New assessment methods for a reformed mathematics education program

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New assessment methods for a reformed mathematics education program

Abstract
There are many factors calling for change in mathematics education in the United States today. Students are not being adequately trained for the working world of tomorrow. The National Council of Teachers of Mathematics has formulated standards which provide a vision of curriculum reform in mathematics. The reform in mathematics education will necessitate a change in methods of assessing student growth. Changes in assessment methods in other curricular areas are examined and the author delineates evaluation methods that would more adequately match the goals of the new mathematics curriculum.
NEW ASSESSMENT METHODS FOR A
REFORMED MATHEMATICS EDUCATION PROGRAM

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Master of Arts in Education

University of Northern Iowa

by Trudy A. Evans
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New Assessment Methods for a
Reformed Mathematics Education Program

Assessment is an integral part of the teaching method. Assessment is conducted for the purpose of evaluating individual student progress, determining instructional needs of the class, and judging the effectiveness of a mathematics program. In order for assessment to be valid, it must align itself with the goals, ideas, and objectives of the curriculum. In this paper, emphasis has been given to methods of assessing individual student progress.

Educators often think of assessment as a component which is separate from teaching, something that is done at the end of a unit of work for the purpose of assigning letter grades to their students. When you consider that assessment can consume up to 40% of the educator's time, it should become a valid activity (Stiggins, 1988). Assessment should be a continuous, ongoing process adding to the learning cycle for the student.

Assessments can be of a formal nature, such as standardized tests or textbook chapter tests, or they may be informal in nature, such as teacher observations.
or student conferences. The effective educator uses continuous assessment techniques for instructional decision-making. If students do poorly at a mathematics task, the educator must determine if the deficit learning is a lack of individual mastery, or denotes necessary reteaching for a small group or the whole class. Caution must be used in selecting assessment items; they should measure that which is valued in the curriculum.

A vast difference exists between testing as we know it in schools and the reflective self-evaluation that takes place in the real world as people pursue worthwhile work (Wolf, 1989). Actors, artists, athletes, and many others practice countless hours and then spend much time evaluating their own performances. They use feedback gained through videotapes and recordings to make adjustments in their activities. We value perseverance and self-improvement in this nation and yet few school assessments allow students to assess themselves and develop this life-long skill of self-evaluation.

There are changes currently taking place in the way elementary reading, science, and mathematics are being taught and changes in assessment methods must naturally
follow for these changes to be long-lasting. This paper addresses the following questions: (a) What factors necessitate change in the way mathematics is being taught in the U.S.? (b) What changes in mathematics teaching are being advocated by the National Council of Teachers of Mathematics [NCTM] in their *Curriculum and Evaluation Standards for School Mathematics*? (c) Why are current evaluation methods not adequate for this reform? (d) What changes have occurred in assessment in other curriculum areas? and (e) What proposals can be made for alternate methods of assessing mathematics instruction?

Related Literature

**Factors Calling for Changes in the Teaching of Mathematics**

Changes are being sought in the teaching of mathematics due in part to the poor showing our students made in the Second International Mathematics Study. The results of this study, released in 1987, indicate that students in the United States scored very poorly in comparison to students in other countries. Not only are the math students in the United States
suffering from an "underachieving curriculum" (McKnight, et.al. 1987); education also suffers from the public attitudes arising as a result of the media blitz concerning these assessment results. As the Sputnik era urged the United States to dramatically upgrade efforts in math and science with the creation of the National Science Foundation, these published assessment data are causing Americans to become alarmed about the "math crisis" in our schools.

The National Research Council (1989, p.1) states that communication has created a world economy in which "working smarter is more important than merely working harder". The workers of today need to absorb new ideas, think creatively, solve unconventional problems productively, and work well together. The most important needs are not mere calculations; there are machines available to do the calculations. Today's workers need to think for a living more than workers have at any other time.

