classes with results being compiled at the school, district, or state level.

Key Questions in Applying Validity and Reliability Concerns to Classroom Assessment

- What am I interested in measuring? Does this assessment capture that?
- Have the students experienced this material as part of their curriculum?
- What can I say about a student's understandings based on the information generated from the assessment? Are those claims legitimate?
- Are the consequences and actions that result from this performance justifiable?
- Am I making assumptions or inferences about other knowledge, skills, or abilities that this assessment did *not* directly assess?
- Have I made appropriate accommodations for the diverse cultural, linguistic, and learning needs of my students?
- Are there aspects of this assessment not relevant to what I am interested in assessing that may be influencing performance?
- Have I graded consistently?
- What could be the unintended consequences associated with this assessment?[54]

Source: National Research Council. (2001). Classroom assessment and the national science education standards. Washington, DC: National Academies Press.

It is important that teacher-made assessments—formative or summative—be well developed and well scored. Yet, teachers and school district staff may not have the expertise to create or find good formative and summative assessments, to score them reliably, and to interpret and use the results. (For a discussion of these issues, see "Key Questions in Applying Validity and Reliability Concerns to Classroom Assessment" sidebar.) This may be exacerbated among middle and high school teachers who interact daily with many students and can become overwhelmed by having to modify instruction for many of them.

Some districts are turning to technology to address this challenge. Vancouver, Washington, participated in a study to develop the Assessment Design and Delivery System, an online assessment authoring system that helps teachers design and interpret assessments of middle school understanding of important science concepts.[53] Teachers using this tool focused their assessments more on conceptual knowledge and created better scoring rubrics than their colleagues who did not use the tool.

Valid and reliable scoring of assessments, especially teacher-made assessments, is essential. Although the accuracy of the final result of a mathematical problem or a laboratory experiment is important, teachers also often exercise some judgment in scoring the work that led to the result. To be fair to all concerned and to produce useful information, it is important that several professionals looking at the same sample of student work reach the same conclusion about its strengths and weaknesses. Scoring rubrics need to be carefully designed, collaboratively benchmarked, and shared with students.[55]

Nonetheless, no matter what kind of assessment is used, it represents only an estimate of what a student knows and is able to do.[56] Large-scale assessments, such as WASL, depend on "a statistical model that characterizes expected data patterns, given varying levels of student competence," whereas teacher-made tests often rely on an intuitive or qualitative interpretation.[57]

"Assessments should not be used to close off opportunities for students;

instead, assessments should be used to identify strengths and weaknesses in the content knowledge of each student."

district-level STRATEGIES

Measure what matters. Prioritize student learning goals in science and mathematics and align district assessments with these priorities.

- Ensure that the enacted curriculum—what is being taught—is consonant with the assessed curriculum. This is especially challenging during periods of innovation and change, requiring a more nimble and responsive assessment system.
- Align the assessment system with the district's vision and goals and discontinue irrelevant or redundant testing. Create a balance between time for instruction and essential assessments.

Promote assessment literacy.

- Routinely release assessment examples from the district that inform teachers, parents, and students of the form and emphases of the assessments.
  - Share the purpose and uses of the assessments with various stakeholder audiences via a Web site, newspaper articles, and school or district-wide meetings that are open to the public.
  - Make clear that an assessment only samples student understanding, not the breadth of content.
- Promptly release the district's assessment results in ways that are easily understood by various audiences, and make clear what the results signify and what they do not signify.
  - Interpret student assessment data and report results to the schools and community.
  - Highlight positive trends, challenges, and plans to address them.
  - Describe how accommodations are made and equity issues are addressed to better serve the district's diverse cultural, linguistic, and learning needs of the student population.

» notes

Create common district-wide assessments for school use.

- End-of-grade mathematics and science assessments clarify expectations and enable swift, direct feedback on student achievement.
- Quarterly common assessments can be used more formatively.
  - Teachers' needs to diversify instruction can make common pacing challenging.
  - When materials are shared for fiscal reasons, assessments can be administered at the end of the unit.
- Common assessments can be tied to professional development in which teachers identify exemplars of proficiency and study nuances of student understanding.
- Issues of validity and reliability should be connected to the development of assessments.[58]

Provide professional development on classroom assessment.

- Develop model instruction that assesses student understanding of facts, vocabulary, concepts, and application of conceptual understanding.
- Model and practice effective questioning techniques in the instruction of mathematics and science.
- Incorporate research findings on feedback that positively affects student learning, such as comments being more effective than grades and revision being more effective than final grades.[59]
- Match the appropriate assessment form to meet the diverse cultural, linguistic, and learning needs for students at different developmental levels.[60]
- Teach protocols to collaboratively assess student work, develop scoring rubrics, and identify models of proficiency.
- Provide ongoing support and resources.
  - Facilitate sharing of assessments among teachers of the same content via a Web-based platform or discussion groups.
  - Guide teachers to online assessment banks and tools.
  - Support trials of innovative performance assessment, portfolio assessments, peer assessment strategies, and standards-based grading and reporting systems. Assess results of pilots and modify if needed.

school-level STRATEGIES

Use common assessments at major curriculum milestones.[61]

- Participate in district-wide development of common assessments and scoring rubrics to ensure that they are well aligned with instructional practices.[62]
- Support all teachers in selecting and pacing content through instructional coaching and departmental collaboration.

Assist teachers in implementing high-quality formative and summative assessments that will optimize opportunities for all students to learn.

- Focus on the types of formative assessments and those that best match particular kinds of knowledge or skill. For example:
  - Short answer quizzes and game formats for vocabulary, labeling diagrams, and facts.
  - Observation of performance (checklist, notes) for application of inquiry and problem-solving skills and interaction with peers in organizing and recording data.
  - Journal writing to reveal current understanding, questions, and misconceptions.
- Help teachers use questioning strategies that challenge all students to reveal their reasoning, think more deeply, and support conclusions with data.
- Institute grading practices that provide students with opportunities to learn from formative assessments.
- Facilitate sharing of formative assessment methods and results.

