Does Everybody Need to Study Algebra?

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(An invited "Sound-Off" column in an issue of NCTM's high school journal devoted to the debate about "Algebra for All.")

It is a mistake to suppose that requiring the nonmathematical
to take more advanced math courses will enhance their understanding
and not merely exacerbate their sense of inadequacy.

-- William Raspberry

Why teach algebra to those who don't or can't appreciate it...
Algebra isn't essential to much of anything...
It is useless torture, ... for the few, not the many.

-- Coleman McCarthy

Even as members of NCTM rally to implement the *Standards*,well-known critics such as Washington Post columnists William Raspberry and Coleman McCarthy--speaking from opposite sides of the political house--raise an alarm. How absurd, they say, to require algebra of all students. Ordinary people don't use algebra in their life or work. So let students choose: those who need math should take algebra, those who don't shouldn't have to.

Critics argue that algebra is a boring, irrelevant impediment that turns off more students than it helps. Yet the *Standards*,call for a three year core curriculum for all students. *Everybody Counts*urges that students study mathematics each year they are in school. Reformist advocates of outcome-based education (OBE) recommend that performance outcomes such as effective problem solving and communication replace seat-time as the requirement for graduation, while traditionalist voices call for accountability in terms of improved test scores.

Let's face it. For most students the current school approach to algebra is an unmitigated disaster. One out of every four students never takes algebra, being diverted instead into dead-end sidings such as general or consumer math. And half the students who do take Algebra I leave the course with a life-long distaste for mathematics. Many of these students go on to become newspaper columnists

or political leaders.

In fact, none of the major voices for change in school mathematics specifically urges that the present version of Algebra I be a requirement for all students. The *Standards,Everybody Counts,*OBE advocates, even President Bush's *America 2000* plan all speak broadly in terms of outcomes for high school graduates, not of particular course requirements at specific grade levels. On this the mathematics community and its critics agree: Algebra I in its present manifestation is not essential for a quality mathematics education.

This is not to say that *algebra*is not essential. Algebraic skills and associated algorithmic thinking are means to the ends of mathematical power *(Standards),*problem solving (OBE), or scientific competitiveness (President Bush). So too is geometric insight, quantitative reasoning, logical clarity, number sense, and statistical experience. Whether students enter the work force directly after high school or continue their studies in higher education, they must be prepared to employ a rich variety of mathematical skills in their work.

McCarthy and Raspberry are partially right. Rarely will high school graduates be faced with problems that present themselves in the language of algebra. Most often they will have to think mathematically about issues laden with incomplete data, ambiguous graphs, uncertain inferences, and hasty generalizations. To perform well when confronted with problems of this complexity, students need more tools than mere algebra.

Mathematical power for all students, the theme of the *Standards,*requires that each student grow throughout each school year in the ability to perform effectively in a variety of authentic settings, rich with detail, surrounded by ambiguity, and imbued with a context that is both realistic and significant. This is what outcome-based performance assessment is all about. It is the educational equivalent of what the business world calls the bottom line.

However, students' progress towards the goal of mathematical power will rarely be uniform. As every teacher and parent knows, students are *very*different: they mature at different rates; their learning patterns exhibit different strengths and weaknesses; their interests and preoccupations shift unpredictably. So to achieve the desired outcome of mathematical power for all students within the chaotic reality of real students in real schools, we must be prepared to abandon rigid curricular structures such as Algebra I that treat all students as if they were alike. The lock-step approach of algebra, geometry, and then more algebra (but rarely any statistics) is still dominant in U.S. schools, but hardly anywhere else. This fragmented approach yields effective mathematical education not for the many, but for the few--primarily for those who are independently motivated and who will learn under any conditions.

In contrast, the *Standards*call for instructional patterns that group students not by curricular objectives (e.g., general mathematics vs. algebra) but by breadth, depth, and approach. This exhortation is not as unrealistic as it might at first appear. Although typical school exercises (e.g., solve x^2 + 4x - 7 = x + 5) have relatively inflexible mathematical prerequisites, authentic problems can be approached in many different ways--by estimation, by graphing, by calculator, by equation, by modeling, by computer. Thus students at many different levels of scholastic and mathematical maturity can work on similar (or identical) problems, each in his or

her own way.

Indeed, evidence from effective programs shows that all students learn better in environments that are rich in context, community, and connections:

- *Context:* Typical mathematics homework and worksheets isolate a single dimension of knowledge from its rich natural context. Most students perform more effectively and more imaginatively when they encounter problems in a context that invites full use of their personal strengths and does not simply rely on a narrow range of skills.
- *Community:* Children learn best in circumstances that reinforce the emotional and social contexts necessary for sustained motivation. Personal engagement is enormously important to students of all ages; effective instruction harnesses this powerful source of motivation.
- *Connections:* To make sense of formal mathematics, students need opportunities to make connections, both to social, historical, or personal contexts as well as to other subjects studied in school. Mathematics is connected to virtually everything, and good teaching constantly reveals these connections.

The NCTM *Standards*are rooted in educational research that shows the personal nature of mathematical knowledge: each student's mathematical insight is constructed as he or she engages the material and uses it in productive ways. Students differ in how long this engagement must be and in the kind of activities that will be productive for the purpose of constructing mathematical knowledge. Nevertheless, for all students, context, community, and connections are what make this engagement productive. All students, not just advanced students, can and should benefit from the rich environment of open-ended problems, group problems, active discussion, and multi-dimensional learning.

Effective programs will provide different levels of expectation for students at different levels of need. Since students learn at very different rates, the time required in projects and practice, and on review, will vary greatly. Instructional practice must provide more time for those who need it immediately at the point when it is appropriate--not months or years later when it is much less effective. What this requires, which Algebra I too often lacks, are challenges appropriate to the child and engagement sufficient to the challenge of learning.

.ul Everybody Counts stresses the nation's dual need to achieve both excellence and equity in mathematics education. "Equity for all requires excellence for all; both thrive when expectations are high." This challenge is sharpened in the *Standards,*and, surprisingly, by critics McCarthy and Raspberry. Both the *Standards*and its critics seek a richer course than the traditional Algebra I. Only then can we face the public with a legitimate claim for more required years of school mathematics.

Students need to learn statistics, geometry, algebra, and computing; they need to acquire both number sense (quantity, measurement, magnitude, units) and function sense (symbolic, graphic, numeric, algorithmic). They must grow in the experience of using mathematics both in school assignments and in ordinary life. Finally, what should really be first, all students must learn to read, write, speak, and listen with language that employs mathematical ideas.

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The school curriculum should be arranged so that all students gain in each of these many dimensions of mathematical power each year they are in school. The reason Algebra I is such an easy target is that it advances only a narrow range of skills, leaving too many important topics for future courses which most students never take. To regain public confidence, school mathematics must continually teach students things that thoughtful adults perceive as important. These are exactly what the *Standards*recommend.

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