

U.S. Government Should Stop Financing Arithmetic Avoidance

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I handed the young cashier five quarters; she wanted to enter the amount into the cash register, but could not calculate their total worth. Twenty years ago, we expected cashiers to know that five quarters is \$1.25. This simple type of arithmetic problem is barely taught today. College math professors are *distressed* by the *declining* level of understanding of arithmetic and algebra by masses of college students.² For example:

Table 1. Decline³ in percent of freshmen entering colleges in Maryland who know arithmetic and real high school Algebra I

Year	1998	2005	2006
Whites	67%	60%	58%
African-Americans	44%	33%	36%
Asian-Americans	79%	74%	76%
Hispanics	56%	42%	43%

Related Data from MD. From 1998 to 2005, the number of white graduates *increased by 11%* (from 14,473 to 16,127), but the number who knew arithmetic and high school Algebra I *decreased* (from 9703 to 9619). Similarly, from 1998 to 2005, the number of African-American graduates who knew arithmetic and high school Algebra I *went down in spite of increased* college enrollments of females by 21% and males by 31%.

At the *high end*: “[From 1985–2005] Fall term enrollments in Calculus II *dropped* from 115,000 to 104,000 [at U.S. colleges].”⁴ Second year, Calculus II is *required* for a college degree in engineering.

That understanding of arithmetic and arithmetic-based algebra (symbolic algebra) has *dropped* considerably among college freshmen is a natural consequence of the avoidance and minimization of arithmetic and symbolic algebra by textbooks and many state math assessments⁵ during the past 20 years. Where did this start?

It started with Education professors against arithmetic calculations.

Only about one out of three education professors surveyed said that its “absolutely essential” to teach math facts ...⁶ So two out of three education professors have taught current teachers, math coaches and state and district math supervisors that it is *not* important for students to memorize math facts.

For the past 20 years, textbooks and state standards of about 45 states have been guided by the National Council of Teachers of Mathematics’ (NCTM⁷) 1989 and 2000 *Standards*, which marginalize arithmetic. The NCTM 1989 *Standards* states: “This is not to suggest that valuable time should be devoted to exercises like $(17/24) + (5/18)$ or $5 \frac{3}{4} \times 4 \frac{1}{4}$ ”.

“[There are] more than a dozen defective K-12 math programs funded by the National Science Foundation. ... from [its] Education and Human Resources (EHR) Division. ...

“The ... radical deemphasis of algebra and arithmetic — the prerequisite to algebra — in NSF-funded and NSF-distributed math programs has stark consequences for science education, especially physics. When the isolation of a variable in a simple equation is laborious for students rather than automatic, the depth of instruction in high school physics courses is severely limited. At the university level, students struggling with elementary algebra find themselves adrift in their calculus classes, and success thereafter in physics courses is elusive.”⁸ (Also engineering courses) [See “School math books, nonsense, and the National Science Foundation”, [American Journal of Physics](#)]

A resource book, for a widely-used NSF funded program, explains: “In the Investigations curriculum, standard algorithms are not taught because they interfere with a child’s growing sense and fluency with the number system.”⁹

Relatedly, “National Science Foundation Systemic Initiatives: how a small amount of federal money promotes ill-designed mathematics and science programs in K-12 and undermines local control of education”.¹⁰ Absurd!

A crucial observation of a 2011 article is “We found ... a deliberate avoidance of symbolic manipulation in algebra” in high school math Textbooks.¹¹ Examples of symbolic manipulation in algebra are $2x + 3x = 5x$ and

Find R from the formula $U = E - IR$. (Answer: $R = (E-U)/I$). (But, only two of three Finnish students, who passed the Finnish Advanced college matriculation examination in mathematics, could solve this equation.¹²)

It was suggested that high school graduates can graph a simple line [like $y = 2x + 3$] *without* a graphing calculator. But, the head of math instruction for the state of Maryland *disagreed*. "The technology is there. It's not going to go away," she said. "There is a limited population who can do math symbolically, the way mathematicians do. If this is an exam for all students, we want to make it comfortable for however students learn." ["With 'Pretend' Testing, a Poor Imitation of Preparing Students", *Washington Post*]

The Prince George's County (Maryland) school system does NOT expect students to know math facts. "a [Prince George's County, Maryland] math coordinator [said] that county students should have a 'sense' of what 9×8 is."¹³ The implication being that students can use calculators to find that $9 \times 8 = 72$.