A symposium on the Wellspring of U.S. Industrial Strength was held in California in December of 1988; it was hosted by the Mathematical Science Education Board [MSEB]. The goal of this symposium was to bring perspectives of business and industry to those
concerned with math education. Industries are demanding workers who are better equipped for today's computer-driven, competitive economy. Workers must deal with computer terminals, automated equipment and data display; they must estimate and solve problems. Workers frequently collaborate rather than work alone. More and more occupations require workers to be able to understand, use, communicate, and explain concepts that are based on mathematical thinking. We face overseas competitors whose youth can outperform ours and whose economies threaten our industrial leadership (MSEB, 1988).

Project 2061, Science for All Americans (1989), is part of a combined science and mathematics project concerned with scientific literacy in our country. The American Association for the Advancement of Science states that reform in science, math, and technology are needed because the nation has not acted well in preparing young people. By both national standards and world norms, United States education is failing its students, especially its minority children, on whom the nation's future is coming to depend.

The question of equal education for minority students is especially important in light of
demographic trends. By the year 2000 one of every three students in the American schools will be a member of a minority and by 2020 today's minority will become the majority students in the United States. According to Workforce 2000 (Johnston, 1987) eight percent of the current labor force consists of scientists or engineers; the vast majority of whom are caucasian males. White males, however, will comprise only 15 percent of the new entrants to the labor force between 1985 and 1990. It is imperative that all aspects of education transcend cultural barriers.

Much of the mathematics currently being taught in schools is the math that was appropriate for a shopkeeper of the 1940s. The basic math curriculum was developed during the period of time from 1400 to the mid 1700s. David and Hersh (1981) claim that we now live in a golden age of mathematical power. Over half of all mathematics has been invented since World War II. With increased technology, the world of mathematics is changing rapidly, and yet many teachers continue to teach the mathematics they were taught.

The dilemma of math instruction in the United States has produced a student population that lacks an understanding of what mathematicians do and the fact
that mathematics is a dynamic, changing discipline. Results from the fourth mathematics assessment of the National Assessment of Educational Progress (Swafford and Brown, 1989) indicate that 35% of the 7th graders and 24% of the 11th graders believe that new discoveries are seldom made in math. About half of the group reported that learning math is mostly memorizing and fewer than half expected to work in careers that require mathematics. The attitudes of today’s students are another hurdle to be overcome in revitalizing today’s math curriculum. Most teachers don’t test the affective domain of mathematics, but it would be a worthwhile expenditure of time.

In spite of increased technology, and the minimal cost factor of hand-held calculators, many students are not using up-to-date technology in their classrooms. Many teachers and parents fear that students will not learn their basic facts if they allow calculators into the classrooms too early. Kouba and Swafford (1989) found that while 90% of the students surveyed had calculators in their homes, fewer than one-third of them used calculators in the classroom. The following table summarizes the findings
of calculator experiences in the classroom for the students involved in the national assessment.

**Availability and Use of Calculators**

<table>
<thead>
<tr>
<th>Percent Responding$^a$</th>
<th>Grade 3</th>
<th>Grade 7</th>
<th>Grade 11</th>
</tr>
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<tbody>
<tr>
<td>A. &quot;Yes&quot; to:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you or your family own a calculator?</td>
<td>82</td>
<td>94</td>
<td>97</td>
</tr>
<tr>
<td>B. &quot;Yes&quot; to:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a school calculator available for use in mathematics class?</td>
<td>15</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>C. &quot;Never&quot; to:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often have you used a calculator?</td>
<td>13</td>
<td>29</td>
<td>13</td>
</tr>
</tbody>
</table>

$^a$ Response rates were .95+  Kouba and Swafford, p.102

New information is emerging regarding how children learn; this necessitates reform in mathematics education. Learning is not a process of passively absorbing information and storing it in easily retrievable, fragmented pieces. Students approach each new task with some prior knowledge, then they build new understandings and construct their own meanings (Resnick, 1987). Ideas are not isolated in memory; they are organized into a schema which utilizes the language one uses and draws on past experiences.
The changes in mathematics needed for informed citizenship and daily living has also changed significantly (MSEB 1990). The need to understand data presented in a variety of ways is most obvious. Percentages, graphs, charts, tables, and statistical analyses are now widely used in newspapers and magazines. Citizens who cannot interpret quantitative data are illiterate in this day and age.