Identify educationally sound strategies for raising student scores on district and state assessments.

- Focus on developing students' understanding of important concepts, regardless of the implications of assessments regarding coverage.[63]
- Embed some assessment items that mimic the form of district or state tests on other assessments and in instruction to help students gain facility with different types of items.

- Analyze student scores to identify ways to ensure a gain for all students.
  - Help students who are getting only partial scores on multiple point items to learn how to get full credit.
  - Ensure that all students practice skills that are common to the assessments, such as interpreting graphs, assessing the design of science investigations, writing a summary, and recognizing key features in problem solving.
  - Provide remediation to students who perform just below proficiency to raise them to proficiency.
- Motivate students to value the opportunity to show what they know and to develop the attitude throughout the year that they are well prepared to perform well.
  - Create an awareness and appreciation of the value of effort in achievement.[64]
  - Maintain a classroom climate during testing that values the individual efforts of students to demonstrate their thinking and ability to apply understanding the best that they can.

» notes

reflective QUESTIONS

Do grading practices and policies support our learning goals and vision?

Are we measuring what matters? Do our tests fairly assess all students to determine their ability to solve problems, think scientifically, and apply knowledge in a new context?

How will I manage the transition to new teaching methods if scores fall and discontent calls for a return to old methods?

What do teachers' concerns tell leadership about how assessments are being implemented? Are professional development plans sufficient to meet the needs of teachers?

Do teachers have time to teach everything that might be tested on the state or district test? What can I infer from a teacher's response to that question?

What are the reasons for the poor performance of some subgroups of students? How do I best analyze the data to determine what's wrong if we've tried various strategies with some success?

assessment summary

At the district level, it is critical that:

- Assessments measure what matters. Student learning goals are prioritized in science and mathematics and district assessments are aligned with these priorities.
- Assessment literacy is promoted.
- Common district-wide assessments are created for school use.
- Professional development is provided on classroom assessment.

At the school level, it is critical that:

- Common assessments are used at major curriculum milestones.
- Teachers are supported in implementing high-quality formative and summative assessments that optimize opportunities for all students to learn.
- Educationally sound strategies are identified for raising student scores on district and state assessments.

resources FOR assessment

Black, P., and Harrison, C. (2004). *Science inside the black box: Assessment for learning in the science classroom.* London: Nelson.

Black, P., and Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 80*(2), 139–149.

Hibbard, K. M., Van Wagenen, L., Lewbel, S., Waterbury-Wyatt, S., Shaw, S., Pelletier, K., et al. (1996). Chapter 6: How are "benchmarks" (models of excellence) selected? In *A teacher's guide to performance-based learning and assessment.* Alexandria, VA: Association for Supervision and Curriculum Development.

Lewis, C. D. (1996). Chapter 5: What is a rubric, and how does it compare in form and function to an assessment list? In K. M. Hibbard, L. Van Wagenen, S. Lewbel, S. Waterbury-Wyatt, S. Shaw, K. Pelletier, et al. *A teacher's guide to performance-based learning and assessment.* Alexandria, VA: Association for Supervision and Curriculum Development.

National Research Council. (2001). *Classroom assessment and the national science education standards.* Washington, DC: National Academies Press.

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment.* Washington, DC: National Academies Press.

National Research Council. (1999). *Testing, teaching, and learning: A guide for states and school districts.* Washington, DC: National Academies Press.

National Research Council. (1993). *Measuring up: A conceptual guide for mathematics assessment.* Washington, DC: National Academies Press.

Wiggins, G., and McTighe, J. (2005). *Understanding by design* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

data-driven decision-making

data-driven decision-making

Despite the best intentions, well-conceived plans, solid research-based analyses, and effective implementation, there are unforeseen challenges and obstacles in reforming mathematics and science education. However, a program with the right blend of long-range vision and short-term agility can identify and overcome these challenges and obstacles in a timely manner. To do so, school and district leaders must engage in regular qualitative and quantitative introspection and analysis to ensure that their vision stays on track.

The Reflective Questions included with each component in this Field Guide are good examples of qualitative introspection. They provide a framework for leaders to think about progress and to engage others in the reflection, while collecting relevant qualitative data that can be widely shared. Based on these insights, reappraisals of plans and midcourse corrections can be considered and implemented.

However, qualitative data alone are insufficient to form or inform a strategy. To identify strengths and weaknesses in their system, school districts should systematically collect quantitative data related to student, teacher, and school performance. For example, districts should be able to describe their:

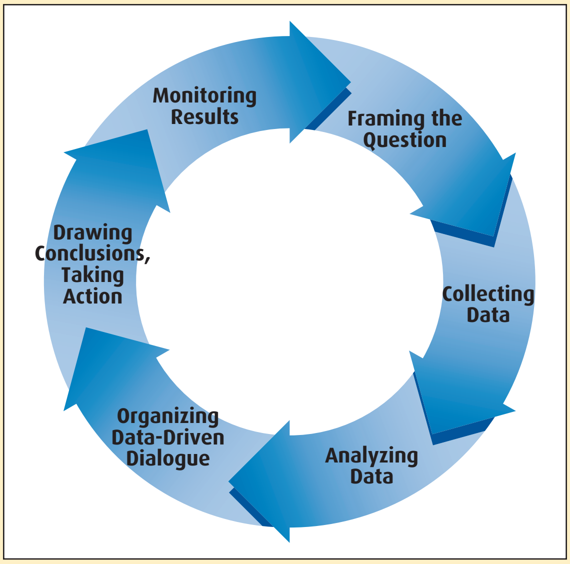
- Student attendance rates.
- Faculty retention rates.
- Faculty qualifications.
- Student demographics, including cultural, linguistic, and learning needs.
- Level of parental involvement.
- Graduation rates.
- Discipline problems.
- Test scores.
- Grade point averages.
- Enrollment in Advanced Placement and honors courses.
- Level of student involvement in extracurricular activities.

