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Reflections on the Tenth Anniversary of *Mathematics and Democracy*

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Reflections on the Tenth Anniversary of *Mathematics and Democracy*

Abstract

Two independent reflections by early proponents of quantitative literacy connect today's numeracy initiative with its origin in concern about school tests, its impact on students today, and the challenges of democracy. Even as interest in QL grows in many places, evidence of need also grows. Moreover, well-meaning programs with other goals—especially at the K-12 level—often channel education in directions that fail to advance numeracy. Examples show that both students and teachers are enthusiastic when offered QL opportunities, but that individual beliefs and public decisions often belie the goals of QL.

Keywords

Mathematics, Democracy, quantitative literacy, K-12 education

Cover Page Footnote

Lynn Arthur Steen is Professor Emeritus of Mathematics at St. Olaf College, a former president of the Mathematics Association of America (1985-1986), a fellow of the American Association for the Advancement of Science (AAAS), and the recipient of three honorary Sc.D. degrees. He is one of the inspirations of the National Numeracy Network and this journal.

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> *On Wall Street today, news of lower interest rates sent the stock market up, but then the expectation that these rates would be inflationary sent the market down, until the realization that lower rates might stimulate the sluggish economy pushed the market up, before it ultimately went down on fears that an overheated economy would lead to a reimposition of higher interest rates.*
>
> -- from a *New Yorker* cartoon

I write this reflection on *Mathematics and Democracy*[1] two weeks before democracy and numeracy collide in voting booths across the United States. It is not an auspicious moment. Candidates and their supporters hurl numbers without restraint or accountability; voters profess beliefs wildly at odds with actual data; and journalists dutifully report conflicting claims with little reflection on their accuracy or consistency. In this unrelenting cacophony of promises and accusations, it is no wonder that people view statistics as little more than "damned lies."

Although both the title and the message of *Mathematics and Democracy* call attention to the Jeffersonian imperative of educated voters as the anchor of democratic government, the roots of this slim volume lie not in education or politics but in science. About fifteen years ago the committee of high school and college faculty who advise the College Board on the AP science exams decided to revise these tests to reflect the increasing use of mathematical and quantitative reasoning in the life sciences. As the physical sciences had much earlier, the rapidly growing biological sciences were beginning to express their key theories and research results in the language of mathematics.

The scientists asked the College Board's mathematics committee for assistance in determining the quantitative tools appropriate for the science exams. This routine request stimulated a wide-ranging discussion, not least because it arrived in the midst of the so-called "math wars" that had been triggered by the 1989 publication of the first nation-wide "standards" for school mathematics.

Instead of responding to the scientists' request with a routine synopsis of topics, the College Board launched a wide-ranging study designed to document the way people consume or use quantitative information in their personal or professional activities. The formal rationale for this broader study was that

[1] Lynn Arthur Steen, ed. 2001. *Mathematics and Democracy: The Case for Quantitative Literacy* (Washington, DC: Woodrow Wilson National Fellowship Foundation). Available at. http://www.maa.org/ql/mathanddemocracy.html (accessed October 28, 2010).

schools educate everyone, not only scientists, so the mathematics that appears on College Board exams (and therefore also in school curricula) should reflect the needs of society at large. The informal rationale was the realization that none of us on the mathematics committee had any clue about what the answer should be.

That is not to say that we had no opinions. We all knew the conventional answer: some synthesis of the curricula advocated by both sides in the math wars (algebra and trig with a dash of statistics) blending basic skills with conceptual understanding. But we also suspected that the vast majority of the adult population lived quite well using much less, and what people needed to improve their lives and society was not just more of the conventional answer. To confirm (or refute) these hunches, as well as to suggest where to look for the answer, we sought ideas from a broad range of knowledgeable people from very different professional backgrounds.

What emerged from this study, exposited in *Why Numbers Count*,[2] is that unlike mathematics, quantitative literacy is characterized by the use of simple quantitative tools to deal with complex issues. When looked at from this perspective, it became immediately clear that numeracy mattered for citizenship as much as for science; that effective strategies for analyzing problems were very similar across different contextual domains; and that the civic rationale for quantitative literacy was both more urgent and more compelling than the scientific one. Thus was born *Mathematics and Democracy*.