As outlined above, there are many factors calling for change in the way that mathematics is taught in the United States. Many students are not being trained for the jobs of tomorrow which will demand mentally fit workers, especially in the field of mathematics. Three out of four students are currently dropping out of mathematics before receiving enough training to accommodate them in the future. Due to the global marketplace, the United States needs more mathematics to stay abreast of world competition. It is essential that Americans no longer sit idly by while the future of the country dims.

Changes being sought in mathematics education

The need for curriculum reform is clear. To guide this reform, the National Council of Teachers of
Mathematics drafted and published *Curriculum and Evaluation Standards for School Mathematics* (1989). The NCTM Standards is a document which provides a framework for curriculum revision. Over fifty mathematical science organizations, professional education organizations, and other organizations have agreed to serve as allies in the national effort to improve mathematics instruction in the United States.

The NCTM document presents fifty-four standards aligned with three age groups: K-4, 5-8, and 9-12. The goals for all student age groups are similar: (1) that they learn to value mathematics, (2) that they become confident in their ability to do mathematics, (3) that they become mathematical problem solvers, (4) that they learn to communicate mathematically, and (5) that they learn to reason mathematically. These goals are based on the idea that mathematics is more than a collection of concepts and skills to be mastered.

Each of the three graded sections of the NCTM include thirteen curriculum standards, as well as a separate section on evaluation. The first four strands are common to all grade levels: (a) mathematics as problem solving, (b) mathematics as communication, (c) mathematics as reasoning, and (d) mathematical
connections. Topics that represent a change in content are, most notably: statistics and probability in the K-4 program, functions and patterns in grades 5-8, and a mathematical core curriculum for all students in grades 9-12. Reform in math education in the 1990s will reflect changes in content and emphasis of the curriculum, as well as approaches to instruction.

The breadth of the mathematics curriculum must be increased. The traditional math program focuses narrowly on a few topics, arithmetic in particular. Students would benefit from a curriculum that "reflects the expanding power and richness of the mathematical sciences" (Steen, 1989, p. 19). Estimation, symmetry, chance, measurements, and manipulation are as much a part of math as computation, and are more interesting for many students.

Teamwork must be encouraged in mathematics. In the world of work, solving complex problems demands the talents of many different people. Students can learn to work together to solve problems, to encourage one another toward meeting a goal, and to guide each other in the steps leading toward the solution. Teamwork is also an effective way to learn mathematics, for it is
through verbal interactions with peers that students truly internalize the concepts.

Full and appropriate use of calculators must be made. Nothing demonstrates the backward nature of our math agenda more than the reluctance of teachers and test makers to allow appropriate use of calculators. Calculators allow students to explore patterns, to perform calculations beyond their understanding, and to creatively approach problem solving through multiple tries without getting bogged down in lengthy calculations.

Instructional practices should include concrete explorations of manipulative materials. Learning theory suggests that children whose mathematical learning is initiated with manipulative experiences will be more likely to bridge the gap between the real world and the abstract mathematical world (Kennedy, 1986). Piaget (1952) contended that cognitive development occurs in four stages and that manipulative materials are significant learning aids at each level. Students who see and manipulate objects have clearer mental pictures and can grasp abstract levels of meaning more easily than those without a concrete base of experience.
Classroom teachers must use strategies that will allow students to be actively involved in mathematics, not just passive receivers of knowledge. Lectures and board demonstrations alone are not sufficient to alleviate misconceptions. Marilyn Burns (1986) notes that math educators must not teach just "what to do", but "what to do and why". Understanding occurs when children learn skills in the context of applications (p. 34).

Problem solving is generally a major goal of any mathematics program. Students generally get adequate exposure to application problems, but they need more practice with nonroutine problem solving. Nonroutine problem solutions require more than a simple application of a single arithmetic operation. An example of this type of problem would involve finding the number of possible ways that four people could line up. The 1976 results of the National Assessment of Educational Progress indicated that students had relatively little trouble solving problems that required only that they choose the correct operation, but students do not do so well with multi-step or nonroutine problem solving. It is further recommended that problem solving not be deferred until students
have mastered computational skills (Carpenter, et.al, 1981). Problem solving reinforces computational skills and provides meaning for their application. Problem solving should be introduced in conjunction with basic skill work.