“Despite the best intentions, well conceived plans, solid research-based analyses, and effective implementation, there are unforeseen challenges and obstacles in reforming mathematics and science education.”

By reviewing these data, schools and districts are not surprised with low test scores if they are coupled with a high rate of student absenteeism or with teachers who are assigned to classes outside their field of expertise. They are not surprised if there is little engagement in academic or extracurricular activities among a diverse student body if the offerings do not take cultural competencies into account. They are not surprised if enrollment in advanced mathematics and science courses is minimal if parents are not involved in course selection.

However, the goal of quantitative data collection is more than simply overcoming surprise. In exemplary schools and districts, leaders consider what the data show, especially where performance falls short of benchmarks and goals, as they set policies and make educational decisions. Data are made

Figure 6: Phases of Collaborative Inquiry



Source: Love, N (2004). *Using data/getting results: A practical guide for school improvement in mathematics and science.* Norwood, MA: Christopher-Gordon Publishers, p. 15.

readily available to the public via a school or district Web site; teachers are able to analyze data and use them to inform and guide their instructional decisions on a regular basis. As depicted in Figure 6, from framing a question to monitoring results, such districts excel at data-driven decision-making.[65]

There is strong evidence that data-driven decision-making can be effective. For example, the Education Commission of the States conducted a study of six successful districts in California, Colorado, Iowa, Maryland, and Texas.[66] Determined to improve unsatisfactory student achievement in their mostly low income, high student mobility neighborhoods, the districts collected similar kinds of data and put the data to similar uses. They routinely collected:

- Demographic data on students and faculty.
- Achievement data on state-, district-, and teacher-developed tests.
- Instructional data about the curriculum, the set of educational experiences to which students were exposed, and the teacher–student assignments.

Most telling, these districts promptly acted on the data; when test scores were low, misunderstandings about specific content were identified, and students were provided with appropriate class placement and additional learning opportunities for remediation.

"The goal of data collection is more than simply overcoming surprise.

In exemplary schools and districts, leaders consider what the data show, especially where performance falls short of benchmarks and goals, as they set policies and make educational decisions."

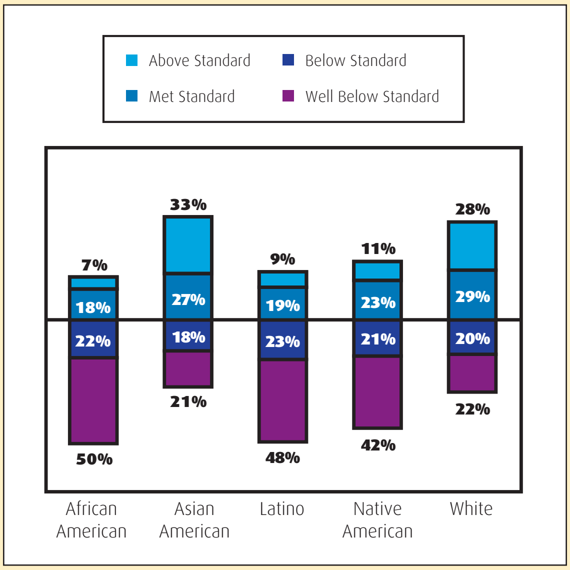
NCLB requires disaggregating data for different groups of students and also demonstrates the importance of collecting the *right* data. Data have upheld what educators already know: that overall averages can mask important differences, thereby obscuring potential leverage points for improvement. Separating student scores by ethnicity, race, family poverty levels, and other characteristics can yield wide discrepancies of achievement that must be addressed.

Figure 7 shows the achievement of students in Washington State against performance criteria and disaggregated by race on the 7th-grade mathematics WASL and the 8th-grade mathematics National Assessment of Educational Progress (NAEP).[67] It is alarming to note that only 7% of African American, 9% of Latino, and 11% of Native American students scored above the standard on the WASL, in contrast to 33% of the Asian and 28% of the White students who scored above the standard of performance. Approximately 20% of Asian or White students scored below basic on NAEP, but approximately 33% of Native American, 50% of Latino, and 40% of African American students scored below basic. These unacceptable achievement gaps must be addressed directly.

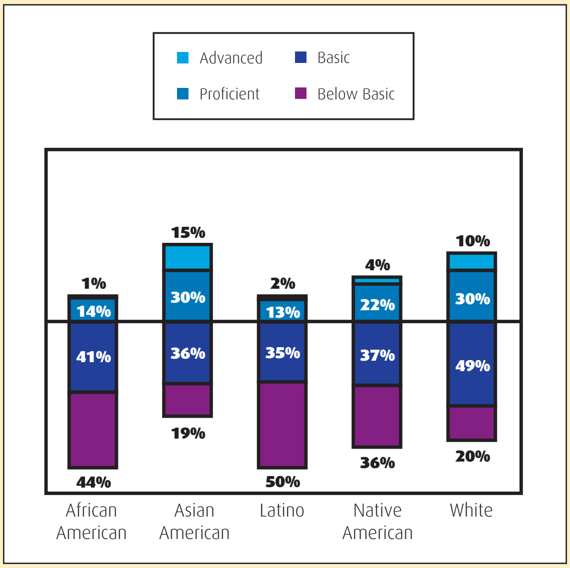
Quantitative data, when coupled with qualitative and other quantitative data, provide a solid starting point to develop policies and practices that will target the necessary help and resources to students and teachers who need it most.

