

# Thinking Algebraically: Promoting rigorous mathematics for all students

*As a math teacher, I know the significance of all students having the opportunity to study and excel in mathematics. Some have said that algebra is “the new civil right” – it certainly is one of the gateways to higher education. It is because of this critical link that we must work harder to improve mathematics instruction, support teachers as they work to improve their practice, and continue to work with parents and the community so they understand the importance of mathematics as a foundation for future success.*

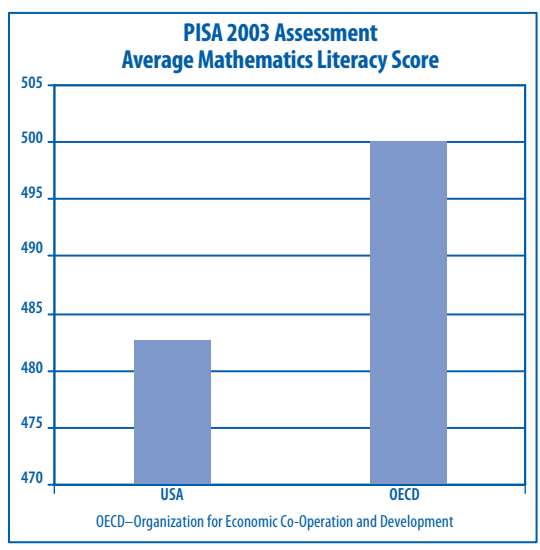
—NEA President Dennis Van Roekel

Each day American workers are in competition for jobs. But they are not just competing for jobs with neighbors across the county or state anymore; the marketplace has grown much more complex and far-reaching than that. Today the American workforce is also competing with our neighbors in India, Brazil, and many other places around the globe. The 21st century global economy depends on a work force that is proficient in mathematics and able to use it to solve problems creatively.

The problem is that American students are not receiving the mathematics background that they need. Mathematics achievement in the United States lags behind other industrialized countries, as

evidenced by international tests such as TIMSS<sup>1</sup>—which measures students on school mathematics—and PISA<sup>2</sup>—which measures students on their ability to apply mathematical principles and concepts. In the most recent PISA data (2003), American 15-year-olds scored below the international average. On the 2003 TIMMS, American 4th and 8th graders scored above the international average, but 17-year-olds did not. These findings are troubling because it appears that as Americans students progress through school, they are actually losing academic ground to their international counterparts. Even American students who took advanced courses did less well than their international peers on these assessments.

Many educators believe that the disappointing results in these international comparisons can be traced largely to the issue of how, when, and to whom algebra is taught in our schools. Algebra is considered a “gatekeeper” course, which means that students must master this content before they will be successful at more advanced mathematics (such as geometry, trigonometry, or precalculus). One issue is that more students must be given the chance to take algebra in the 8th grade (recommended grade level). Another is that we need to offer more preparation and support for those who do tackle this content because students who have difficulty with algebra are effectively precluded from further study of mathematics.



State	Mathematics Graduation Requirements
Alabama	4 units* <sup>3</sup> , including 1 unit each of Algebra I and geometry
Florida	3 units, including 1 unit of Algebra I or higher
North Carolina	Beginning with the class of 2013, college prep students—Algebra I, geometry, Algebra II or Integrated Math I, II, III
West Virginia	3 units, including Algebra I and 1 unit above

Studies indicate that in this country, the 8th grade curriculum emphasizes arithmetic at the expense of algebra, while other industrialized countries such as Japan and Singapore focus on higher level math skills such as algebra and geometry at this grade level. Further, most students in Japan and Singapore are taught and are expected to master a high level of mathematics content in the 8th grade, in stark contrast to students in the United States who are by now often separated into different ability tracks, with only the most advanced students encouraged to study algebra. The American practice of tracking students into different skill or curricular groupings, starting as early as elementary school, effectively denies them an opportunity to develop valuable marketable skills. The markedly different attitude to universal access to higher level mathematics embraced by other countries, and the United States' disappointing results in international assessments, should serve as a wake-up call to all stake-holders to re-examine America's go-slow and elitist approach to introducing algebra to students.