All students should study mathematics every year they are in school. The National Council of Teachers of Mathematics urges that all students take a core curriculum of mathematics. All students would be exposed to all fields of mathematics, with depth of coverage depending on student ability. Mathematics is not a science to be studied by an elite few; the NCTM is advocating mathematical literacy for all. Students who are college-bound will need four years of mathematics instruction to meet college requirements, and those students who are not preparing for college will need mathematics skills to succeed in a society that values technology.

Teachers need to stimulate creativity in mathematics. Too often students think that mathematics is a science in which only one method exists for solving a problem, there is a single correct answer, the teacher has the answer, and if you get the answer you will be successful. Students should be allowed to
show and discuss multiple approaches to a single problem.

Exemplary mathematics teaching will demonstrate connections. Students should discover the math disciplines that are inter-related and they should experience these connections at every opportunity. These connections reinforce mathematics ideas learned in different contexts. Fragmentation of mathematics concepts must be avoided.

Communication must be encouraged in the math classes of the 1990s. Learning to read, write, and speak about mathematical topics is important for application of learning to take place, and also as a strategy for understanding mathematical processes. Students can write in journals to clarify their understanding and reflect on their experiences in learning mathematics. This writing will enhance learning for the student, and allow the teacher to easily assess the student's level of understanding. Students should be allowed to discuss mathematics processes, not just listen passively as the instructor lectures.

Several topics which currently consume a major portion of the school mathematics program will reduce
dramatically if the standards are implemented. Rote memorization and paper-and-pencil algorithms will no longer take up the vast majority of time in the classroom. Fractions, long division, and two-column geometry proofs will become less important. Two-column proofs in geometry exist only in textbook exercises; they are not a part of the real world of mathematics. Calculators in the working world make arduous paper-and-pencil calculations unnecessary and reduce the importance of fractions due to the decimal display of numbers.

Assessment methods will need to change to meet the demands of the new curriculum. If methods of evaluation do not change, then teaching innovations will be short-lived. Teachers will not encourage the use of calculators and computers in their classrooms if technology is not a part of the assessment process.

Inconsistencies Between NCTM Standards and Current Evaluation Methods

The Standards are a vision of improving math education through a change in content, instructional methods, and evaluation. Becoming mathematically literate means much more than performing well on a
checklist of isolated mathematical procedures. Becoming a successful problem solver means more than finding a solution to a simple, well-defined written math problem. Real world problems are often "fuzzy" and do not possess the simplistic, delineated form of problems presented in math classes.

Many opportunities exist in the classroom for the teacher to informally assess levels of understanding. These informal methods allow for great flexibility and a probing for depth of understanding and ability to transfer learning to new problem situations. Informal methods are continuous, teacher-generated, and frequently change in focus as teachers implement the standards in their own classrooms. Formal assessment, however, will offer a greater challenge for teachers; these measurement devices are most often developed through formal means and decided upon by the policy-makers of the school district.

In America, but not in other countries, objective, multiple-choice tests are the norm; they are objective, cost-effective, and easy to administer and score (MSEB, 1989). Multiple-choice tests as used in America lead to wide-spread abuse. These tests become ends in themselves, not means to diagnose individual
weaknesses. Too often teachers teach to the test, not to the curriculum, or to the children. These tests stress lower-, rather than higher-, thinking skills, emphasizing direct student responses to narrow questions, rather than stressing original thinking and creativity. Normed testing ignores the vast range of differences in learning rates.

Current standardized tests place undue emphasis on tedious calculations performed under high-duress timed conditions. Students are not afforded the opportunity to demonstrate their problem solving abilities or their reasoning skills under these conditions. Students who might grasp the concepts but who work at a slower pace are penalized by the time constraints of standardized tests.

