Reflections

A selection of brief observations by participants at the national Forum, "Quantitative Literacy: Why Numeracy Matters for Schools and Colleges," offering different perspectives on issues covered at the Forum.

To advance quantitative literacy, improve college algebra

For many reasons, the most effective way to advance quantitative literacy (QL) is to improve the traditional college algebra course to serve as a foundation course for QL. The improved course should focus on elementary data analysis, functions, and modeling. It also should emphasize developing communication skills, the use of appropriate technology, and small-group projects. The goal of the course should be to enable students to gain confidence in their ability to approach quantitative problems in other disciplines, in society, and in the workplace. This goal underscores the importance of interdisciplinary cooperation both in the development and in the ongoing assessment of the course. This cooperation would establish links to other disciplines that can provide problem-solving experiences for students based on their college algebra course. In this manner, college algebra can merge with quantitative literacy to form problem-solving programs that extend throughout students' academic careers. The interdisciplinary component is essential to realize the potential of a symbiotic relationship between improved college algebra and quantitative literacy.

There are several advantages in improving the traditional college algebra course over establishing a new course to serve quantitative literacy. For example, college algebra is well entrenched in the college curriculum, it serves more students than any other credit-bearing mathematics course, and it is a college gateway for a large percentage of students. Moreover, traditional college algebra is generally recognized as a course that *does not work*. It is characterized by high FDW (fail, drop, withdraw) rates, few students advancing to calculus, and content not applicable to student interests. Thus many mathematics departments may be receptive to changing both the focus and the content of the traditional course.

Improving college algebra to serve as a foundation course for quantitative literacy allows us to avoid both the political problem of finding a home for a competing course and the practical problems of attracting students and developing faculty support. Avoiding these unnecessary challenges allows us to focus on the more important issues of building interdisciplinary collaboration and developing appropriate curricula. The growing parallel movements to improve college algebra and to develop quantitative literacy programs can and should reinforce each other.

—Don Small, Department of Mathematics,
United States Military Academy

Look for QL in major organizing questions, not in techniques

Despite learning a great deal from the QL Forum, I was repeatedly reminded of the narrowness of many people's disciplinary thinking, of how difficult it is for some to imagine teaching outside their own discipline or to make meaningful cross-curricular connections. I worry about the constricted vision many folks have of curriculum development. For many, QL was simply another potpourri of (mathematics) techniques to be sandwiched into some kind of course that had to be fit (somehow) into the existing sequence of departmental offerings. Although many at the Forum recognized the need for "applications," few saw the applications as anything other than a delivery vehicle for the QL or mathematical techniques, the latter being the real meat. If QL goes down this road—a smorgasbord of techniques squeezed into a general education course—I think we run the danger of not addressing the real need outlined in the case statement in *Mathematics and Democracy: The Case for Quantitative Literacy,* namely, the need of citizens to find a use for mathematics that connects with their perception of the real world.

Although several people I spoke with seemed interested in developing curricula around organizing questions and themes rather than disciplinary content, they were, initially, uneasy with the idea. Because their mind was still on a set of content to be covered, it took a while for them to begin to see how this could be done. The notion of designing curricula around important questions was, at first, quite a stretch. One person said that it was a great idea but that it would never fit into the departments he knew. I took that to be a measure of how ingrown and isolated higher education has become from the society that supports it.

One way of exposing how banal curriculum design questions have become at most universities would be to do a QL analysis of departmental and curricular structures. By analyzing the currencies we use to justify our academic enterprise (numbers of majors, time to graduation, course sequencing, needs of majors, graduate school preparation, hiring priorities, etc.), we might gain some insight into what really drives curricular design. My hunch is that such an analysis would not engage the important questions facing homo sapiens on this planet at this time in history. Little wonder that students often find our courses disconnected from the real world.

The twenty-first century will be a "crunch" time for our species. We currently are engaging in wholesale destruction of the ecosystem and far too many of us are chasing far too few natural resources. To the degree that the academic curriculum does not organize itself to confront these important questions, it will continue a decline into irrelevance. Designing QL to address some of

these crucial questions will go a long way toward connecting with students' perception of the real world.