National education organizations, state and local school boards, mathematics educators, and researchers have discussed how and when to teach algebra, and how to integrate it into the preK-14 grade curriculum. The National Council of Teachers of Math (NCTM) recommends that students develop a "solid foundation of understanding and experi-

ence [of algebra] during the elementary years as preparation for work in middle and high school."<sup>4</sup>

There is some cause for optimism on this issue. A subject that used to be taught exclusively at the high school level or reserved for the "talented" few is now a graduation requirement for all students in many states. Algebra is seen not only as the foundation to higher-level mathematics courses and college academics, but in as many as 21 states it is now, or will soon be, a requirement for high school graduation.

### Opening the algebra gate to success

There are several significant issues to address in opening the algebra gate to success. One, we must create a national mathematics imperative. Students will have a better chance of succeeding in algebra if they know that mathematics is important and valued by their parents and the other adults in their lives.

Mathematics and those who study it have never had throngs of supporters. In a recent study, parents acknowledged that mathematics, science, and technology were important, but not necessarily for *their* children.<sup>5</sup> Creating a citizenry that values mathematics, sees its' importance, and works diligently to impart that knowledge to young people is necessary to the bigger picture.

Second, we need to better prepare students in the elementary grades. The mathematics that is taught to students from preschool up to the 8th grade matters. Students who receive a strong math foundation in the early grades are much more likely to be successful in algebra later on. In fact, in 2006 the National Mathematics Advisory Panel (created by Presidential executive order) recommended that students receive in-depth instruction in three areas to prepare them for success in algebra: fluency with whole numbers, fluency with fractions, and particular aspects of geometry and measurement.<sup>6</sup>

Third, we must ensure that all students are taught by well-prepared, licensed teachers who are using a well developed, articulated, and coherent Pre-K-7 mathematics curriculum. Math teachers must have a

deep understanding of both pedagogy and content. The research makes it clear that students achieve more when they have a series of effective teachers. Some researchers believe that teachers are the single most important factor affecting student achievement and that the effects of teachers on student achievement are both additive and cumulative.<sup>7</sup> One well-regarded study finds that having an effective teacher leads to students exceeding one grade-level equivalent in annual achievement growth.<sup>8</sup> The practice of teaching is both complex and specialized.<sup>9</sup> Educators need consistent, rigorous, professional development to continue to perfect their practice. Researchers such as Linda Darling-Hammond<sup>10</sup> emphasize the importance of adopting policies that support professional development for teachers.

### Taking the longer view

The U. S. Census estimates that workers 18 and over with a bachelor’s degree earn an average of \$51,260 a year while their counterparts with a high school diploma will earn an average \$27,915 annually. Completing a bachelor’s degree is worth nearly double in lifetime earnings. Clearly, entering college and successfully completing a degree pays off significantly.

But getting more students to consider higher education as an option requires advance planning by both the student and his or her parents. And key to that planning includes being aware of the importance of foundation and gatekeeper courses. Successfully completing algebra early in a student’s middle/high school career places them higher in the math pipeline and may increase the chances of students applying to and attending college.

In fact, college-bound students need to meet certain college entrance requirements. The American College Testing Program (ACT) recommends students complete three or more years of Algebra I and higher (rather than general math, business math, or consumer math). The College Board, the organization that administers the SAT, recommends that students take both algebra and geometry. To satisfactorily

complete college entrance courses and admitted to college, students must “enter the gate.” That means being prepared to successfully complete their first algebra call.

Finally, we need to shift our own thinking about algebra and see the broader value of this subject to today’s

students who will be tomorrow’s workers. It’s no longer enough just to insist that students take the course as a prerequisite to higher mathematics. Instead, we need to embrace algebra as a way to solve problems. Algebra is about more than solving problems in a mathematics class. It’s necessary for the continued economic solvency of our nation. Today’s workplace requires workers to read diagrams and manuals, interpret graphs, maintain records and interpret statistics, and make predictions from data. Schools, communities, federal, state, and local governments, and business must work together to impart a sense of urgency in and around this subject.

