The Research for

IMPACT Mathematics

Performance-Based Assessment

Results and Validation

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Assessment in Mathematics – One of the Six NCTM Principles

"Assessment should be more than merely a test at the end of instruction to see how students perform under special conditions; rather, it should be an integral part of instruction that informs and guides teachers as they make instructional decisions. Assessment should not merely be done to students; rather, it should also be done for students, to guide and enhance their learning" (National Council of Teachers of Mathematics [NCTM], 2000).

Assessment is the process of gathering evidence (data) about a student's knowledge of, ability to use, and disposition toward mathematics and of making inferences from that evidence to improve instruction, monitor student progress, and evaluate student achievement (NCTM, 1995). The process of assessment includes planning the assessment, gathering evidence, interpreting the data, and using the results. Assessment is essential to teaching and learning mathematics. Classroom assessments that teachers use day in and day out provide one of the most powerful tools available for improving student achievement (Olson, 2002).

According to NCTM (1995), assessment should

- reflect the mathematics that students need to know and are able to do,
- enhance mathematical learning,
- promote equality,
- be an open process,
- promote valid inferences about mathematical learning, and
- be a coherent process.

Research indicates that making assessment an integral part of classroom practice is associated with improved student learning. A review of about 250 research studies concluded that the learning of students, including low achievers, is generally enhanced in classrooms where teachers include attention to formative assessment in making judgments about teaching and learning (Black & Wiliam, 1998).

The National Council of Teachers of Mathematics (2000) states the following about assessment.

- Feedback from assessment tasks can also help students set goals, assume responsibility for their own learning, and become independent learners.
- Assessment and instruction must be integrated so that assessment becomes a routine part of the ongoing classroom activity rather than an interruption.
- Assessment provides the information teachers need to make appropriate instructional decisions. When teachers have useful information about what students are learning, they can support students' progress toward significant mathematical goals.
- To maximize the instructional value of assessment, teachers need to move beyond a superficial "right or wrong" analysis of tasks to a focus on how students are thinking about tasks.

Standardized Testing versus Performance-Based Assessment

Standardized tests, the cornerstone of public school assessment, measure content knowledge or rather, "Do you know it?" but do not measure students' skills or ability to perform higher-level thinking. Standardized tests may reassure a school's staff about student progress or alert them to trouble ahead, but they do little to inform teachers about how students are thinking, what they understand, where they are falling down, and how teachers might specifically change their own instructional practices to address students' difficulties (Foster, Noyce, & Spiegel, 2007). Therefore, they give an incomplete picture of student achievement.

Performance-based assessment, on the other hand, can give a more complete picture of student achievement by answering the questions, "How well can you use what you know?"

Performance-based assessments generally

- allow students to create their own response rather than to choose between several already created answers,
- are criterion-referenced, or provide a standard according to which a student's work is evaluated rather than in comparison with other students,

- concentrate on the problem-solving process rather than on just obtaining the correct answer, and
- require that trained teachers or others carefully evaluate the assessments and provide consistency across scorers.

Performance-based assessment more closely links assessment and instruction, more accurately measures the mathematics skills and knowledge, and allows a more complete account of student academic development. Also, teachers can integrate performance-based assessments into the instructional process to provide additional learning experiences for students.

Performance-based assessment cuts across ranges of mathematical processes, including modeling and formulating, inferring and drawing conclusions, checking, evaluating, and reporting. With performance-based assessment, teachers can see what students understand and how they can apply knowledge because they require students to actively demonstrate what they know, rather than select an answer from a ready-made list. Therefore, performance-based assessments are a more valid indicator of students' knowledge and abilities (Michigan State Educational Briefings, 1998; Office of Education Research, 2003).

Research suggests that learning how and where information can be applied should be a central part of curricular areas. Research also suggests that students exhibit greater interest and levels of learning when they are required to organize facts around major concepts and actively construct their own understanding of concepts in a rich variety of contexts. Performance-based assessment requires students to structure and apply information, and thereby helps to engage students in this type of learning (Office of Education Research, 2003).

