

Part 4 • Reaching All Students

“Perhaps most important, is a fundamental underlying belief...Virtually everyone ‘has it’ in mathematics, and the job of the teacher (or school) is to help the student realize that potential.”

Usiskin, 1993

Overview

“Equity for all requires excellence for all; both thrive when expectations are high.”
NRC, 1989

An effective society respects and attends to the concerns of individuals and of groups. “Excellence has to do with individuals, and equity is a property of groups. Individuals and groups, like excellence and equity, ought always to be examined together. One without the other is incomplete” (Willie, 1997).

Excellence and equity are complementary goals—each one rounds out the other, and together they push the educational achievement bar higher for all students. To establish high standards and raise expectations without adequately addressing the needs of students in underserved populations is to perform an injustice first and foremost to those students, and just as importantly, to our society as a whole. The National Commission on Excellence in Education recognized this when they stated that favoring either goal alone could lead to “a generalized accommodation to mediocrity in our society on the one hand or the creation of an undemocratic elitism on the other” (*Nation at Risk* cited in Willie, 1997).

“Besides being an issue of justice, creation of a society where equal opportunity exists in access to mathematics has become an economic necessity.”
NCTM, 1996

Although children enter school with the capability to learn mathematics, certain groups become underrepresented in mathematics classes and fail to fulfill their mathematical potential (Kober, 1991, p. 22). Existing disparities would suggest that education has not provided equal opportunity or equal access, nor has equal performance been attained. In tracked systems, low level mathematics classes are not effective in providing the powerful remediation required to maintain student progress through a standards-based curriculum. The slogan, “Mathematics for All,” is a reminder of the imbalance that exists between equity and excellence in the educational arena.

In the SciMath^{MN} *Statement of Equity for Mathematics and Science Education* (1997), equity means “equitable access to high-quality science and mathematics education and equitable treatment in classrooms, schools, and post-secondary education institutions for every student, leading to high levels of knowledge, skill, and educational attainment in mathematics and science. Transforming instruction in mathematics and science to achieve an equitable education system depends on the commitment and participation of all stakeholders, including students, families, business/industry partners, community members, policy makers, and educators at all levels. Working collaboratively, these stakeholders can ensure that an educational system provides challenging learning opportunities leading to high achievement in science and mathematics for ALL students.” (See Chapter 7: *Making It Happen* for more specific information on what various stakeholders can do to support this effort; see Appendix C for the complete *SciMath^{MN} Statement of Equity*.)

“It is clearly documented that inequities exist and that they can be alleviated.”
Carey et al., 1995

Equitable instruction in mathematics must be geared toward inclusiveness with respect to gender, socioeconomic status, ethnicities/cultures, disabilities, and languages. In order to address equity issues in the mathematics classroom, teachers will need to investigate their own beliefs about “mathematics for all.” Teacher awareness of equitable practices, self-observation via videotapes and/or peer coaching, and reflection with thoughtful action can begin to create classrooms which expand, rather than limit, the learning potential of all students.

Research suggests that groups, as well as individuals within groups, may have different learning needs according to their culture, language, socialization patterns, and expertise. Different teaching strategies may be more effective in meeting the diverse strengths and mathematical potential of some students. However, in traditional classrooms, direct instruction, individualized seat work, and memorization of procedures have dominated the teacher’s instructional practice. Achieving a significant transformation in the mathematical learning experiences of all students will require aligning best practice with a coherent and focused curriculum and multiple and varied assessments.

For Further Study of Topics in Part 4

Armstrong, T. (1994). *Multiple intelligences in the classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Cuevas, G. & Driscoll, M. (1993). *Reaching all students with mathematics*. Reston, VA: NCTM.

Lawrence, G. (1991). *People types and tiger stripes: A practical guide to learning styles*. Gainesville, FL: Center for Applications of Psychological Type, Inc.

Lynn, L. & Wheelock, A. (1997). "Making detracking work." *Harvard Education Letter*, 13(1).

Secada, W.G., Fennema, E., & Adajian, L.B. (1995). *New directions for equity in mathematics education*. Cambridge, UK: Cambridge University Press.

Thornton, C. & Bley, N. (1994). *Windows of opportunity: Mathematics for students with special needs*. Reston, VA: NCTM.

Trentacosta, J. & Kenney, M.J. (Eds.) (1997). *Multicultural and gender equity in the mathematics classroom: The gift of diversity: 1997 yearbook*. Reston, VA: NCTM.

