

# Moving Beyond Standards and Tests

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*Invited testimony at the initial meeting of the Commission on Mathematics and Science Education established by the Carnegie Corporation of New York and the Institute for Advanced Study in Princeton, New Jersey to assess science and mathematics teaching in the U.S., identify and analyze successes and failures, and provide recommendations for improving K-12 science, math, and technology education.*

Education policy today appears to operate within a particular standard model of "politically correct" beliefs: that all students should prepare for college, that teachers should teach to externally prescribed standards designed to prepare students for college, and that students should pass standards-based tests before receiving a high school diploma. This, so the theory goes, is the way to create a "diploma that counts."

I believe we need a different model since the standard model simply isn't working:

- Only two-thirds of students who enter ninth grade graduate on time. For minorities, on-time graduation rates are closer to 50%.<sup>1</sup>
- In the last decade, the average literacy of adult Americans has declined at virtually every level of educational attainment.<sup>2</sup>
- Fewer than one in eight students from families in the bottom income quartile earn a four-year degree, as compared with 75% in the top quartile.<sup>3</sup>

Many believe also that the policy goal of making college-prep the default curriculum is based on questionable assumptions about the future labor market. I leave that debate to labor experts, noting only that the majority of jobs still depend more on personal attributes and on-the-job training than on advanced high school courses.

Mathematics—my field—plays a special role in the standard model. It is taught in every K-12 grade; testing and "adequate yearly progress" is required by NCLB; it is examined on college admissions tests; it is a prerequisite for many careers; and it is often required for college degrees. Yet when asked to name the most useless things they were learning, high school students spontaneously named advanced mathematics and science.<sup>4</sup> Three-fourths report that they find such courses irrelevant and, consequently, do poorly in them. The consequences of boredom with school mathematics are everywhere evident:

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<sup>1</sup> Peter Schmidt. "High-School Students Aim Higher Without Learning More, Federal Studies Find." *Chronicle of Higher Education*, March 9, 2007. [chronicle.com/weekly/v53/i27/27a03201.htm](http://chronicle.com/weekly/v53/i27/27a03201.htm).

<sup>2</sup> *Literacy in Everyday Life: Results From the 2003 National Assessment of Adult Literacy*. National Center for Education Statistics (NCES 2007-480), April 2007. [nces.ed.gov/Pubsearch/pubsinfo.asp?pubid=2006470](http://nces.ed.gov/Pubsearch/pubsinfo.asp?pubid=2006470).

<sup>3</sup> Jennifer Engle & Colleen O'Brien. *Demography Is Not Destiny: Increasing the Graduation Rates of Low-Income College Students at Large Public Universities*. The Pell Institute for the Study of Opportunity in Higher Education, May 2007. [www.pellinstitute.org/files/files-demography\\_is\\_not\\_destiny.pdf](http://www.pellinstitute.org/files/files-demography_is_not_destiny.pdf).

<sup>4</sup> Alison Kadlec & Will Friedman. *Important, but Not for Me*. *Public Agenda*, September 2007, p. 13. [www.publicagenda.org/research/research\\_reports\\_details.cfm?list=110](http://www.publicagenda.org/research/research_reports_details.cfm?list=110).

- In the last 20-30 years, enrollments in advanced high school mathematics courses have nearly doubled, yet the average mathematics score on the 12th grade NAEP trends assessment has changed hardly at all.<sup>5</sup> More seat time, it seems, has not translated into more learning.
- The proportion of college students who need remedial work in mathematics— approximately one in three—has changed hardly at all during the last three decades. In fact, only one in four undergraduate mathematics enrollments is in college-level courses; collegiate enrollments in high school level mathematics (below college algebra) is ten times as large as in advanced courses (beyond calculus).<sup>6</sup>
- In the 2005 12th grade NAEP mathematics test, four times as many white students were judged proficient as were black and Hispanic students.<sup>7</sup>
- In recent years, the proportion of under-represented minorities that demonstrate proficiency on the NAEP mathematics tests has slipped in each ethnic group.<sup>8</sup>

One reason for this lack of progress is a lack of public consensus on the criteria for proficiency. Afraid of political repercussions, states typically set much lower standards than does NAEP. "Passing scores" on state tests range from the 6th to 77th percentile<sup>9</sup> and what many states call "proficient" is more like what NAEP calls "basic."<sup>10</sup> Many states also set shockingly low goals for high school graduation.<sup>11</sup>

Another reason is a misfit between the traditional college-prep curriculum and the interests of many students. Today's mainstream high school mathematics curriculum was designed for students planning to take college-level mathematics (calculus and beyond); historically, these were the 20-25% of students interested in STEM fields. Both logic and evidence suggest that not everyone is equally well served by a model of mathematics education originally designed for prospective scientists and engineers. To interest and benefit all students, high school mathematics needs to reflect the full breadth of mathematical practice (e.g., data analysis, algorithms, probability, statistics).

