

Numerical Common Sense for All

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“We hold these truths to be self-evident, . . . “Our nation’s call to revolution begins with a statement with a definite mathematical flavor. The remainder of the Declaration of Independence draws certain conclusions from these self-evident truths. Yet in illuminating what might flow from this foundation, the Constitution of the United States and its implementation severely limited opportunities for access to literacy and participation in the economy and politics of the country. For example:

- All men (but not women) were created equal.
- Women were not allowed to vote.
- Slaves were worth three-fifths of a free person in apportioning taxes.
- Slaves were not to be taught to read.

The documents on which the nation was founded assumed that logic could justify the revolution that they felt forced to undertake, and that basic literacy, if not universal, was sufficiently widespread to sustain the nation. In an agricultural society (at the time of the revolution nearly ninety percent of the U.S. population was involved in farming), this low level of literacy was sufficient. As the economy of the United States has moved from farm, to commercial, to industrial, to knowledge-based, the level of literacy required of the population has increased, as has the level of education provided by the state. By 1920, nearly universal junior high school education made the presumption of universal literacy common, although many still could not read. Only about four percent—the rich, well born, and lucky—pursued a college education, yet literacy in the

United States was considerably more widespread than in other countries. At the end of World War I, for example, the British Army had a literacy rate of less than fifty percent while the literacy rate in the United States was approximately seventy percent.

The increase in college and university enrollments that came with the end of World War II, aided by the GI Bill and driven by an expanding economy, resulted in a rapid increase in literacy in the United States. But what students were taught and what they could do with their knowledge began to diverge from the needs of society. School learning is just not the same as practical know-how. Historically, the United States has harbored a deep strain of anti-intellectualism: “If you’re so smart, why ain’t you rich?” Fortunately, this attitude has been somewhat balanced by a special appreciation for common sense and practical know-how: “Them engineers say that bees can’t fly.”

Common Sense for Today

In our complex, knowledge-based society, common sense now requires much more than the ability to read carefully and to think logically. The nation now requires that its citizens and workers have the ability to reason in a commonsense way in situations involving numbers, graphs, and symbols. Yet such abilities are de-emphasized and even shunned in our schools, colleges, and universities. The most important task now facing the education community is to find an appropriate balance between teaching rules of thumb that get the job done quickly and intellectual abstractions that eventually will create more effective and efficient rules of thumb.

Unfortunately, many teachers of algebra (myself included) provide instruction that constricts rather than expands student thinking. Several years ago I discovered that students leaving my elementary algebra course could solve fewer real-world problems after the course than they could before the course: they thought, after completing the course, that they had to use symbols to solve problems that they could previously solve with reasoning and arithmetic. Similarly, students in my differential equations course, although quite capable of manipulating symbols, often could not interpret the results of their manipulations either in the real world or in the purely mathematical world. Such educational failure

reminds me of the Vietnam War stories of villages that had to be destroyed in order to be saved. Common sense says this was wrong, yet we continued destroying villages.

Politicians recognize that our schools are not producing students who can solve simple quantitative problems or use their mother wit to understand and cope with the world. It seems that we are not alone in this paradox. In Japan, a nation known for the high quality of student performance on international mathematics assessments, the academic community has decided to reduce by 30% the amount of time spent on mathematics in schools. Proponents of this change, including some of Japan's leading research mathematicians, argue that this reduction is appropriate because Japanese students, although they know a great deal, despise mathematics and are loathe to use it in their daily lives. A similar reduction is under discussion in Singapore as it tries to find ways of making mathematics more appealing.

These changes in countries known for their excellence in mathematics education suggest many challenges for the United States, a country not known for similar excellence. What educational opportunities should we provide for our students to increase their quantitative common sense so they can be more efficient workers and more effective members of the community? Who should be in charge of this effort to increase quantitative common sense or quantitative literacy? What, indeed, is quantitative literacy?

For me, quantitative literacy is more like art than science. I know it when I see it, but I cannot easily define it. On any given day, for any one person, quantitative literacy may include reconciling a bank statement, analyzing data to support or oppose a local government proposal, estimating how to split a lunch bill, debugging a program by working from assumptions toward a logical conclusion, deciding which medical treatment to pursue based on statistical evidence, building a logical court case, or understanding the risks in investing for retirement.