Lifetime Earnings (million)	
High School Graduate	1.2
Bachelor’s	2.1
Master’s	2.5
Doctorate	3.4
Professional	4.4
Source: U.S. Census	

### NEA’s call to action

NEA believes that we must address this issue on at least three fronts:

- Educate the public, parents especially, about the importance of algebra:** With the help and support of business and community groups, local education agencies (LEAs) should design and implement a public engagement campaign to educate the public, especially parents, on the importance of appropriate preparation for algebra, as well as the successful completion of algebra in preparation for advanced mathematics.
- Support professional development for primary and intermediate teachers:** Most elementary students receive their mathematics instruction from their regular classroom teachers. Teachers receive their professional development through

a number of venues and providers. LEAs should provide support for teachers as they develop their own individual professional development plans and LEAs must help build the capacity (leadership support, knowledge base, resources, mathematics coaches) for teachers to engage in meaningful professional activities that are central to enhancing student achievement.

- 3. Build on the recommendations of the National Math Panel:** State education agencies and educators should review education materials using the National Panel's recommendations and other materials to ensure that the content taught is preparing students for success in algebra I.

## References

<sup>1</sup> TIMSS-Trends in International Mathematics and Science Study, <http://nces.ed.gov/timss/>.

<sup>2</sup> PISA-Programme for International Student Assessment, [www.pisa.oecd.org/pages/0,2987,en\\_32252351\\_32235731\\_1\\_1\\_1\\_1\\_1,00.html](http://www.pisa.oecd.org/pages/0,2987,en_32252351_32235731_1_1_1_1_1,00.html).

<sup>3</sup> Carnegie Units, Education Commission of the States, <http://mb2.ecs.org/reports/Report.aspx?id=900>.

<sup>4</sup> National Council of Teachers of Mathematics, *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics*, 2007, [www.nctm.org](http://www.nctm.org).

<sup>5</sup> *Important, But Not for Me: Parents and Students in Kansas and Missouri Talk About Math, Science, and Technology Education*, [www.publicagenda.org/reports/important-not-me](http://www.publicagenda.org/reports/important-not-me).

<sup>6</sup> National Mathematics Advisory Panel, *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*, U.S. Department of Education: Washington, DC, 2008.

<sup>7</sup> W.L. Sanders and J.C. Rivers, *Cumulative and residual effects of teachers on future students' academic achievement*. Knoxville, TN: University of Tennessee Value-Added Research and Assessment Center, 1996.

<sup>8</sup> E. Hanushek, *The trade-off between child quantity and quality*. *Journal of Political Economy*, 100(1), 84–117, 1992.

<sup>9</sup> S. Loucks-Horsley, P.W. Hewson, N. Love, and K.E. Stiles, *Designing professional development for teachers of science and mathematics*, The National Institute for Science Education, 1998.

<sup>10</sup> L. Darling-Hammond, *Teacher Quality and Student Achievement: A Review of State Policy Evidence*, Education Policy Analysis Archives, 8(1), 2000, <http://epaa.asu.edu/epaa/v8n1/>.

## Resources

### **Gender Equity in the Math and Science Classrooms: Confronting the Barriers that Remain,**

National Education Association, 2004.

[www.nea.org/achievement/images/genderdoc.pdf](http://www.nea.org/achievement/images/genderdoc.pdf)

### **National Staff Development Council's Standards for Staff Development.**

[www.nsd.org/standards/about/index.cfm](http://www.nsd.org/standards/about/index.cfm)

**Quiet Crisis: Falling Short in Producing American Scientific and Technical Talent.** This important summit, held in December 2005, has led to much work around the issue of developing an adequate science and engineering workforce.

[www.rpi.edu/homepage/quietcrisis/info.html](http://www.rpi.edu/homepage/quietcrisis/info.html)

### **Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.**

This congressionally requested report by the National Academies makes four recommendations along with 20 implementation actions that federal policymakers should take to create high-quality jobs and focus new science and technology efforts on meeting the nation's needs, especially in the area of clean, affordable energy. Published in 2007.

[www.nap.edu/catalog.php?record\\_id=11463](http://www.nap.edu/catalog.php?record_id=11463)