In the decade since, many promising initiatives have been launched, including the electronic journal *Numeracy* and its interdisciplinary sponsor, the National Numeracy Network. Statisticians regularly talk about quantitative literacy, as do many mathematicians. The Mathematical Association of America sponsors a special interest group on QL and hosts a Web page[3] with on-line chapters from several QL books (including *Mathematics and Democracy*). Colleges and universities have added QL (or some equivalent euphemism) to their goals for general education and have expanded courses or programs designed to help students achieve these goals.

The status of numeracy in secondary schools is much less favorable, however. Common standards, backed by high stakes tests, focus on basic numeracy in grades K-6 followed by rapid movement into traditional mathematics in higher grades. This entrenched model, designed to support science (aka STEM) disciplines, does little to help high school graduates become

[2] Lynn Arthur Steen, ed., *Why Numbers Count: Quantitative Literacy for Tomorrow's America* (New York: The College Board, 1997)

[3] http://www.maa.org/Ql/index.html (accessed December 28, 2010).

quantitatively literate citizens. Most adults have been exposed to some version of this conventional curriculum, with discouraging results. Consider, for example,

- The political uproar caused by the word "trillions" (as a measure of the national debt) when virtually no one has any idea how big that really is. Major newspapers routinely confuse "million" with "billion" and neither editors nor readers notice.

- The public outcry when a medical panel recommended that unless family history suggests otherwise, women in their 40s should forgo routine mammograms—since for these women the risks incurred by over-diagnoses exceed those of under-diagnosis. Critics dismissed the data as irrelevant.

- The widespread public disavowal—including half of the major 2010 candidates for the U.S. Senate—of the scientific consensus that human enterprise has changed global climate.

In a democracy, public innumeracy leads inevitably to bad public decisions. All sorts of public policies depend on data mediated by complex computer models. Politicians select and amplify striking numbers, invariably out of context. Reported endlessly, these numbers become mindless totems in a data-drenched world.

Most authors in the various QL volumes, myself included, argue for QL as an antidote to mindless number-mongering. Increasingly, however, I have come to appreciate what psychologists have reported for years, namely, that beliefs persist regardless of evidence. Quantitative literacy, as mathematicians would say, is a necessary but not a sufficient condition for individuals to change beliefs based on evidence from a numerate argument. People generally remember and use only those numbers that confirm pre-existing beliefs. QL, it turns out, is only a prelude to an even greater challenge of mathematics and democracy, namely, to help citizens make decisions that are anchored in evidence and logic rather than in *a priori* beliefs.

— Lynn Arthur Steen, October, 2010

> *"For good or ill, [numbers] are today's preeminent public language – and those who speak it rule. Quick and cool, numbers seem to have conquered fact."*
>
> -- Michael Blastland and Andrew Dilnot in *The Numbers Game*

In June 2009 I helped lead a weeklong workshop for 25 mathematics and science teachers on quantitative literacy (QL). The primary source material was a casebook[4] of 24 case studies of media articles (mostly from newspapers) that had its beginnings nearly a decade earlier when *Mathematics and Democracy* (*M&D*) was published and the 2001 national forum Quantitative Literacy: Why Numeracy Matters for Schools and Colleges was being planned. A major portion of our workshop days was devoted to searching five daily newspapers for additional articles for new case studies to use to teach QL in school mathematics and sciences classes. The workshop was repeated in summer 2010 and again was filled to capacity. Teachers responded very favorably to this unusual but now popular workshop. As one said, "Where else can one be challenged to reason quantitatively and get paid (daily stipends provided by an NSF grant) to read the newspaper."

The casebook of case studies was compiled to teach a course in mathematical reasoning that I developed at the University of Arkansas, first offered in Fall 2004.[5] From the beginning, recurring themes threaded through students' reaction to the course. One was, "this is different from any math course I ever had." Another, in the words of one student in the first experimental section, "This course takes off the table once and for all the question of where will I ever use this." Students who had experienced limited success in traditional mathematics courses were suddenly in a new environment, engaged in, as stated by Carnevale and Desrochers in a paper[6] written for the 2001 QL forum, that "cognitive soup of

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[4] Bernard L. Madison, Stuart Boersma, Caren L. Diefenderfer, and Shannon W. Dingman. 2009. *Case Studies for Quantitative Reasoning: A Casebook of Media Articles*, 2nd ed. (New York: Pearson, 2009).