Fortunately, opportunities to use quantitative literacy abound. Unfortunately, few in the mathematics community see quantitative literacy as important enough to emphasize in their teaching. This is partially because we mathematicians have a different agenda for our students but also because we really do not know how to teach quantitative literacy effectively. This may sound like an insult but it really is not. We know what we

know—mathematics—very well, but the quantitative literacy that students really need to learn touches on every aspect of life. For example, what percentage of people in the United States die alone in institutions and what does that mean for you and yours? Quantitative literacy is important because no one knows what life will be like in the future.

Quantitative Literacy in the Curriculum

Mathematicians need help to develop curricula that provide students opportunities to be involved both in abstract thought and practical problem solving. These two goals are not mutually exclusive but mutually supportive. The problem of quantitative literacy is not a deficiency that someone has to be blamed for but a symptom of the monumental changes our nation has experienced during its two centuries of existence. All nations, as they move into a knowledge-based environment, face similar problems and all will have to develop their own solutions that match the special needs of their populations.

Academic mathematicians point out that the quality and quantity of mathematics graduate students who received their secondary and college mathematics education in the United States have reached dangerously low levels. Some suggest, in response, that we should change the entire secondary school curriculum to more clearly emphasize abstract symbolic reasoning, even if it is at the expense of real-world, data-driven analysis and problem solving; however, because we are only talking about a few hundred mathematics Ph.D.'s per year, common (quantitative) sense suggests that the benefits may not outweigh the cost of such a drastic change in pedagogical practice.

Others say that applied real-world problems are so important that they should be taught in every discipline, even if at the expense of abstract pure mathematics. Clearly neither of these extremes will serve the country well. A balance is required and will eventually be reached. I believe in the multiplication tables (yes, through the 12s) and the distributive law, not only because they are needed to understand algebraic problem solving well enough to get correct answers but also because they are (in part) the basis of quantitative literacy—which encompasses citizenship, personal finance, personal medical decisions, and work-related spreadsheet analyses. As do many mathematicians, I embrace real-world problems (if

carefully chosen and not overemphasized) because they can engage students in the abstraction, generalization, and logical thought that are the lifeblood of academic mathematics.

But even if mathematicians wanted to, they cannot teach quantitative literacy alone. Mathematicians need the help of other disciplines in secondary school and university departments to support the cause of quantitative literacy. Interdisciplinary activity is becoming more and more common and is beginning to be rewarded in academic life. Indeed, interdisciplinary work may now be possible without damaging a faculty member's chances for tenure or level of prestige. We need more courageous mathematicians (and other faculty) who will risk working outside the usual boundaries of the academic reward system. We need more courageous mathematicians who are willing to do both applied and pure mathematics even at the risk of criticism from their colleagues. Examples of such courage have begun to appear at the highest level in other countries. Many in this country have shown this courage as well.

The world of mathematics is changing, not only in practice but also in its very nature. It will continue to change, as everything does. Certainly it will always rely on the logical foundations of Euclid, the symbolic contributions of Vieta, the analytic contributions of Gauss, Cauchy, and Weierstrass, and on digital computing pioneered by von Neumann. Mathematics has a wonderful and exciting past. It is having a wonderful and exciting present. The future, however, is at risk because we in the mathematics community have not focused sufficiently on the needs of society. We can satisfy these needs in many ways—by preparing teachers, by offering ideas for developing quantitative literacy, and by using that quantitative literacy to encourage more students in the United States to become users of mathematics as well as mathematicians.

In the continuing quest for life, liberty, and the pursuit of happiness in our knowledge-based nation, we need to provide a new kind of common sense—a quantitative common sense—based on basic mathematical concepts, skills, and know how. The mathematics community will participate in providing our nation, both young and old, male and female, native born and immigrant, rich and poor, of every race and faith, with this new common sense. We will do it gladly, secure in the knowledge that we are building the intellectual foundation for our cherished discipline while supporting the well being and continued success of our nation.