The argument for persevering despite the evidence cited above rests on avoiding, in President Bush's apt phrase, "the soft bigotry of low expectations." No one wants to argue the case for bigotry. But this argument has a flaw: it assumes that college is high but work is low, that

<sup>5</sup> National Center for Education Statistics. *Nation's Report Card: Long-Term Trend*. Institute of Education Sciences, U.S. Department of Education, 2005. [nces.ed.gov/nationsreportcard/ltr/results2004/nat-math-perf.asp](http://nces.ed.gov/nationsreportcard/ltr/results2004/nat-math-perf.asp).

<sup>6</sup> David J. Lutzer et al. *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States Fall 2005 CBMS Survey*. Providence, RI: American Mathematical Society, 2007. <http://www.ams.org/cbms/cbms2005.html>.

<sup>7</sup> *The Condition of Education: Academic Outcomes, Mathematics Performance of Students in Grade 12*. National Center for Education Statistics. <http://nces.ed.gov/programs/coe/2007/section2/indicator12.asp>.

<sup>8</sup> Jeffrey Mervis. "U.S. Math Tests Don't Line Up." *Science*, 315 (16 March 2007) 1485. [www.sciencemag.org/cgi/content/full/315/5818/1485](http://www.sciencemag.org/cgi/content/full/315/5818/1485).

<sup>9</sup> Chester E. Finn, Jr., and Michael J. Petrilli. *Foreword to John Cronin, et al., The Proficiency Illusion*. Thomas B. Fordham Institute, October 2007. [edexcellence.net/institute/publication/publication.cfm?id=376](http://edexcellence.net/institute/publication/publication.cfm?id=376).

<sup>10</sup> *Mapping 2005 State Proficiency Standards Onto the NAEP Scales*. National Center for Educational Statistics (NCES 2007-482), June, 2007. [nces.ed.gov/nationsreportcard/pubs/studies/2007482.asp](http://nces.ed.gov/nationsreportcard/pubs/studies/2007482.asp).

<sup>11</sup> Daria Hall. *Graduation Matters: Improving Accountability for High School Graduation*. Education Trust, August 2007. [www2.edtrust.org/NR/rdonlyres/5AEDABBC-79B7-47E5-9C66-7403BF76C3E2/0/GradMatters.pdf](http://www2.edtrust.org/NR/rdonlyres/5AEDABBC-79B7-47E5-9C66-7403BF76C3E2/0/GradMatters.pdf)

abstraction is high but specifics are low, that algebra is high but computers are low, that what formerly only elites studied is high, and everything else is low. This way of thinking is a contagious conceit that has spread from the academic elite to much of society.

Twenty years ago, with substantial aid from NSF, the collegiate mathematics community launched a nationwide project to bring calculus into the modern age. The goal of this effort was cleverly described by Robert White, then president of the National Academy of Engineering, to make calculus "a pump rather than a filter" in the nation's scientific pipeline. *To improve education, especially STEM education, we need school mathematics to serve as a pump, not a filter.*

Unfortunately, evidence shows that the standard model is much more a filter than a pump. A third of the age cohort is lost before high school graduation; a third of graduates are lost in the transition to college; and a third of entering college students are slowed by required remediation. Low income, Hispanic, and Black students fare even worse. Most of these students leave the education system with their potential talents for STEM and other careers largely unfulfilled.

In recent years the American high school has been faulted for not being sufficiently challenging, relevant, equitable, and engaging.<sup>12</sup> The standard model only addresses the first of these deficiencies. Moreover, it depends for motivation not on incentives but threats (for students, no diploma; for schools, loss of funds)—an approach to learning that is well known to be relatively ineffective. Too many high school students just don't care—especially not about mathematics, the subject that everyone loves to hate.