Another basic problem with standardized tests is the undue emphasis placed on getting the correct solution. Problem solving involves collecting data, choosing proper strategies, planning the steps, and calculating correctly. Pity the poor student who uses the correct numbers, plans the strategy well, sets up the problem correctly, and then makes a careless error on the calculation. This student knows much more about
math than the student who simply makes a blind guess, but the test does not make this distinction.

One of the greatest changes will need to take place in realignment of assessment tasks so that they closely match the goals, objectives, and teaching methods advocated by the Standards. Teachers will not make serious, long-lasting changes without the assurance that they will be testing students in the same manner in which they teach them. If students are allowed to rely on manipulatives during the math class, then manipulatives should be available for student use during testing.

A recent study examined six widely used standardized tests to determine their alignment with the grade 5-8 Standards (Romberg, Wilson, & Khakelila, 1990). The six tests were those identified as the tests most widely used at both the district and state level. Each item on each test was classified according to the content of the question, the process required to respond to the item, and the level of the response required. The conclusion of this study was that the current forms of these six widely used achievement tests do not adequately cover the range of content advocated by the Standards.
A barrier to implementing changes in a calculator-using society has been the restriction against using calculators on standardized tests. This restriction alone places much undue emphasis on arithmetic and limits the breadth of the math curriculum. The NCTM in its position statement "Calculators in the Classroom" (1986) recommended the integration of the calculator into the school mathematics program at all levels in classwork, homework, and evaluation, (p.1). The Mathematical Sciences Education Board states that a clear implication of today's technological realities is that calculators should be allowed on all tests (MSEB, 1987).

In 1986 the Missouri Department of Education issued a policy statement supporting calculator use at all levels. Consequently the University of Missouri developed a battery of achievement tests to implement this legislation. Computational skills were tested in the elementary grades while calculators were permitted for use in testing for grades 7 and above. The secondary tests were not developed to test calculator skills, but rather to test application of mathematics knowledge free from computational distractions. The
state's test battery, the Missouri Mastery and Achievement Test (MMAT) was first administered in the spring of 1987. Local schools determined whether or not students would use calculators. The most frequently cited reason for prohibiting calculators was the inability of the district to provide hand-held calculators for the student body. Students using calculators performed significantly better ($p<0.01$) on the total test than those students who did not use calculators. Of most significance, however, is that using calculators on math tests affords reviewers of test results a clear picture of student deficiencies (Long, Reys, & Osterlind, 1989). Errors on tests allowing calculator usage are not due to computation, but a lack of understanding of the problem or the process for solving the problem.

Every student believes that the test is the major determinant of what is important in the curriculum. When calculators are not allowed on tests, students believe that the most important part of mathematics is learning to do computational procedures by hand. For many students, in fact, this rote memorization of arithmetic procedures is the essence of their mathematical experience (Heid, 1988).
There are, however, other aspects of mathematical literacy not addressed by current assessment methods. New evaluation procedures should involve gaining information about student ability to use mathematical language to communicate ideas; ability to reason and analyze; and evidence that the student can label, verbalize, and define concepts. New evaluation methods should seek information about mathematical disposition. The evaluation should determine how willing a student is to persevere in mathematical tasks, and how inventive and flexible he/she is in trying alternative methods of solving problems.

Assessing student knowledge is a major task for any educator, and should be a valid and productive activity. The evaluation standards (NCTM, 1989) indicate that assessing students' mathematical knowledge should "go beyond measuring how much information they possess to include the extent of their ability and willingness to use, apply, and communicate that information" (p. 205). Students should have an opportunity to demonstrate a knowledge of their understanding of the relationships among various mathematical disciplines. As the Standards get implemented in schools, the standardized tests will
have to change to reflect more accurately the new vision in mathematics education.

Changes in Assessment in Other Curricular Areas

Science

Changes in science teaching methods at the elementary level include much more process, or "hands-on", instruction. Typical evaluation centers on recall of specific information encountered in textbooks, lectures, and other class activities. Typical questions emphasize the meanings of words and their concepts. There is little evidence that students are ever tested for their ability to use information they gain, or indeed to do anything other than acquire knowledge (Yager, 1984). A more complete view of science would, however, consider five domains: processes, creativity, attitudes, and applications, as well as knowledge (Yager, 1987).