[5] See papers in the previous issue of *Numeracy*: Shannon W. Dingman and Bernard L. Madison, "Quantitative Reasoning in the Contemporary World, 1: The Course and It's Challenges," *Numeracy* 3 (2), Article 4, 2010, and Bernard L. Madison and Shannon Dingman, "Quantitative Reasoning in the Contemporary World, 2: Focus Questions for the Numeracy Community," *Numeracy* 3 (2), Article 5, 2010.

[6] Anthony P. Carnevale and Donna M. Desrochers, "The Democratization of Mathematics" in *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges (*Princeton, NJ: National Council on Education and the Disciplines, 2003), 21-31. Available at http://www.maa.org/ql/pgs21_31.pdf (accessed October 28, 2010).

words and numbers that assumes the shape of social contexts." A few students yearned for the more structured, cleaner world of the method du jour mathematics courses, but most of these soon adapted to the fuzzier but more relevant problem situations confronted in the media articles. Student interests surface through the articles used in the class as well as through new articles brought to class and presented by students. Students took part ownership of the course, learning that there is much to be gained by thinking quantitatively about commonplace issues, as *M&D* states in its opening paragraphs.

Mathematical reasoning is probably the wrong title for the Arkansas course; quantitative reasoning (QR), which I use interchangeably with QL, is more apt. In the decade since *M&D* was published, QL has become better understood and broader than most believed, even broader than outlined in *M&D*. It is certainly broader than the everyday applications of mathematics or statistics, as numeracy (i.e. QL) was defined for much of the twentieth century. For example, the cognitive soup of QR includes comprehending quantities and how they are used and misused in the contemporary world. Understanding depends heavily on experience with quantities, including a healthy collection of personal quantitative benchmarks. At the 2007 Wingspread[7] interdisciplinary workshop on QL and teacher education, the broad landscape of QL was evident, but the focus of discussions was not on the definition or extent of QL (an important developmental benchmark) but rather how to structure programs.

In the words of one scholarly publications editor, *M&D* made QL respectable. It and the initiative that it heralded provided ideas and authority to develop QR courses or programs. These courses and programs of QL across the disciplines opened up the world around our students and made understanding commonplace issues important. *M&D* prompted democratization of mathematics and statistics and pushed us to think deeply about the constructs of QR and how our students develop QR. Construct discussions now focus on broad values such as critical reading, interpretation, assumptions, number sense, representation, analysis and synthesis, communication, and, of course, calculation. As we push the discussion forward by articulating what we value in QR, we will understand better how to assess student work and to assess QR learning goals at all levels of education.

As we push forward, and there is quite a long way to go, we must learn from the current shortcomings of education. One of those shortcomings of mathematics education has been its lack of connections to commonplace issues. This has made it difficult to practice what is learned in mathematics classrooms,

[7] See *Calculation vs. Context: Quantitative Literacy and its Implications for Teacher Education*. ed. B.L. Madison and L.A. Steen (Washington DC: Mathematical Association of America, 2003). Available at http://www.maa.org/Ql/calcvscontext.html (accessed October 28, 2010).

and, without practice, the trace of this learning fades and often disappears. Because QR does apply to commonplace issues, continued practice is not only possible but also likely if it is meaningful and helpful.

Although *M&D* may have empowered some of us in higher education to develop QR courses and programs, powerful forces are working against doing likewise in K-12 where individual instructors and schools have less flexibility in what is taught. Consequently K-12 QR will need to be infused into existing strands, all of them, across the curriculum. Young students come to school already engaged in QR about the world around them. Instead of educating that out of the students with formal schooling, including mathematics, QR should be encouraged and leveraged to learn K-12 material better and to connect that learning to the everyday world. This will require changes in teacher education programs and professional development of current teachers, the purpose of the workshop discussed at the beginning of this piece. The success of that workshop indicates that teachers (and through them, their students) are eager for such a critically important shift in education, to relevancy and currency.

The predictive closing sentence of the Case Statement in *M&D* sums up the challenge: "Indeed, as the twenty-first century unfolds, quantitative literacy will come to be seen not just as a minor variation in the way we functioned in the twentieth century but as a radically transformative vantage point from which to view education, policy, and work." As yet that radical transformation is far from accomplished, but my experience with students and teachers in the ten years since M&D confirms the transformative nature of QL and the pressure for success fueled by hunger for better understanding of the increasingly quantitative world around us.

— Bernard L. Madison, October, 2010

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