Figure 7: Comparison of Students' Mathematics Achievement on the 2005 WASL and 2005 NAEP

2005 WASL Grade 7 Mathematics



2005 NAEP-Washington Grade 8 Mathematics



Source: Education Trust. (2006). *Education watch Washington: Key education facts and figures—Achievement, attainment and opportunity from elementary school through college.* Washington, DC: Author.

district-level STRATEGIES

» notes

Apply student assessment data to the management of mathematics and science programs.

- Measure what matters. Align what is measured with what is most valued.
- Interpret student assessment data appropriately.
  - Criterion-referenced data indicate levels of proficiency in select content areas but nevertheless are an incomplete sample, and scores do not fully reveal the depth and breadth of student understanding. Teacher assessments and student work portfolios help to complete the picture.[68]
  - Normed student data are best used as an overall indication of progress toward a norm, which itself needs to be understood as a moving target.
  - Progress of individual students can be followed to measure the impact of instruction, accounting for the diverse cultural, linguistic, and learning needs of students.
  - Student assessment scores can be aligned with data on opportunities for students to learn.
- Disaggregate data to reveal achievement gaps among subgroups and to identify content problem areas.

Use data on student, faculty, curriculum, and instruction to evaluate program implementation and effectiveness.

- Identify data that can be used to assess each incremental step toward long-term goals.
  - State the goals so that they are specific, measurable, and attainable; identify the resources needed; and offer a deadline.[69]
  - Assign responsibility for monitoring, collecting data, and reporting to specific staff members. Build team meeting agendas with these reports and discussions in mind.

- Apply multiple sources of data to elaborate on the context of each question or concern, including for example:
  - Teachers' length of service, preparation, and participation in professional development.
  - Students' mobility, absenteeism, prior grades, and feeder elementary schools.
  - Information about school discipline, safety, and staff turnover.
  - Data on attitudes and perceptions of teachers, site administrators, students, and parents.
  - Content and priorities in plans of instructional coaches, as well as their data on school leader team activities and teacher fidelity to the program.
- Focus on measuring impact rather than measuring input.
  - Input measures include number in attendance at professional development, but impact measures look for changes in classroom practices.
  - Identify what concrete evidence will show that each goal is being met.

Make data available in a timely and informed manner.

- Student testing should give sufficient time to learn and not unduly interrupt and preempt instruction.
- Corrective actions to improve curriculum and instruction should follow a rapid turnaround time.
- Time should be given to score items that measure deeper student understanding and thoughtful interpretation of results.
- The efficiency of the use of data should be assessed by a mapping process that is similar to curriculum mapping.[70] Identify the following:
  - What data are important to have?
  - Who is responsible for gathering or disseminating the data?
  - How and when will the data be published and for whom are they published?
  - What are the intended uses by each recipient and the probable timeline?

Develop proficiency among school leadership teams to make data-driven decisions.

- Train school leaders to become experts in identifying and stating problems as well as designing solution strategies.[71]
- Provide forums for sharing the approaches and results generated by school teams.
- Enable schools to use data more proficiently and find needed information.
  - Assist schools with disaggregating data for their use.
  - Perform analyses of data to share with schools.

- Model a data-driven decision-making culture until it becomes second nature by doing the following:
  - Asking for and making use of pertinent data.
  - Expecting that a description of a "problem" be accompanied by both data and a thoughtfully proposed solution.
  - Delaying decisions when more data are needed and the stakes are appropriately high.
  - Valuing reflective questioning during a search for answers.

Make data reports available to the community.

- Systematically collect and apply data from the community to improve both the programs and communication with the public.
- Survey parents and policy-makers to assess their reaction to current methods of reporting data, find out what information they want, and measure their comprehension of traditionally reported data.
- Revise current school report cards, and augment current reporting methods to provide more detail and balance or more understandable analysis.
- Provide student and school data to parents in a universally accessible format to meet the linguistic needs of the community.

» notes

school-level STRATEGIES

Collect data on student learning.

- Use formative and classroom summative assessments to inform instruction.
- Analyze assessment data to identify trends and draw tentative conclusions that can be tested in practice to improve all student learning.
  - Experiment with alternate instructional strategies in several small groups and compare results.
  - Gather more data through observation, student work samples, and peer coaching. Revise instruction accordingly.
  - Systematically and regularly share the inquiries and results among all staff members.

Use multiple sources and kinds of data when making decisions.[72]

- Include such school-wide factors as:
  - Mathematics or science course enrollment and student demographic information.
  - Student grades by course and demographic subgroups.
  - Student proficiency by feeder elementary schools.
  - Graduation and dropout rates.
- Include such student factors as:
  - Student proficiency in science or mathematics by gender.
  - Student attitudes toward learning mathematics or science before and after taking courses.
  - Cultural, linguistic, and economic factors affecting prior experience and background knowledge of students.
- Include such home factors as:
  - Parents' goals for students regarding mathematics and science.
  - Expectations with a cultural basis.

» notes

- Include such teacher factors as:
  - › Details of preparation in the subject area.
  - › Length of service.
  - › Level of fidelity to new programs.
  - › Assessment data across departments disaggregated by content area.

Develop a culture of continuous improvement throughout the school.

- Identify what school-level data will be collected and analyzed so that deadlines and responsibilities can be assigned.
- Collaboratively develop hypotheses for problems that the data analysis suggests.[73]
- Collect qualitative and quantitative data to investigate hypotheses:
  - › Teachers undertake classroom-based action research in alternate instruction and assessment strategies to meet the diverse needs of all students.[74]
  - › Instructional coaches observe teacher and students and provide feedback.
  - › Teacher teams use lesson study to focus on specific student learning outcomes.[75]
  - › Interested teachers review and field test replacement curriculum units.
  - › Leadership team members research cultural norms that affect learning and consult with community members.
  - › Department staff review and revise common assessments.
- Focus on what matters most; select highest priorities related to student learning for the time-consuming tasks of collecting and working with data. Share plans and results widely among the professional learning community.