“Justice in mathematics will not be achieved until the goals of education are met equally by both sexes.”

Fennema, 1990

“There is no evidence that females as a group have less aptitude for math than males.”

Kober, 1991

“Gender differences in mathematics performance are predominantly due to the accumulated effects of sex-role stereotypes in family, school, and society.”

NRC, 1989

Gender

What Research Says

Research reviews by Jacobs and Becker (1997, p. 108) show that traditional teaching strategies in mathematics classes favor learning styles of boys over girls. This imbalance can lead to inequities in participation and outcomes.

A review of research shows both achievement and attitude differences between males and females:

- In high stakes tests, such as the mathematics subtest of the SAT, large gaps persist, with girls scoring 35 points lower than boys (National Coalition for Women and Girls in Education, 1996).
- Women are less likely to enter fields that require advanced mathematics and science degrees. While women hold 32 percent of bachelor degrees in computer/mathematics sciences, they hold only 18 percent of the doctoral degrees (NSF, 1996).
- In Minnesota, when comparing the number of baccalaureate and graduate degrees in mathematics, science, engineering, and technology, females only achieve parity with males in the life sciences (Johnson, 1997).

Research cited in Campbell (1995, p. 226) also indicates the following differences:

- Females are more apt than males to doubt their competence in mathematics and to be less confident in their mathematics ability.
- Self confidence drops for females in early adolescence before they experience any academic decline.
- Males receive more praise, a greater number of disciplinary contacts, and more general teacher-initiated contacts than females.

Implications for the Classroom

Mathematics teaching has traditionally stressed and emphasized deductive proof, absolute truth, certainty, algorithms, abstraction, logic, and rigor. To build on the strengths of all students, teachers must balance teaching strategies which address different learner needs. Teachers need to provide a balance of learning strategies by also promoting intuition, experience, conjecture, generalization, induction, creativity, and context in the mathematics classroom (Jacobs & Becker, 1997, p. 108).

In creating a gender-fair program, teachers can make a conscious effort to equalize the amount and type of classroom interactions which encourage female participation and success. They can:

- observe and monitor their questioning patterns to be sure they have equitable instructional interactions with both girls and boys
- eliminate both blaming and non-specific praising statements from their verbal behavior
- provide hands-on and/or spatial activities on a regular basis
- encourage cooperative interaction and discussion among students
- pair girls with girls often to provide increased opportunities for girls to use mathematics materials, technology, and assume leadership roles
- increase interactions with and expectations of females on high-cognitive-level mathematics activities
- accept student responses and encourage divergent thinking
- invite female mathematicians and scientists to class as role models and/or study female mathematicians.

“Research shows that students’ cultural milieu greatly influences their learning preferences; people are socialized to learn in various ways.”
NREL, 1997

Race, Ethnicity, and Culture

What Research Says

Culture is meaningful because it suggests what we can take for granted as common information, language, and priorities (Hilliard, 1995, p. 100). If teachers never employ styles that are compatible with cultural norms, students’ connections with the mathematics curriculum and subsequent learning of mathematical concepts are greatly decreased (Stiff, 1990, p. 155).

Studies of students from underrepresented racial/ethnic groups show that:

- Performance gaps between white students and students of color are documented by the end of second grade, and are wider for older students and on questions requiring higher level thinking (Stiff, 1990).
- Large differences in performance and course enrollments exist; e.g., 60 percent of white and Asian students enroll in Algebra II versus less than 50 percent of African Americans, Hispanics and Native Americans (NSF, 1996, p. xv).
- African Americans take about one year less of high school mathematics than the national average (Kober, 1991).
- Non-white students are more heavily enrolled in lower-level math courses; e.g., 24-35 percent of Hispanics, African Americans, and Native Americans are enrolled in remedial classes versus 15 percent of whites and Asians (NSF, 1996, p. xv).
- NAEP results for Minnesota show that many ethnic groups perform below comparable groups from other states in spite of the high mean performance shown for Minnesota students in general (Reese et al., 1996).
- African Americans, Hispanics and Native Americans make up 12, 10 and 1 percent of the population respectively but form only 3.5, 3 and .02 percent of the science and engineering work-force (NSF, 1996, p. xviii).