IMPACT Mathematics and Performance-Based Assessment

At the center of each *IMPACT Mathematics* unit is a high-quality, research-based performance assessment that drives instruction. Each performance-based assessment gives students an opportunity to show what they know, understand, and can do by requiring students to evaluate, optimize, design, plan, model, transform, generalize, justify, interpret, represent, estimate, and calculate their solutions. The assessments also help teachers determine student progress toward mastery of critical mathematical concepts.

IMPACT Mathematics' performance-based assessments, based on the NCTM *Principles and Standards for School Mathematics*, were created by MARS, the Mathematics Assessment Resource Service, a U.S.-based international team of experts in mathematics education and assessment from the University of California-Berkeley, Michigan State University, and the Shell Centre in Nottingham, England.

The development of performance-based assessments by MARS was grounded in the belief that mathematics assessment should

- assess mathematics that counts, focusing on important concepts, skills and processes;
- be fair to students and provide opportunities for them to show what they know, understand and can do;
- be fair to the curriculum, offering a balance among long and short tasks, basic knowledge and problem solving, individual and group work, and the spectrum of concepts and processes reflected in the NCTM Standards;
- be of such high quality that students and teachers learn from them so that assessment time serves as good instructional time, and assessment and curriculum work together in harmony;
- provide useful information to teachers so they can judge the effectiveness of their instruction; to parents so they can see where students are doing well and where work is needed; and to administrators so they can judge the quality of their programs.

Essential design inputs included knowledge of the research on learning and performance in mathematics; skill, experience, and creative imagination in task design; and careful refinement through systematic development.

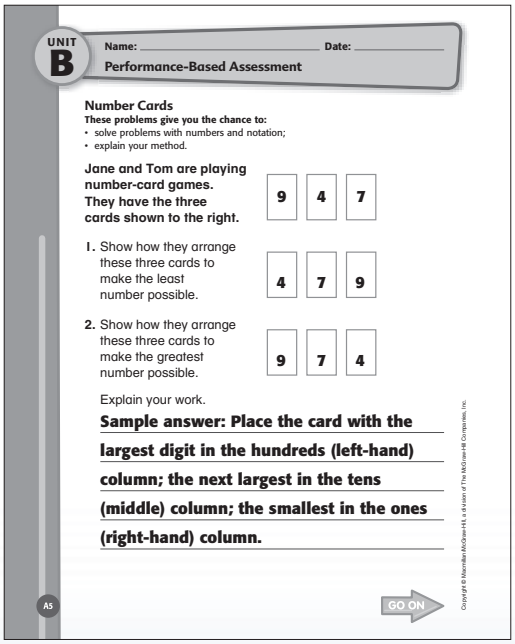
Four key design principles guided the development of performance-based assessment tasks.

- Present students with worthwhile mathematical tasks set in practical contexts.
- Demand substantial chains of reasoning.
- Include non-routine problem-solving.

- Sample, in a balanced way, the broad domain of mathematical performance that international standards specify for the grade.

Each performance-based task went through a development review process to ensure validity and usability for student evaluation and continued improvement in instruction, including student testing and review by teachers and recognized U.S. and international experts in mathematics education and assessment. During the development review process, a scoring rubric was created and refined for each performance-based task, and sample student work was collected.

The scoring rubric includes possible student responses (as shown below), alternative acceptable strategies, and point values to assign. The sample student work shows a range of scores to allow teachers to see what a response might look like for a given source. Rubrics along with scored student work accompany *IMPACT Mathematics* performance-based assessment tasks, allowing teachers to evaluate student progress and knowledge. These also help teachers to diagnose student misconceptions and to prescribe an instructional path for individual students. There may be times when a student performs very well on a performance-based assessment but has difficulty transferring this knowledge into the more traditional multiple-choice format of many standardized tests. *IMPACT Mathematics* provides teacher support for helping students make this transition to be successful in all testing situations.



