

Quantitative Literacy: Why Numeracy Matters for Schools and Colleges

By Lynn Arthur Steen

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"As our society is driven increasingly by science and technology," observed NSF Director Rita Colwell at recent Washington forum, "the need to establish levels of quantitative literacy becomes ever more important." Using the anthrax crisis as an example, Colwell showed how the public would have benefited from better scientific and quantitative literacy. "When we have little direct control over our fate, a firm understanding of probability can alleviate some of the stress."

Colwell's remarks were made to an audience of over 100 scientists, mathematicians, educators, and policy leaders at a forum on quantitative literacy (QL) held at the National Research Council last December. Supported by the Pew Charitable Trusts, the forum was sponsored by the National Council on Education and the Disciplines (NCED) and hosted by the Mathematical Sciences Education Board (MSEB) in cooperation with the MAA. A report on the forum, including background papers distributed to participants and a white paper on quantitative literacy will be published later this spring.

For purposes of discussion, the forum's white paper defines quantitative literacy (also called "numeracy") as the "quantitative reasoning capabilities required of citizens in today's information age." Speakers elaborated on this broad definition in various ways. Harvard mathematician Daniel Goroff illustrated QL with applications of Bayes' theorem to health policy; Yale mathematician Roger Howe emphasized the policy implications of understanding orders of magnitude and significant digits.

"Business would be 'ecstatic' if graduates were quantitatively literate"

Retired General Electric engineer William Steenken, citing the importance of "six-sigma" performance expectations in industry, said that business would be "ecstatic" if high school and college graduates were quantitatively literate. Limnologist David Brakke, Dean of Science and Mathematics at James Madison University, spoke of the need to understand rates, risks, and variability in managing natural resources, and of the increasing role of quantitative reasoning in legal matters such as DNA fingerprinting and interpretation of laws about endangered species. "The most important constraint on public policy," argued Johns Hopkins economist Arnold Packer, "is public ignorance."

Despite occasional confusion about the curricular relations between mathematics, statistics, and quantitative literacy, participants spent relatively little time seeking a precise definition. Indeed, prior to the forum participants had studied a surfeit of proposed definitions, some provided by authors of nine background papers, others by the recent NCED volume *Mathematics and Democracy*. Most of the discussion focused on implications for educational policy of a commitment to achieve the appropriate levels of quantitative literacy that Rita Colwell emphasized in her remarks.

One challenge was conveyed by Anthony Carnevale, Vice President for Public Leadership of the Educational Testing Service (ETS). He asserted, with uncommon eloquence, that quantitative literacy is not so much about mathematics and democracy as about the "democratization of mathematics." Citing data from many sources, he argued that mathematics education has always been about separation — of rich from poor, of boys from girls, of elites from plebeians. Mathematics, reported Carnevale, is the "biggest barrier to upward mobility in educational attainment."

"Quantitative literacy is about the democratization of mathematics"

Because of the strong association of mathematics with economic success, mathematics education has had the effect — if not the aim — of affirming existing social structures. Carnevale argued that the QL movement is really part of a much larger societal effort towards increased democratization. While conceding that a segregated economy headed by mathematically trained elites is efficient from a strictly economic perspective, he urged the QL movement to focus on egalitarian rather than economic goals.

A different challenge came from Janis Somerville, Senior Associate with the National Association of (College and University) System Heads. Somerville described the incoherence of messages about mathematics conveyed in the transition from high school to college, where different tests (high school exit, college admissions, college placement) administered at different times for different purposes stress very different aspects of mathematics. For many reasons, these inconsistencies have disparate impact on students from different socio-economic

groups so that by age 24, the proportion of youth from high-income families who have graduated from college is seven times that of those from low-income families. And, as Carnevale's data shows, mathematics is the biggest contributor to this differential.

Somerville cautioned participants not to make a bad situation worse by adding quantitative literacy to this mix without first resolving the dilemma that might be created if schools adopted two different tracks — algebra, trig, calculus for elites, quantitative literacy for others, most of whom will be either poor or minority. NCTM president-elect Johnny Lott observed that in such a system the calculus-bound students might be the most ill-served since they receive a much narrower foundation in mathematics.

Several papers and participants added an international perspective to the forum's QL discussions. MSEB member Jan de Lange of the Freudenthal Institute in Utrecht argued in a background paper that "mathematical literacy" is a broader and better term than QL. Moreover, he asserts, if mathematics were taught as it should be taught — for reasoning rather than for mastery of algorithms — there would be little need for a distinction between mathematics and mathematical literacy. Michel Merle of the University of Nice described plans of a commission in France to refocus school mathematics on four areas of contemporary importance: geometry, numeracy, statistics, and computer science. Mogens Niss of Roskilde University in Denmark, former secretary of the International Commission on Mathematical Instruction (ICMI), described similar changes under way in Denmark in which the school mathematics curriculum will be defined not by a list of topics but by the characteristics of different levels of proficiency in relation to a core set of mathematical competencies (e.g., reasoning, argumentation, communication, modeling, representation).

In a robust discussion, participants reacted to what they had heard in the context of what they know from their own experiences. Linda Kime (University of Massachusetts) and Don Small (US Military Academy) suggested focusing QL efforts on college algebra because "that is what everybody takes." Linda Rosen, Vice President for Education of the National Alliance of Business, reminded participants of the "accountability juggernaut" that is bearing down on education, and urged advocates of QL to think more carefully about how to "scale up" to levels that can have a measurable impact. Charlotte Frank, vice president of McGraw Hill and a member of the New York State Board of Regents, pointed out that QL will not happen unless it is measured in assessments. Gene Bottoms of the Southern Regional Education Board (SREB) urged greater flexibility in mathematics instruction: "It shouldn't take 36 weeks to fail Algebra I." Arizona mathematician William McCallum said that other disciplines need to take ownership of QL, since QL cannot succeed if it remains only an initiative within mathematics departments.

Indeed, Jeanne Narum opened the forum by suggesting how QL can support the "what works" philosophy of the science-oriented Project Kaleidoscope which she directs. George (Pinky) Nelson, director of AAAS Project 2061 — a major national K-12 program designed to bring science to all Americans — saw in QL an opportunity for much-needed increased cooperation between science education and mathematics education. He suggested that the social sciences may be best suited to take the lead in supporting QL across the curriculum.

"Other disciplines need to take ownership of quantitative literacy"

In summarizing major themes of the forum, AMS President and former MSEB chair Hyman Bass noted the nearly unanimous view that quantitative literacy must be taught across the curriculum (or perhaps "in the disciplines," which is not quite the same thing). While mathematics and statistics contribute central knowledge and skills, other disciplines provide the contexts which are so important for quantitative literacy. A second observation, echoed by many participants, is that quantitative literacy is not a curriculum (and certainly not a single course), but an approach to pedagogy. Russell Edgerton, former president of the American Association of Higher Education (AAHE) linked these observations together: "The more that QL education is about pedagogical practices (for example, the kinds of assignments students are given), the wider the possibilities are that many courses across the curriculum can contribute to students' quantitative literacy."

One outgrowth of the forum is a National Numeracy Network (NNN) that is being created to help support schools and colleges that are exploring ways to infuse QL into their curricula. The NNN will provide support in five areas: policy, practice, professional development, dissemination, and assessment. Several centers will serve as the core of NNN; current centers and directors are Trinity College (Judith Moran), Dartmouth College (Kim Rheilander), The Washington Center, (Emily Decker), and the K-12 TORCH program (Richard Bennett). Susan Ganter of Clemson University is director of National Numeracy Network.

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