Implications for the Classroom

There are numerous examples of schools and classrooms where students exceed expectations for performance. The question, therefore, is not whether students of various racial/ethnic backgrounds can or cannot achieve high mathematical skills; rather it is which means will elicit maximum success in mathematics? (Walker & Chappell, 1997, p. 202). Teachers must:

- expect students of all racial/ethnic/cultural backgrounds to achieve
- consider students’ language, culture, and community as assets rather than liabilities
- recognize that all racial/ethnic/cultural groups are part of traditions that have contributed to our common mathematics knowledge base
- increase student-to-student and student-to-teacher interactions
- increase the cognitive level of interactions with students of color
- avoid tracking, which systematically removes students from opportunities to learn important mathematics
- use diverse and flexible assessments to determine students’ strengths
- use immediate and effective remediation to counteract poor performance results
- vary the instructional styles in the classroom

“Attending school regularly is the most consistent and reliable predictor of success on the [Minnesota 8th grade] mathematics and reading examinations.”
Myers, 1997

" Si se puede, 'It can be done.'"

Flores, 1997

" Words and phrases have definite meanings and represent ideas that if not understood prevent the learner from fully understanding the message conveyed."

Cuevas, 1990

" It is by integrating the development of language in the context of mathematics instruction that we may give these students the 'key that unlocks the door to the world of mathematics.'"

Cuevas, 1990

Language

What Research Says

A student's native language plays a role in the development of his/her mathematical skills and concepts. Research shows that concepts and skills can be reinforced when students have the opportunity to discuss them in their native language (Cuevas, 1990, p. 160). Flores (1997), however, reports that in many schools limited English proficiency (LEP) acts as a filter which limits students' opportunities in the following ways:

- limited English proficiency is often equated with limited talent and expertise
- a disproportionate number of children who do not speak English are labeled as learning disabled
- students are often prevented from discussing and explaining material to one another in their own language
- very few programs for gifted and talented students are offered in languages other than English

Students with limited English proficiency may also have specific difficulty with the precise use of language in mathematics compared to daily communication. The vocabulary, syntax, and format of mathematics may be unfamiliar to them. This can also hinder some learning disabled students who have difficulty with decoding, visual-spatial relations, directionality, and sequencing skills (Kober, 1991).

Language skills also include the components of listening, comprehending, reading, writing, and speaking (Cuevas, 1990, p. 159). Difficulties may be caused by inability to understand either the spoken or written word or both. Additionally, students may also exhibit differences between their conversational and their academic skill in either English or their native language.

Implications for the Classroom

Mathematics teachers can address LEP students' special needs by using the following strategies (Kober, 1991; Cuevas, 1990):

- recognize that not all LEP students have the same needs
- become familiar with each student's background in order to use culturally relevant problems and contexts
- modify lessons to cut down on the use of new vocabulary terms and phrases
- use visual aids, diagrams, and hands-on experiences to help clarify the meaning of verbal and written information
- incorporate activities that teach the language of mathematics in context; include vocabulary, listening, reading, speaking, and writing skills
- maximize communication opportunities for students in English as well as their native language
- adjust instruction, class discussions, and assessment to include visual representations and nonverbal communications with verbal instructions
- promote student enrollment in mathematics courses, since language development is attained better when language is used in context

“With as many as 10 percent of the population disabled in some way, the nation can ill afford continued under-representation of disabled persons in mathematical careers.”
NRC, 1989

“It is important to remember that students with special learning needs are individuals with many of the same needs as other students.”
Bley, 1994

“In recent years, the growing use of computers as an aid for persons with disabilities and as a tool for mathematicians provides yet another effective link to enable persons with disabilities to succeed in mathematics-based careers.”
NRC, 1989

Physical Disabilities

What Research Says

Most students with physical disabilities are quite capable of learning and achieving at the same level as their peers even though they may work more slowly or require adaptive devices. In spite of this, research shows that students with disabilities often have low academic self images.

Research focused on students with physical disabilities also indicates that (Kober, 1991; NRC, 1989):

- programs which place special needs students in separate classrooms negatively affect achievement
- inclusive programs benefit students academically and socially
- educational technology, including computers and calculators, can be adapted for use by disabled students and can result in higher mathematics achievement

Implications for the Classroom

The teacher can assess the impact of a student’s physical disability on learning by answering the following questions (Bley, 1994, p. 138):

- What learning strengths are intact?
- What learning abilities are suppressed by each disability?
- What learning or teaching styles are most compatible with this student’s specific learning needs?