Make data widely available.[76]

- Provide frequent reports to the school advisory board, making it a partner in the culture of continuous improvement.
- Include parents in data analysis and application at the earliest stages.[77] Protect student privacy when involving others.
- Illustrate progress with student and teacher quotes, examples, and work samples. When possible, include demonstrations and activities in public outreach.
- Balance messages about state assessments or plans with local school information.
- Be honest about challenges and your openness to solutions.

reflective QUESTIONS

What will I hear in conversations when data are becoming more valued in making decisions?

What data have surprised me or others lately? Why were they a surprise?

When data confound me, what should I do?

Do I understand that treating all students the same is not respecting their diverse cultural, linguistic, and learning needs? What will help us address the different needs of our students in learning mathematics and science?

Do I recognize the difference between factors in school and home that we have control over and those that we don't?

Do I have any research base for selecting which changes are most likely to have a positive impact? What resources can assist?

When and where can low expectations be best challenged? Am I prepared to do so?

data-driven decision-making

summary

At the district level, it is critical that:

- Student assessment data are carefully applied to monitor and manage implementation of the mathematics and science programs.
- Data on multiple student, faculty, curriculum, and instruction factors are used to evaluate program implementation and effectiveness.
- Data are available and applied in a timely manner.
- School leadership teams develop proficiency in making data-driven decisions.
- Data reports are made available to the community.

At the school level, it is critical that:

- Data collection on student learning is planned and carried out.
- Multiple sources and kinds of data are brought to bear in making decisions.
- A culture of continuous improvement characterizes staff interactions.
- Data are made widely available.

resources FOR data-driven decision-making

Data Use: Data Primer, North Central Regional Educational Laboratory (NCREL). http://www.ncrel.org/datause/dataprimer/

Education Commission of the States. (2002). *No Child Left Behind issue brief: Data-driven decision-making.* Retrieved January 30, 2007, from http://www.ecs.org/clearinghouse/35/52/3552.pdf

Improving Education Practice Through Data Use: Data-Driven Decision-Making. http://edadmin.edb.utexas.edu/datause/index.htm

Love, N. (2004). *Using data/getting results: A practical guide for school improvement in mathematics and science*. Norwood, MA: Christopher-Gordon Publishers.

Sargeant, J. (2001). *Data retreat facilitator's guide.* Naperville, IL: North Central Regional Educational Laboratory.

community AND stakeholder support

community AND stakeholder support

Whether politicians are talking on the airwaves or families are talking around the dinner table, education is a hot topic. The stakes are high in these discussions: politicians promise to improve student achievement if elected, and parents do care about the answers to "what did you do in school today?" Consumers of the K–12 education system—higher education institutions and the business community—also give voice to their concerns and hopes.

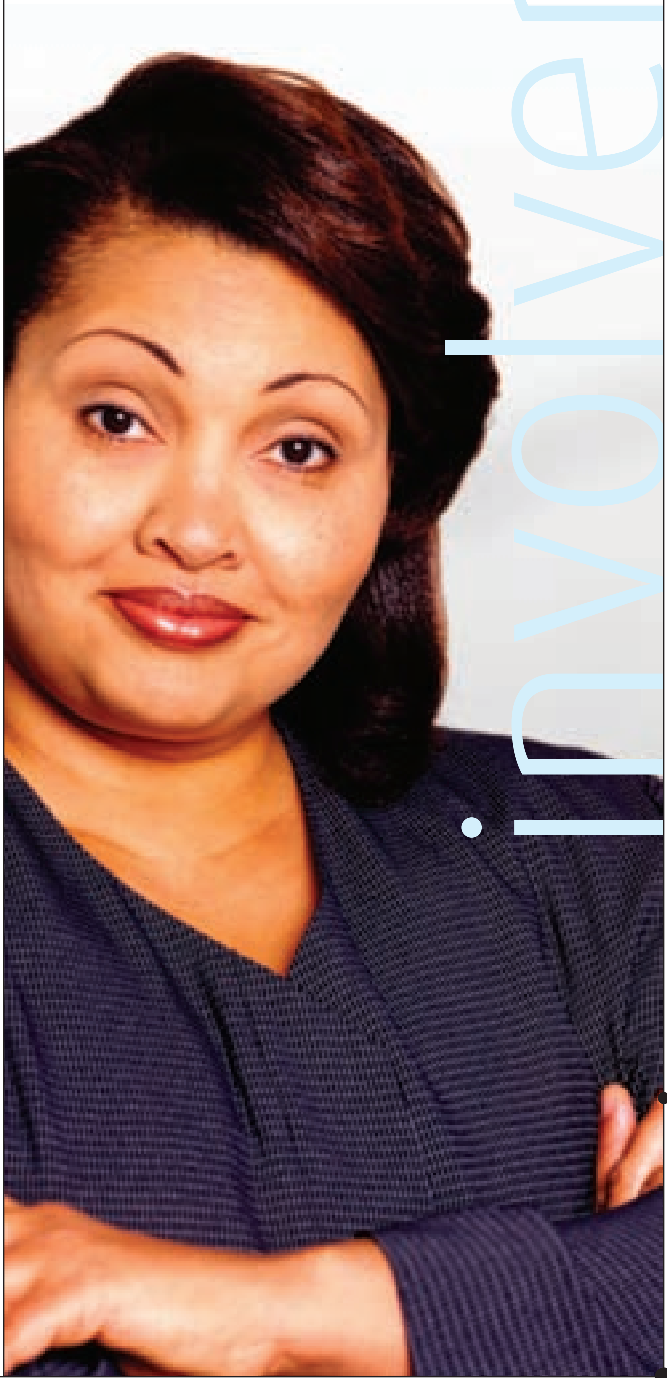
involvement

Implementing change in a system as deeply entrenched as K–12 education is hard work. There will inevitably be some disagreements, disappointments, setbacks, and unanticipated obstacles. Given the high level of legitimate public interest in education, gaining widespread community support and involvement is crucial.