UNIT B

Name: _____ Date: _____

Performance-Based Assessment

Number Cards

These problems give you the chance to:
- solve problems with numbers and notation;
- explain your method.

Jane and Tom are playing number-card games. They have the three cards shown to the right. 9 4 7

1. Show how they arrange these three cards to make the least number possible. 4 7 9

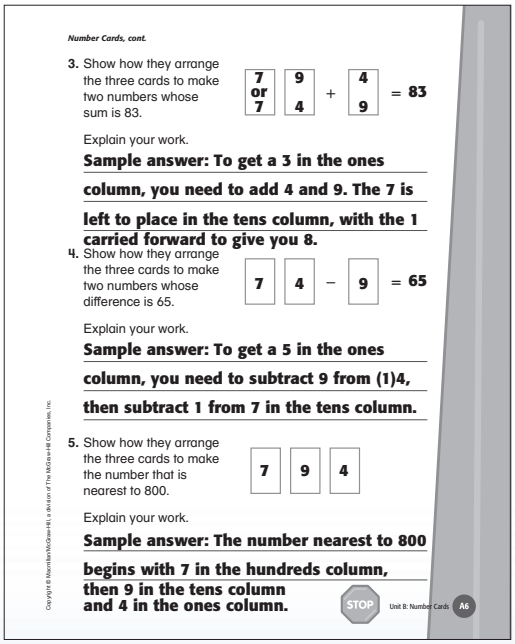
2. Show how they arrange these three cards to make the greatest number possible. 9 7 4

Explain your work.

Sample answer: Place the card with the largest digit in the hundreds (left-hand) column; the next largest in the tens (middle) column; the smallest in the ones (right-hand) column.

GO ON

A5



Number Cards, cont.

3. Show how they arrange the three cards to make two numbers whose sum is 83. 7 or 7 + 9 4 = 83 / 4 9 = 83

Explain your work.

Sample answer: To get a 3 in the ones column, you need to add 4 and 9. The 7 is left to place in the tens column, with the 1 carried forward to give you 8.

4. Show how they arrange the three cards to make two numbers whose difference is 65. 7 4 − 9 = 65

Explain your work.

Sample answer: To get a 5 in the ones column, you need to subtract 9 from (1)4, then subtract 1 from 7 in the tens column.

5. Show how they arrange the three cards to make the number that is nearest to 800. 7 9 4

Explain your work.

Sample answer: The number nearest to 800 begins with 7 in the hundreds column, then 9 in the tens column and 4 in the ones column.

STOP

Unit B: Number Cards A6

Results with MARS Performance-Based Assessments

Over the years, MARS performance-based assessments have been used both throughout the United States and internationally. Below are a few examples of the results of their use.

Interviews with Clients using MARS Performance-Based Assessment

In the fall of 2000, Inverness Research Associates conducted interviews with clients using MARS performance-based assessments to determine what clients thought about the quality, usefulness, and uniqueness of the performance-based assessments, as well as the extent to which MARS materials and services were a "substantial improvement" over other assessment-related services.

Inverness Research Associates found the following results.

- *Quality*. The quality of the performance-based assessments to be consistently high and that most interviewees would "absolutely recommend" MARS to others. All interviewees reported the MARS performance-based assessment tasks as "excellent." They found them to be complex without being complicated, student-centered and mathematically sound in a way that other assessment items are not. Clients liked that the assessments seek to uncover what students really know and are able to do.
- *Usefulness*. Interviewees found the performance-based assessments to be very **useful** and that students and teachers learned an enormous amount from "the doing" and the scoring of their tasks. Teachers generally found the results informative. One teacher remarked, "It's a great assessment tool because the kids get credit for showing their understanding of the math. It reminds me of those big, long problems in college and your professor gives you some points for showing your work."
- *Uniqueness*. The performance-based assessments were considered a **unique** project, offering innovative services. MARS performance-based assessments helped teachers inform their teaching and tie it back to what they were going to do in the classroom.
- *Substantial Improvement*. MARS performance-based materials and support were found to be a substantial improvement over other similar assessment materials and support (St. John, Houghton, & Tambe, 2000).