Structuring an appropriate mathematics education for the physically handicapped child may be a matter of providing or adapting appropriate instructional aids. In addition, teachers may need to:

- recognize that students with disabilities may have different life experiences, so some contextual references may not be as helpful to them
- assess the learning strengths of disabled students and teach to these strengths as often as possible
- use a variety of appropriate learning approaches, including visual, auditory, kinesthetic/tactile
- use technology to enhance learning experiences of student with disabilities
- use a partner or assistant to work with disabled students in the classroom as appropriate
- modify testing procedures and formats
- recognize the accomplishments of physically handicapped mathematicians and scientists

Hearing impaired students may not appear to understand the mathematics when in fact they are not understanding the language that is being used (Bley, 1994, p. 142). When working with hearing-impaired students, teachers should highlight and write out new vocabulary and ideas using explanations that are direct, succinctly stated, and carefully presented.

“There are no guarantees that an awareness of style will improve mathematics instruction, but there are some exciting possibilities.”
Driscoll, 1980

“Learning style...is crucial in explaining why certain instruction works with some students and not with others”
Lawrence, 1991

“In the classroom, the teacher continually shifts her methods of presentation from linguistic to spatial to musical and so on, often combining intelligences in a creative way.”
Armstrong, 1994

Learning Styles

What Research Says

The examination of learning styles has interested psychologists much longer than it has educators. This helps explain the fact that more is known about what learning styles are than what teachers should know or do about them (Driscoll, 1980). Howard Gardner’s research (1993) on children and brain-damaged adults led him to point out that a “one size fits all” definition of intelligence is inadequate to describe a child’s potential. This led him to develop a theory of multiple intelligences which states that individuals have different strengths in a range of intelligence areas, and that no one set of teaching strategies will work best for all students at all times.

Research has identified some effects of individual learning styles in the classroom:

- when students experience only one type of teaching style, some are at an advantage and others are at a disadvantage
- when teacher and student styles match, students are more likely to receive higher grades and evaluations than when they do not match
- while cultural experiences influence student learning styles, it should not be assumed that all members of any group have the same learning preference
- there is a tendency to think others are more like us than they really are and that others share the same learning styles
- styles are not as rigid as commonly believed and can vary depending on factors such as time, place, and task

“One clear conclusion of research is that educators must avoid the trap of assuming that a child’s lack of success is due to a lack of talent. It could be due to a lack of opportunity or to an improper match between instruction and student learning style” (Driscoll 1980, p. 84).

Implications for the Classroom

Our own learning preferences reveal some of the differences that can affect mathematics learning and performance:

- sense modalities (visual, auditory, kinesthetic)
- preferences for working alone or with others
- linear/analytic approaches compared to global/spatial approaches
- reflective thinking versus impulsive doing

Students who are aware of their own learning styles can be proactive in finding ways to complement their learning. In the classroom, the key to accommodating students’ various learning styles is to thoughtfully and systematically vary the instructional approach of lessons. This can be done by:

- listening to students or using inventories to assess how students learn best
- using observations about student learning styles to modify instruction, not to label
- encouraging a variety of thinking styles in problem solving situations
- providing a variety of open-ended as well as structured learning situations
- providing a variety of materials
- varying the amount and type of practice to meet individual needs

“MYTH: Learning mathematics requires special ability, which most students do not have.”
NRC, 1989

“One thing was certain: The children could not learn algebra if they were not exposed to it.”
Hilliard, 1995

“Twice as much, twice as fast, twice as hard’ is not an appropriate program for highly talented students.”
Keynes in NRC, 1989

“The best time to learn mathematics is when it is first taught; the best way to teach mathematics is to teach it well the first time.”
NRC, 1989

Detracking

What Research Says

In the United States many people believe that learning mathematics depends on special ability. In many other countries, however, students, parents, and teachers all expect that by working hard, most students can master mathematics. Student achievement in these countries and in effective intervention programs in the United States indicate that students achieve, not because of special techniques, but because they are exposed to consistent high-quality instruction and high expectations.