Several factors have come together to increase the frequency and intensity of the focus on K-12 education. The NCLB Act of 2001, for example, has sensitized the public to the potential for federal policy to significantly impact education decisions at the state and local levels. NCLB's requirements for disaggregated student achievement data across demographic groups defined by race and ethnicity, poverty, English-language proficiency, and special education status have made clear the achievement gaps that exist for too many students between the groups and the generally unacceptable achievement levels in reading and mathematics.

Disappointing results from state assessments are often in the hometown papers. For example, Washington State's governor and state superintendent proposed a short-term easing of the mathematics requirements for high school graduation as a result of low scores on the state assessment. Only 51% of 10th-grade students and 59% of 4th-grade students passed the mathematics section of the WASL in spring 2006, and 29,000 high school juniors are in danger of not graduating from high school if they don't pass the WASL mathematics test soon.[78] Disappointing results compared to international results, especially in mathematics and science, are another common refrain.[79]

Meanwhile, 15 organizations, representing the largest and most innovative U.S.

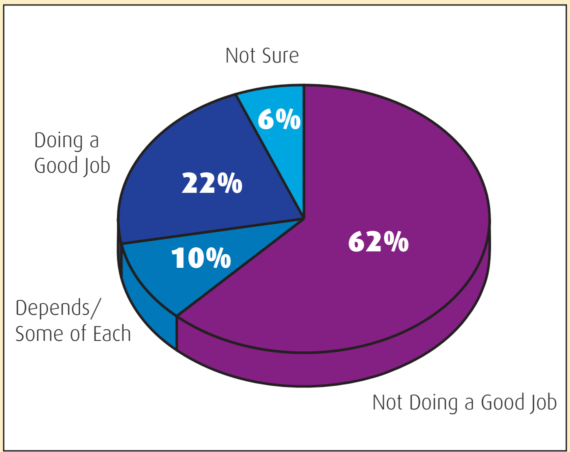


companies, have set a goal to double the number of science, technology, engineering, and mathematics graduates with bachelor's degrees by 2015.[80] Motivating this call to action is concern about U.S. competitiveness in the world marketplace and the lack of knowledge and skills of American workers.

Significant cultural mindsets can confound public support for increased rigor in mathematics and science. For example, most students in many countries think that they do well in mathematics and science. Yet, students from the highest performing countries—which do not include the United States—cite significantly lower perceptions of their own performance than that of their age cohort worldwide.[81] Ironically, those who ought to be most confident are not, and those who should be questioning their own performance are not. Although U.S. students purport to understand the need for hard work to master mathematics and science, they devote less time outside of school to studying than their international peers; apparently those in the highest achieving countries put in additional effort to compensate for their self-perceived academic shortcomings in mathematics and science.[82]

According to data collected in 2003, U.S. parents tend to be very satisfied with the schools that *their* children attend.[83] For example, 58% of parents are very satisfied with their children's school, 59% are very satisfied with their children's teachers, 58% are very satisfied with the academic standards of schools, and 60% are very satisfied with the order and discipline of schools. These four self-reported aspects of parental satisfaction with education have gone unchanged for more than a decade.

Figure 8: Perceptions by Americans on the Adequacy with Which Public High Schools Prepare Students for Higher Education and the Workplace



Source: U.S. Department of Education, National Center for Education Statistics. (2006). The condition of education 2006, Washington, DC: U.S. Government Printing Office.

Yet, when asked generally about the success of the education system, Americans respond far more negatively. For example, in public opinion research commissioned by the Business Roundtable, 62% of those polled felt that public high schools were inadequately preparing graduates for higher education and the workforce (Figure 8). Analysis of the data along the lines of gender, race and ethnicity, and parental status also showed some differences.

District and school leaders face a challenge and an opportunity to engage and garner the support of the community, especially of specific educational stakeholders. The following set of strategies should guide efforts to engage all needed constituencies.

district-level STRATEGIES

Keep the community and stakeholders well informed of the goals and progress of the district's vision and plan.

- Meet regularly with an advisory committee that includes representatives from stakeholder groups—the business community, higher education, principals, parents, guidance counselors, local politicians. Solicit input and advice related to community outreach.
- Designate an individual in the district office who will be the point person for all public input regarding the initiative and will also report regularly to staff and the advisory committee.
- Publish—in universally accessible formats—concrete, positive anecdotes from students, parents, teachers, volunteers, and community members.

Develop a clear message and communicate it.

- Develop initial messages to articulate the goals for the programs and a process to develop and vet regular updates.
- Educate the community about the rationale behind innovations; for example:
  - Scientific and mathematical literacy are important for all adults to make personal decisions and understand issues of importance to local, national, and global communities.
  - Recent research into learning science and mathematics stresses the importance of understanding big ideas by being able to connect facts, procedures, concepts, and vocabulary to practical applications and to connect knowledge among disciplines.
  - Learning how to think scientifically and mathematically includes learning to collect and analyze data and pertinent facts, providing explanations based on data, and communicating findings to others.
  - Classroom activities should emphasize building these skills as a context for learning content.
- Reach various audiences with appropriate frequency and language(s):
  - Provide monthly updates for members of the board of education.
  - Provide regular electronic reports to middle school principals with messages, anecdotes, and summaries of professional development, data, and expectations.
  - Schedule quarterly briefings with the editorial boards of local newspapers.
- Select media and language(s) most likely to reach the audiences:
  - Web site updates about the goals and progress of the initiative.
  - Videos explaining goals and offering glimpses of student learning for speakers at community or school meetings or for Web site or district television.
  - Newsletters and other existing print media.