Silicon Valley Mathematics Initiative

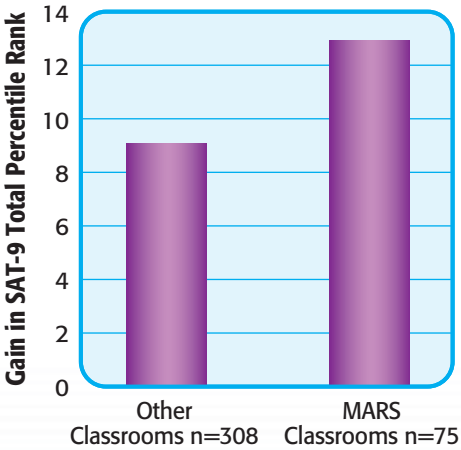
The Silicon Valley Mathematics Initiative (SVMI) was established in 1996. It is a partnership with Noyce Foundation and Santa Clara Valley Mathematics Project at San Jose State

University to support local school districts with mathematics professional development. The Initiative currently includes 35 school districts representing five counties of the Bay Area and supporting more than 2,050 teachers and 80,000 students annually.

Early work of the Initiative focused on providing pedagogical content coaching that included intensive in-class coaching to improve instruction and the support of math coaches and comprehensive professional development that included summer institutes and school-year workshops for teachers, coaches/leaders, principals and administrators. Later on, in an effort to provide a richer assessment measure for school districts, the Initiative formed the Mathematics Assessment Collaborative (MAC) to focus on what and how to assess student learning. MAC developed a performance-based assessment system comprised of ongoing formative assessment to inform instruction and summative assessment annually using MARS performance-based assessments.

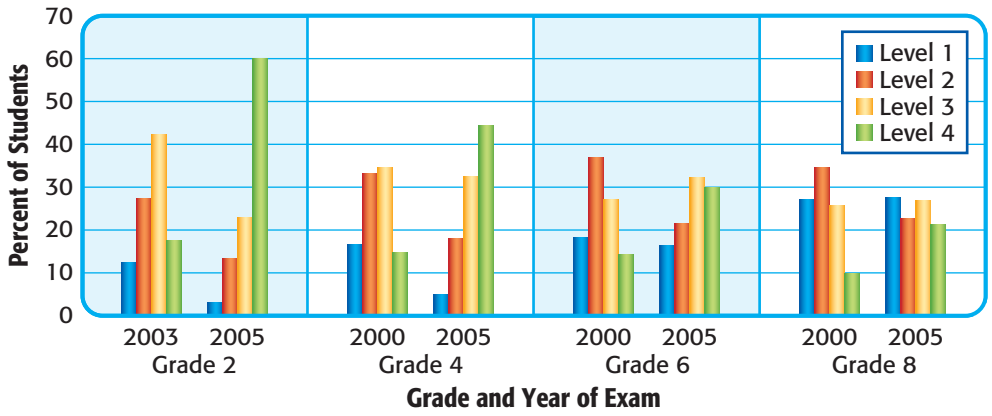
In 2000, the SVMI conducted a case study of one district to determine the effect of the program, content coaching, professional development, and performance assessment (using MARS), on students' SAT-9 scores in one district. They compared students whose teachers participated in SVMI programs and those whose teachers did not. They found that students in participating classrooms had an average gain of 13 percentile points, compared to a gain of 9 percentile points for students not in participating classrooms (See Figure 1 below). This accounted for a 45% difference in percentile growth (Noyce Foundation, 2000).