As a result of tracking practices based on perceived ability differences, many U.S. students do not have the opportunity to participate in standards-based mathematics learning. Research (Oakes, 1985, p. 91) shows that tracking:

- does not increase student learning
- prevents the opportunity to learn important mathematics content and increases the educational gap among students
- tends to widen the achievement gap and retards the academic progress of many students, especially those in the average and/or low achievement group (Barquet, 1992)
- results in an unfair and disproportionate placement of poor students and students of particular racial/ethnic groups in low achievement and non-college bound classes

Implications in the Classroom

Giving students the opportunity to learn mathematics means that teachers start where students are, not where “they ought to be.” From that starting point, teachers expect and help students to go as far as possible. Accommodations for low and high achievers can still be used to provide remediation, enrichment, differential assignments, and depth of coverage. The goal, however, is to provide all students with the opportunity to study a core curriculum and make progress toward high standards.

Programs that are successful in addressing varying abilities (Eddins & House, 1994, p. 321; Leder, 1995, p. 217):

- base instruction on problems and activities that can be approached from different levels (concrete to more abstract)
- ask open-ended questions that allow for individual exploration and investigation
- frequently assess student understanding and flexibly regroup students for different instructional units
- create a classroom environment that supports all students—an environment in which the teaching style mirrors the nature of mathematical inquiry
- promote a broader definition of what constitutes evidence of mathematical accomplishment
- involve multiple measures to identify and encourage promising students
- offer flexible pathways along which gifted students can encounter rich ideas through challenging, nonstandard learning experiences
- excite students about the wonder of mathematics and encourage them to invest their talents in mathematics
- expose students in lower achieving groups to more challenging content and sophisticated discussions about mathematics
- choose and/or modify tasks appropriate to the skills and the sophistication of understanding of individual students

"Homogenized is only better for milk."

Davidson & Hammerman, 1993

"The fundamental objective of education always has been to prepare students for life. The new objectives for school mathematics...do not depart from this tradition but rather, reaffirm it."

NCTM, 1996

"Not only must the mathematics we teach meet the social and economic demands of [an increasingly complex] world, but also we must take steps to ensure that everyone participates in that world."

Secada, 1990

Reaching All Students: A Summary

In theory, homogeneous groups make it easier for teachers to help students who are all "at the same level." In reality, people don't come in homogeneous groups regardless of how hard we try to make them do so. "Even if we could find an entire class of children who tested at exactly the same level in mathematics, there would be some who got that score because they were intuitive problem solvers, others because they were fast at computations and therefore got a lot done, and still others because they were slow but very accurate in their work" (Davidson & Hammerman, 1993).

The Curriculum and Evaluation Standards for School Mathematics and the *Minnesota Graduation Standards* clearly agree that all students can learn mathematics and must be given the opportunity to do so. This commitment to mathematics for all must effect changes in teachers' beliefs, curriculum materials, instructional strategies and assessment paradigms. "The goal of every teacher should be to provide all students with the opportunity to develop their full human potential in an environment where...differences are respected and valued and where full participation and partnership are the norm" (Stiff, 1993, p. 6).

There are no quick fixes to our present situation in school mathematics, but there are recommendations that can help us reflect and modify our classroom practice:

- Start from where students are.
 - Review only when necessary.
 - Place students in courses in which they have opportunity to be successful.
 - Allow students of different ages to do the same mathematics.
- Set high expectations.

Students with talent in mathematics can be found in any group. Their potential will not develop, however, unless it is properly nurtured and encouraged.
- Provide the same high-quality curriculum and instruction for all students.

Incorporate problem solving and real-world applications into the core curriculum.
- Provide multiple points of entry to rich mathematical tasks.

Conceptual learning should not be put on hold while students develop proficiency in memorizing facts or computational speed.
- Emphasize all aspects of mathematical discourse.

The nature of discourse and the level of interaction in the mathematics classroom is an important indication of how well the needs of different students are being met.
- Provide immediate and effective remediation.

Make every attempt to prevent students from falling behind. Many students need to know that they are behind and, with support and encouragement, need to work harder to catch up.
- Use technology to support student learning of mathematics.

Calculators and computers have the potential to make learning more active and dynamic, and hence, more effective.
- Use fair and meaningful assessment and testing procedures.

Providing both an excellent and an equitable mathematics education for all students will depend on the commitment and participation of all stakeholders, including students, families, business/industry partners, community members, policy makers, and educators at all levels. Working collaboratively, these stakeholders can ensure that our educational system provides challenging learning opportunities leading to high achievement in mathematics for ALL students.