Among academic subjects, failure in high school mathematics plays a disproportionate role in driving students to drop out. Increasing the rigor of courses already perceived as useless is unlikely to remedy this problem. *The focus of curricular change should not just be to make courses and programs more challenging, but to make them more relevant, more equitable, and more engaging.*

### **Conclusions and Conjectures**

I don't pretend to have solutions to these problems. What I can offer are some observations and conjectures that may stimulate discussion that will help in your work:

*High school programs should be designed first to meet the citizenship and livelihood needs of all students, and only secondarily to meet the expectations of higher education. Unless this is done, the majority of students will continue to see mathematics as "useless." But if it is done well, many of these students who now drop out will emerge equipped with skills of quantitative literacy and analytical reasoning that are valued in the workplace, in society, and across the college curriculum.*

*Calculus is not the sole pinnacle of mathematics in the 21st century.* Mathematics teachers, in consultation with college and community leaders, need to rethink the mathematics curriculum to broaden its focus from specific skills required in calculus to skills that everyone needs. The lasting habits of mind for which mathematics is highly valued—precise definitions, logical

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<sup>12</sup> W. Norton Grubb & Jeannie Oakes. 'Restoring Value' to the High School Diploma: *The Rhetoric And Practice Of Higher Standards*. Education Policy Research Unit, Division of Educational Leadership and Policy Studies, College of Education, Arizona State University, Oct., 2007. [epsl.asu.edu/epru/documents/EPSP-0710-242-EPRU.pdf](http://epsl.asu.edu/epru/documents/EPSP-0710-242-EPRU.pdf).

thinking, mental acuity—do not depend on the kinds of mathematics studied. But student interest and motivation does.

*The mathematical knowledge needed for informed democracy is virtually absent from the school curriculum.* Important societal uses of mathematics such as social choice (voting), health insurance, fair division, mortgage payments, retirement planning, and personal privacy (data mining) depend on mathematics that is accessible to high school students but—because calculus is king—they are rarely taught. Headlines regularly tell us the price we pay for this neglect.

*Mathematics can connect to virtually any student interest.* That's why mathematics is so powerful and why it is required. We should take advantage of that power by enlisting students' emerging career interests in support of high quality mathematical thinking wherever it leads. Learning how to understand and express quantitative arguments is a powerful skill useful both in college and careers, but it is rarely developed by extensive work on factoring or solving equations.

*Students who see mathematics used regularly will remember it better and will realize that it is not "useless."* Conversely, students who rarely see mathematics being used by someone other than a math teacher will conclude the opposite. Mathematics teachers cannot by themselves correct society's habit of math avoidance. Teachers of other high school subjects, especially the natural and social sciences and vocational programs, should use mathematics whenever appropriate and should work with mathematics teachers to coordinate topics. Mathematics across the curriculum is every bit as important as writing across the curriculum.

*Inquiry-based instruction is one of the few proven strategies for creating relevance and engaging students.* However, student-led inquiry frequently leads in unpredictable directions, often into topics not included in state standards or examined on external tests. Teachers need the knowledge, flexibility, and mandate to support students wherever their inquiry may lead.

*High schools focus on elementary applications of advanced mathematics whereas most people really make more use of sophisticated applications of elementary mathematics.* This accounts for much of the disconnect noted above, as well as the common complaint from employers that graduates don't know any math. Many who master high school mathematics cannot think clearly about percentages or ratios.

*Knowledgeable and enthusiastic teachers trump most other variables that influence school education.* It is counterproductive to let external standards and high stakes tests overrule (much less define) high quality teaching. Unfortunately, the current regime of state standards and high stakes tests has undermined the enthusiasm and limited the flexibility of many fine teachers—even as it also provides needed structure for weaker teachers. It is a blunt tool that wreaks as much as it fixes.

*Colleges need to encourage multiple pathways into the mathematical sciences.* High schools focus on calculus because they think that is what colleges value. It is unrealistic to expect high schools to become more flexible if colleges do not vigorously promote breadth and flexibility in the admissions process. College placement tests in mathematics are especially narrow and misaligned with society's needs.

*One final thought:* Everyone recognizes that America's "system" of postsecondary education, although far from perfect, is remarkably effective. That's in part because it isn't really a system at all, but a large variety of freely competing independent institutions. Its strength derives from

its variety and diversity, from community colleges to research universities, from liberal arts colleges to specialized business colleges. Around the country some high schools—public, charter, and private—have sought to develop similar variety through career academies or thematic pathways or magnet schools. These are very promising options since they address the key issue of student motivation.

If designed from scratch, it is hardly plausible that the mathematics component of a fine arts academy would be the same as the mathematics component of a STEM academy. In this digital age, there is plenty of valuable and challenging mathematics that supports the fine arts, but it is not the same as today's canonical college-prep curriculum. Neither for that matter would be the mathematical component of a bioscience academy, where combinatorial methods and statistical inference would be far more visible than in the traditional curriculum.

The ever-present danger of parallel pathways is that one—traditional calculus-prep—will be seen as superior to all the others (because that is what gets students into Harvard). This is not an insurmountable hurdle, however. Schools can guard against this danger by ensuring that the performance expectations are equally high in all pathways. They will need support, however, from colleges—especially the elite institutions—who need to welcome graduates of different streams on an equal footing and give each appropriate opportunities to continue the study of mathematics.