Current standardized tests are not true indicators of student learning in science according to Raizen & Kaser (1989). The tests are not informative concerning students' ability to conduct scientific investigations. Being able to identify and explain scientific procedures does not mean that an individual cognitively
knows when that procedure is appropriate or that the individual even knows how to conduct that procedure. Furthermore, through allowing only one, pre-selected correct answer, these tests are in conflict with the beliefs of science—that scientific knowledge is tentative and subject to change based on gathering of new evidence.

If we are to move toward better science assessment, tests must begin to probe the process by which students solve a scientific problem, rather than simply record the answer. Students should have opportunities to demonstrate not just isolated scientific facts; they must also practice their skills in using the tools of science in some hands-on activities. An effective assessment of science learning might also include sorting through a realistic situation in which the problem is not indicated; this would allow the students to pick out their own problems and identify the information needed to solve the problems.

Martinez and Lipson (1989) advocate mastery assessment of science; they suggest that teachers make greater use of images. Use should be made of still and moving images, including computer simulations. Through
the computer simulations, children can interact with materials or objects that are dangerous, expensive, or unobtainable.

There are many new methods which might be used to gain increased knowledge of student ability in science. Teachers can assign science projects, and require students to keep a journal in which they jot down discoveries made during the project period. The projects might consist of written reports, models, demonstrations, or experiments. Students' laboratory notes or records of experiments carried out might be collected; they could provide the teacher with useful information. Teachers might keep records of hands-on work such as measuring, classifying, and observing. Keeping records of skills learned might highlight the importance of the scientific method in the total science curriculum. Students would realize that process knowledge, as well as information retrieval, is an important component of the science curriculum.

Reading

Much change has occurred in the teaching of reading over the last several years. Writing to read, whole language, emerging literacy, and inventive
spelling are just a few of the new terms being used in discussing reading instruction.

As in the areas of math and science, "assessment has not kept pace with advances in reading theory, research, or practice" (Valencia and Pearson, 1987, p.726).

Pikulski (1989) lists four considerations for needed change in reading assessment: (1) the nature of the procedures and the materials must be significantly broadened, (2) the evaluation instruments must be selected and interpreted in light of the purposes for which they are being used, (3) assessment must shift from being test-centered to becoming teacher- and pupil-centered, and (4) the form of assessment must reflect the goals of instruction and the dynamic nature of the reading process. These ideas are very similar to the needed reforms in mathematics assessment.

A portfolio should contain several different methods of assessment to show a more complete picture of student growth. Formal measurements should be included, such as norm-referenced and criterion-referenced scores. Informal "snapshots" of growth might include writing samples; sample materials used in the grade level; self assessments; and teacher notes.
concerning attitude, oral expression when reading aloud, fluency in reading, and creativity.

One of the nice things about portfolio use is that student work does not disappear. The students have time for processing. The folio provides a place to store writings until incubation is complete, until notes change into writings, and until revision takes place for certain pieces. When students have the opportunity to page through a collection of materials showing their growth over a year's time, they are struck by what they have learned and the progress they have made (Wolf, 1989).

Flood and Lapp (1989) also suggest that a portfolio includes voluntary reading program reports. Voluntary reading is a must for student growth to occur. A report of the results of leisure reading, as well as a clear explanation to parents about the importance of voluntary reading, should be included in the portfolio.

Lewis and Lindaman (1989) offered information on how their district has solved the task of evaluating student writing. Their Iowa school district collects writing samples during fall and spring from students in grades 2-12. The students evaluate their two writing
samples, noting differences and improvements, and these evaluations as well as the writing samples are sent home for parent comments. These materials are then gathered and stored in a cumulative writing folder for comparison with future writings. The teachers also use holistic assessment methods, such as rank-ordering the papers, to validate student growth.