- Posters for school and district buildings.
- Monthly "Coffee with the Superintendent," including wide publicity about the opportunity for interested citizens to stop in for an informal discussion.
- Speeches at such community organizations as the Chamber of Commerce, Rotary Club, and League of Women Voters.
- Local newspapers, supported by a district contact person, with an open-door policy for reporters to gather needed background.

• Designate a staff member to serve as a community liaison; preferably one who speaks the languages reflected in the community.

• Ensure that public input is frequently sought and used.[84]

- Hold public forums about the program.
- Gather information about concerns and perceptions at every meeting through notes, surveys, evaluations, or comment cards.
- Survey students, parents, teachers, and administrators to gather data about implementation, perceptions, and attitudes.[85]
- Set goals for frequency of communication, measure indicators of effectiveness at least annually, and adjust both messages and media sources as needed.

• Work with district-level staff and school administrators on responding to negative feedback:

- Media trainers suggest reiteration of positive messages in response to negative attacks.
- Hot topics vary by community but can include: memorizing traditional mathematics facts, the use of calculators, cooperative learning, science concepts of biological evolution and human sexuality, grading practices, and homework help. Develop appropriate responses.
- Educators should be prepared to describe the process used to review and select instructional materials. Documentation of the process is also desirable.

» notes

Develop specific strategies to engage diverse cultural and linguistic communities in the initiative.

- Ensure diverse representation on all district committees and outreach efforts.
- Create partnerships with key community-based organizations that serve specific cultural and linguistic communities. Examples include:
  - Nationally recognized organizations with local affiliates, such as the NAACP, Urban League, La Raza, Refugee Federation Services, and LULAC.
  - Smaller, local organizations that support newly arriving immigrant populations.
  - Churches, synagogues, mosques, and other religious institutions.
- Establish alliances with other major public institutions that also serve diverse populations. Examples include:
  - Public libraries.
  - Community colleges.
  - Public health agencies.
  - Community centers.
  - Social service agencies.
- Ensure all program materials are available in the most commonly spoken non-English languages in the local community.
- Dedicate a portion of the district's Web site to information and resources that are targeted to the needs of the district's diverse communities.

Welcome community partners to participate actively.[86]

- Offer opportunities for volunteers to contribute time, expertise, or materials. (For more information, see "Roles of Community Volunteers in Schools" sidebar.)
- Provide orientation and training for volunteers in appropriate language(s).
  - Information on the initiative, mutual expectations, and the culture of schools will be valuable to share.
  - When volunteers participate in the classroom, teacher partners should be included in the orientation.
- Collect information on the experiences and effects of volunteer participation and make continuous adjustments to the deployment and contributions of the volunteers.
- Plan formal and informal recognition opportunities.
- Offer opportunities that promote effective strategies for working with students with diverse cultural, linguistic, and learning needs.

Roles of Community Volunteers in Schools

Volunteers can provide valuable assistance in direct program support/advice or work behind the scenes, and volunteers can be involved with administrators, teachers, or students. These varied roles are outlined in Table 3 below, with suggestions regarding the ways volunteers can be involved (interaction), specific examples of what this involvement may be (illustration), as well as the added value of volunteers being involved (impact). This information provides starting points for building mutually beneficial partnerships among stakeholders.

Table 3: : Interaction, Illustration, and Impact of Roles of Community Volunteers in Schools

Interaction	Illustration	Impact
DIRECT PROGRAM SUPPORT AND ADVICE ROLES		
Become part of program infrastructure.	• Become a member of school or district advisory committee.	• Support each local school and district by direct participation. • Learn and share with others information about progress and challenges.
Become a program advocate.	• Participate in informational activities to become well informed. • Speak out informally in support of programs. • Be prepared to be an advocate when needed.	• Informed, vocal community support can make or break innovative school programs.
BEHIND-THE-SCENES ROLES		
Contribute expertise on information technology.	• Customize or create software for data management, inventory of science materials, etc. • Train and support a school troubleshooting team for computers, handheld devices, and science probeware. • Develop system and software to manage distribution and inventory of science or mathematics materials.	• Informed, vocal community support can make or break innovative school programs. • Better and timelier analysis of student data can improve instruction. • Minimize downtime for essential instructional materials. • Develop capacity at the school. • Ready-to-use kits of materials decrease prep time of teachers. • Consumable and replacement materials can be bought in bulk.

Interaction	Illustration	Impact
BEHIND-THE-SCENES ROLES *(cont.)*		
Contribute organization skills.	• Help prepare materials for use. • Organize instructional materials at school or district.	• Make materials ready to use science materials, and organize multipiece mathematics manipulatives. • Put disorganized, scattered materials to use.
Contribute communication skills.	• Help to develop a communications plan for the mathematics and science programs. • Help to design and print newsletters and flyers.	• Generate community knowledge and support. • Develop polished products.
Contribute tangible resources.	• Printing. • Surplus paper. • Surplus calculators, handheld computers, printers. • Science supplies.	• Teachers and administrators can identify materials that are in short supply or are prohibitively expensive in school budgets. • Ask for supply lists for each grade, and match them with possible resources.
Contribute development expertise.	• Help to identify potential grantors. • Help to write proposals. • Organize small fundraisers for specific, unmet needs.	• Leveraging existing resources will maximize impact. • Attention to sustainability will help maximize impact.
ROLES WITH ADMINISTRATORS		
Open existing management classes to educator participation.	• Topics of interest may include leadership, strategic planning, project management, time management, etc.	• Opportunities for mentoring administrators may follow. • New insights into school needs can be learned.
Open existing technical training to educator participation.	• Expertise in developing presentations, using digital media (e.g., photos, video, sound), managing data, generating data reports, and desktop publishing may be of interest.	• Opportunities to mentor or follow up may develop. • Administrators can develop professional development for teachers.