Figure 1
Average Gain in Math Percentile Rank Between 1999 SAT-9 and 2000 SAT-9



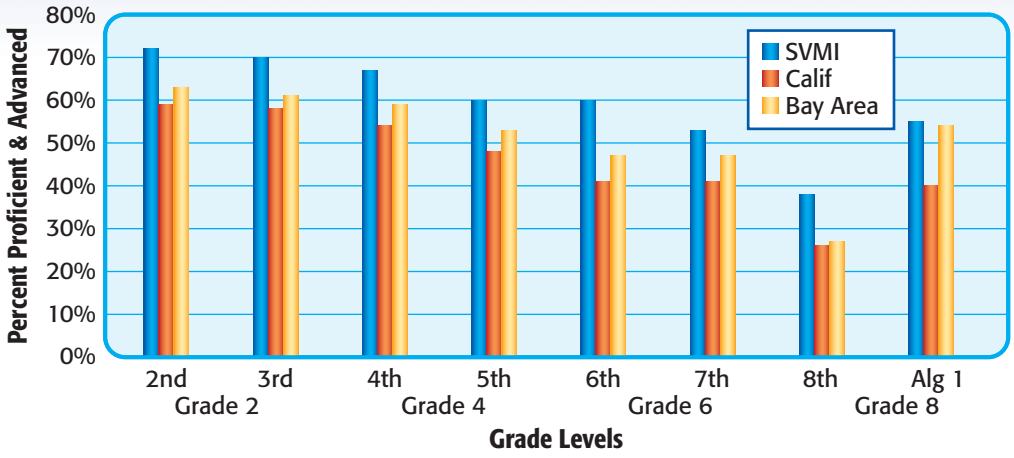
In 2005, a comparison of student achievement scores on the STAR exam between the first year of implementation and 2005 revealed that students performed at higher levels of achievement at every grade level after the introduction of the SVMI program and MARS assessments.(See Figure 2 below). These findings are encouraging because the population served by the SVMI teachers is slightly poorer (37% vs. 30% National School Lunch Program), a demographic factor that has been shown to limit achievement. The findings also reinforce that students of SVMI teachers, who typically engage their students in high-level problem solving and more open, constructed-response tasks, outperform other students on the more procedurally oriented STAR exam despite challenging economic factors (Noyce Foundation, 2007).

Figure 2
Student Achievement By Performance Levels on MARS Exam
Comparison Between First Year and 2005



In 2006, more than 70,000 students of 1300 teachers in the 35 districts participated in the MARS performance-based assessment exam. As seen in Figure 3 on page 11, a comparison of student scores (grades 2 – 8th and Algebra 1) on the California Standards Tests in 2006 revealed that the percent of students who scored proficient and advanced was higher in Initiative districts than those not part of the Initiative. Also, the percent of students taking Algebra in 8th grade was higher in SVMI districts (72%) than the Bay Area (42%) and the State (47%) (Noyce Foundation, 2000).

Figure 3
California Standards Test 2006



Over time, it has become clear to the Initiative that the performance-based assessments, the scoring sessions, and the performance reports have all contributed to their desired outcome of informing and improving instruction. They believe the scoring process sheds light on students' thinking as well as on common student errors and misconceptions. The emphasis on understanding core ideas helps teachers build a sound sequence of lessons.

Summary

The only meaningful products of the United Stated educational system are individuals who "use their minds well" (U.S. Department of Education, 1991).

McGraw-Hill is committed to the idea that curricula should strive to reach all of the *Principles and Standards for School Mathematics*, thereby providing road maps that help teachers guide students to increasing levels of sophistication and depths of knowledge. The NCTM *Principles and Standards for School Mathematics* were developed to accomplish several goals, including assessment. McGraw-Hill is proud to provide *IMPACT Mathematics* with MARS performance-based assessments as an informed road map to excellence in mathematics education in the 21st century.

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