Recommendation 1. The NSF and U.S. Dept. of Education should support those colleges of education, that train future elementary and middle school teachers to be *fully knowledgeable* in elementary and middle school math and to know the importance of arithmetic and algebra.

As Secretary of Education Arne Duncan said (May 11, 2009 at Brookings Institution): "You all well know that it is hard to teach what you don't know. When we get to 6th, 7th, and 8th grades, we see a lot of students start to lose interest in math and science, and guess why? Because their teachers don't know math and science so it is hard to really instill passion and a love for learning if you are struggling with the content yourself."

The *inadequate* preparation in mathematics of future elementary school teachers by 67 of the 77 colleges surveyed was documented by the very good National Council on Teacher Quality (NCTQ) 2008 report, "**No Common Denominator: The Preparation of Elementary Teachers in Mathematics by America's Education Schools**" [NOT].¹⁴

Warning. The influential NCTM's president continues the attacks on algebra: "Endless Algebra—the Deadly Pathway from High School Mathematics to College Mathematics".¹⁵ This was essentially "seconded" at a TED Talks \$5000+ conference.¹⁶ The implementation of this attitude will prevent the achievement of President's Council of Advisors on Science and Technology (PCAST) goals for increasing the numbers of Science, Technology, Engineering, and Mathematics (STEM) graduates.

Recommendation 2. It is crucial that NSF and Dept. of Education cease funding grants to colleges of education and professional development that promote *avoidance* of Arithmetic and Algebraic calculations. Rather NSF and Dept. of Education should fund grants to colleges of education that do *promote* learning and understanding of arithmetic and algebraic calculations.

ENDNOTES

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² This is why the MD/DC/VA SECTION of the Mathematical Association of America (MAA) has broken tradition by issuing its first statement ever on “College Professors’ Concerns on Mathematical Preparedness of Incoming College Freshmen” [http://sections.maa.org/mddcva/HS_students.php The MAA is the Mathematical Association of America, the professional association of college professors of mathematics for college math instruction.]

I paraphrase its key recommendation as: Students should be able to perform basic calculations in Arithmetic and in Algebra, without the assistance of calculators. This should not need to be said. Relatedly, see my report “Comments on Statement on Mathematical Preparedness” at www.math.umd.edu/~jnd/On.MD.MAA%20.htm

³ My analysis was based on data by the Maryland Higher Education Commission’s (MHEC) Student Outcome and Achievement Report (SOAR). This is the latest data available.

Caveat. *This particular data counted only students who graduated from Maryland (MD) high schools in 1998 and 2006, then entered a college in Maryland the same year. (Not counted were graduates who went to colleges outside MD or did not go to college the same year.)*

⁴ See: “Is the sky still falling?” At www.ams.org/notices/200901/tx090100020p.pdf

⁵ For example: The Maryland (MD) High School Assessment (HSA) on Algebra excludes all symbolic manipulation; even $2x + 3x = 5x$ is *excluded*. Passing this test is a high school graduation requirement.

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www.edexcellence.net/dohttp://www.edexcellence.net/publications-issues/publications/cracks-in-the-ivory-tower-1.html

⁷ NCTM is the professional society for math teachers and college professors of math education, not college professors of math.

⁸ <http://www.csun.edu/~vcnth00m/nsf.html>

⁹ *ibid*

¹⁰ By McKeown, M, Klein, D, Patterson, C, in Sandra Stotsky (ed), *What's at stake in the K-12 standards wars: A primer for educational policy makers*, New York, Peter Lang Publishing, Inc., 2000, 313–369.

¹¹ By Guershon Harel and W. Stephen Wilson, “The State of High School [Math] Textbooks”

<http://www.ams.org/notices/201106/rtx110600823p.pdf>

¹² <http://elib.mi.sanu.ac.rs/files/journals/tm/23/tm1221.pdf> which also notes that “Barely half the students could calculate: $(1/3 - 1/7)/4$ ”, [Answer: $4/84 = 1/21$].

¹³ In the July 4, 2007 *Prince George's Gazette* on the web at

www.gazette.net/stories/070407/prinsch174932_32360.shtml

¹⁴ www.nctq.org/p/publications/reports.jsp

¹⁵ J. Michael Shaughnessy at www.nctm.org/about/content.aspx?id=28195

¹⁶ Arthur Benjamin's formula for changing math education, a 3 minute video:

www.youtube.com/watch?v=BhMKmovNjvc&feature=relmfu