The real value of a portfolio does not lie in its physical appearance, but in the mindset it instills in those who use the portfolio approach for reading assessment (Valencia, 1990). Portfolios represent a reading philosophy that views assessment as an integral part of the instruction. Portfolios offer an expanded definition of assessment in which multi-dimensional indicators of learning are gathered in an on-going, continuous fashion. This is an assessment method that publicly states that the process is as important as the product.

Summary and Conclusions

As stated in a previous section of this paper, today's assessment methods are inappropriate for evaluating student progress in a revitalized mathematics curriculum. Utilizing ideas from science
and reading, and ideas included in various readings on evaluation, it is the writer's intent to delineate testing methods that more adequately match the mathematics curriculum.

One of the most important changes to be made in the mathematics curriculum is a decrease in isolated mathematics facts, and an increase in relevant problem solving, exploration, discovery, and application. To be aligned with this curriculum, the tests must become more than mere regurgitation of math algorithms. The tests should require more complex mental processes. New testing instruments should be multi-dimensional and include teacher- as well as student-input.

New testing procedures might involve students in performance tasks in which they combine content and process as they design their own solutions, perform necessary calculations (using the tools of the classroom, such as manipulatives, calculators, and computers), and present individual solutions to the class with a discussion of procedures. The task might be long term, involving three to five class periods. Some videotaping could be used to aid the teacher in assessing the final product.
An example of a performance task as outlined above for an upper elementary class might be planning a classroom party for twenty-five children. The children would need to plan time schedules, party favors, games, and refreshments. They would need to use grocery ads and determine the amount of money needed and the necessary menu items. Depending on the grade level, the task could be complicated by giving a maximum amount of money. This creates the need for comparison shopping—comparing such things as canned soda pop versus Kool-aid or decorated bakery cakes versus box mixes. A decision would need to be reached on whether students should be required to figure the tax into the total amount. Students might also evaluate one another and select the best-planned party.

A performance task like planning a party would involve many of the curriculum strands outlined in the Standards. Most importantly, the students would be using mathematics to solve problems. The students would be communicating mathematically as they explained their plans to the other class members. Mathematical reasoning would need to be applied to the time constraints and to the amounts and types of foods selected for the party. Connecting math to the real
world would be a significant factor in this real problem. Other significant areas of the curriculum which might receive attention in this task are concepts of whole number operations, whole number computations, and estimation (how much food would be needed?).

Student mathematics portfolios would benefit the assessment procedure. Students could keep computations, problem solving records, journal entries, and self-assessment comments in a folder to be retained from year to year. When students understand a new mathematics procedure, they could write about the steps involved in the procedure, and keep this note in the portfolio. Students would feel a real sense of pride and accomplishment as they review the learning they achieved over a year, or several years.

The NCTM has published a pamphlet on evaluation of nonroutine problem solving (Charles, Lester, & O'Daffer, 1986). The tools offered in this booklet are more holistic in nature than the traditional means of assessing problem solving. The evaluation is made by the teacher according to student attitude and behavior, as well as the solution. Points are assigned for selecting an appropriate strategy, trying a different strategy when stuck, working cooperatively with others
in the group, demonstrating a willingness to try problems, persevering in attempts, and finding the correct answer. As stated before, this is a much truer picture of student growth than that obtained by merely checking the final answer.

Technology offers many possible future assessment methods to consider. An interactive computer test might be an evaluative tool. If levels of questioning became too difficult for the student, the computer would select easier levels of questioning. Not only would the teacher know that the student doesn't know the answer, but how far back teaching must go to assure the fundamentals for success. This would be a much more valid instrument and it would make assessment truly part of the teaching and learning process, not merely an add-on for assigning a grade at the end of the unit of study.

Assessment should critically evaluate the extent to which students (a) have internalized information, (b) can apply the information to new situations that require creative thinking and reasoning, and (c) communicate mathematically. Assessment should also evaluate student attitudes toward mathematics; their self-confidence in handling mathematical situations,
and the extent to which they value mathematics. In order for the goals set forth in the Standards to be reached, assessment must change and keep pace with the changes in instruction.
References


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