Continued on next page.

Table 3: : Interaction, Illustration, and Impact of Roles of Community Volunteers in Schools *(cont.)*

Interaction	Illustration	Impact
ROLES WITH ADMINISTRATORS *(cont.)*		
Chair advisory group, facilitate planning meetings.	• Progress in meeting goals can benefit from outside facilitation and participation. • Become an informed community advocate for the mathematics and science programs.	• Work closely with responsible school staff to meet their needs. Be prepared to lend support when and where it is needed.
Assist with reviewing instructional materials.	• When new materials are being considered, participate in reviewing the content for accuracy and importance.	• Participation with master teachers will supply the critical review for how topics are taught.
ROLES WITH TEACHERS		
Participate in the professional development of teachers.	• Apply your science or mathematics background to help identify the importance and applications of content. • Supply updated science content. • Learn how teachers help students understand new content.	• Prior coplanning will reveal expectations and helpful roles. • These activities will be coordinated by district providers.
Assist teachers in the classroom.	• At the teacher's direction, provide assistance to facilitate the students' explorations and problem-solving. • At the teacher's request, provide examples of how content is applied or encountered in professional life.	• Previous common experiences in professional development will be valuable.
Host teachers at your business to demonstrate how mathematics and science is done or applied.	• Teachers' can incorporate real-life examples to help engage the interest of students. • Teachers own content knowledge can be broadened.	• The duration can range from a short open-house to year-long or summer internships.
Adopt a teacher or department.	• When you find a teacher that you connect with, offer your assistance, contribute resources, and help with planning.	• The longer you patiently interact, the more you will discover what your most helpful roles may be.

Interaction	Illustration	Impact
	ROLES WITH STUDENTS	
Be a mentor.	• Help with school work and homework during school or school-sponsored after-school programs. • Coach student work on class projects. • Help to plan and execute science fair projects. • Play mathematics or science games (supplied by teacher) with students to reinforce learning.	• Some classroom experience or conferences with teachers will prepare you to approach content at the appropriate student level. • A longer term commitment makes mentoring successful, and short or intermittent participation disappoints students.
Participate in or organize informal mathematics or science programs.	• Look into existing after-school programs. • Mathematics and science "Olympiads" or other competitions are fun and reach highly motivated students. • Invention programs support creativity and innovation. • Business and economics programs put mathematics into context.	• Teachers and after-school providers can always use help in these out-of-school events. • You can become an informed advocate for today's youth.
Participate in career events.	• Informally relate how learning science and mathematics prepares students to succeed in careers. • Relate specific examples of work in your field that may motivate students.	• Hands-on activities or exploration that gives a taste of your work are especially popular. • General "you can do it because I did" messages are memorable to students, particularly to those who see you as a role model (e.g., by gender or ethnicity).

school-level STRATEGIES

Develop a coherent message for the school mathematics and science programs.

- Develop a shared understanding of the district vision and what it means for teachers and the school.
- Frequently discuss benefits of the initiative for teaching and learning, and work to maintain active support among teachers, who are among the most credible advocates and spokespersons.
- Recognize past successes, and emphasize ways in which the initiative builds on strengths.
- Provide information on district resources that are available to help communicate with parents and students.
- Keep teachers in the school—other than mathematics or science teachers—informed about the initiative.

Establish two-way communication with students and parents.[87]

- Designate a school staff member to serve as a community/parent liaison.
- Publish up-to-date information on the school's Web site.
- Splash pictures, samples, and articles throughout print media from the school.
- Convene an active parent council for the programs, including parents who work in science or mathematics-rich professions.
- Involve parents in hands-on activities at parent meetings, conferences, and science or mathematics family nights.[88]
- Showcase student work and student spokespersons in school and community activities.
- Help parents understand how and why expectations of students are changing[89] and what changes parents can expect in homework, grading, and results.

Develop an outreach plan to ensure active participation of the school's diverse cultural and linguistic families.

- Identify "key communicators" among the school's parent community who can serve as liaisons to specific community populations.
- Create partnerships with nearby community organizations such as clinics, youth centers, libraries, social clubs, businesses, and nonprofit organizations.

- Establish a calendar for the principal and other school leaders to participate in local community events.
- Ensure that all school and program materials are accessible and sensitive to the diversity of all local parent needs.

Use community volunteers in the mathematics and science programs.[90]

- Collaborate with district leaders to identify opportunities for community participation. (For more information, see "Roles of Community Volunteers in Schools" sidebar.)
- Start with modest expectations and commitments, and let deepening relationships suggest wider opportunities.
- Orient and oversee volunteers' activities so that teachers and volunteers find the experience rewarding and effective.
- Plan recognition and appreciation ceremonies for volunteers and in-kind contributions.

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reflective QUESTIONS

Are all those who care deeply about our school—parents, community leaders, students, teachers—pulling in the same direction to enable the new programs to succeed? Do I know what is behind different views and varied levels of commitment?

How do I know that our stakeholder messages are being received and interpreted in the way that we intended?

When concerns about the initiative are raised, what types of responses are most beneficial? How do we make midcourse corrections when the concerns have legitimacy?

What information is most useful or needed to make me a better communicator with the community?

community and stakeholder support

summary

At the district level, it is critical that:

- The community and stakeholders are kept well informed of the goals and progress of the program.
- A clear message is developed and communicated.
- Specific strategies to engage diverse cultural and linguistic communities in the initiative are developed.
- Community partners are welcomed to participate actively.

At the school level, it is critical that:

- A coherent message is developed around goals and features of the school's mathematics and science programs.
- Two-way communication between students and parents is developed.
- An outreach plan to ensure active participation of the school's diverse cultural and linguistic families is created.
- Community volunteers are used in the mathematics and science programs.

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March 2007

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