—**Robert Cole,** Evergreen State College

Ensure quality in the way subjects are taught

I came to this Forum with a general interest in how the academy can take more responsibility for ensuring that undergraduates acquire core abilities (or literacies) that require persistent work across a variety of courses. I came away with a heightened awareness of the importance of clarifying whether students acquire an outcome such as quantitative literacy as a result of the subjects they experience (the curriculum) or of the way these subjects are taught (the pedagogy).

The answer is obviously both. But the more that the answer lies with the pedagogical practices students experience (for example, the nature of the assignments students are given), the wider the possibilities are that many courses across the curriculum can contribute to the desired objective. In the case of quantitative literacy, it seems that many elements (such as statistical competence and data analysis) could be acquired through a wide range of courses.

It is encouraging that so many faculty and so many courses can contribute to the acquisition of quantitative literacy, as well as to other literacies such as writing. But it is also discouraging because our internal mechanisms for quality assurance (for example, curriculum review committees) are overwhelmingly focused on what subjects are taught, not on whether subjects are taught in ways that help students acquire core abilities. So I also left with the conviction that we have to invent mechanisms of quality assurance that look at how courses are being taught as well as simply at whether the content of the courses seems right.

—**Russell Edgerton,** Director, Pew Forum on Undergraduate Learning

Teach and assess for QL in all curriculum areas

After spending a weekend discussing quantitative literacy, it became clear that QL competencies include skills that all students should have before they graduate from high school as well as skills they should have on an even more sophisticated level as college graduates. Young students acquire QL skills at a very basic level when learning about saving money in a bank or writing a check, as well as when talking together about what to order for a class party and then preparing a chart listing how many different kinds of drinks, sandwiches, or pizzas are needed. QL is clearly very important. It should be infused in all curriculum areas and then assessed in these areas to provide teachers with guidance in determining appropriate next steps. The QL skills of interpreting and discussing data and then presenting information in a coherent manner are absolutely essential if our young people are going to be successful as responsible citizens in this new world of technology.

—**Charlotte Frank,** Vice President, McGraw-Hill and New York State Regent

The changing role of numbers in everyday life

My primary impression from the Forum is of an emerging QL vanguard at a range of institutions that is eager to change the courses in and goals of the mathematics curriculum in the interest of practical competence. Some envision a campus wide campaign potentially extending across every discipline; others favor special courses or programs; and still others believe that new courses within mathematics and statistics departments, or reorientation of existing courses, can work equally well. There also is a substantial minority of QL skeptics, not opponents of the goal but realists who emphasize the cost of professional development for college faculty and (especially in two-year colleges) the burdens of remediation. They seem to favor much longer-term measures, seeing the movement as a gradual reorientation.

Both groups appear ready to eliminate or place less emphasis on certain aspects of the mathematics curriculum to highlight QL. Both also feel helpless to fight against the accountability movement—oddly to me, because the rationale for accountability is precisely the development of QL skills. Perhaps they are right that public opinion will accept only one idea at a time, but if so it is sad. (Of course, if voters lack QL, how can anybody hope to get them to change their minds by presenting them with the data? Then again, as a number of participants observed, the meeting itself revolved more around values than numbers.)

The Forum also reflected a movement against mathematics as pure gatekeeping for medicine and other professions. One mathematician acknowledged the priority he and his colleagues give to prospective majors: "We want to clone ourselves." There well may be a certain conflict between identifying and nurturing of future mathematician-teachers, especially the "naturals" who might otherwise choose subjects such as computer science and economics, and developing the practical skills of average students.

From the papers and discussions, I would conclude that the most promising approach at the college level might be to acknowledge that only a minority of the mathematics, science, and social science faculty are potentially strong QL teachers. I would favor identifying and working with this motivated group rather than trying to bring everybody on board at once. For QL to succeed, it must be perceived as an intellectual challenge by the faculty, not just as a remedial activity. I can easily imagine that an economist or sociologist might feel that teaching QL skills just delays developing the substance of their own courses.

An inspiring example for QL might be the late Edward Purcell, whom I got to know when I was in the Society of Fellows at Harvard. He had a Nobel Prize in physics, but he equally loved simple and elegant explanations—for example, how to tell if a set of numbers might have been tampered with, or why quantum theory is necessary for the world as we know it. For many years he wrote a wonderful column for the *American Journal of Physics* that consisted largely of Fermi problems—back-of-the-envelope calculations mixing common sense with sensible estimates—proving that QL can be a high art in its own right.

At least one Forum participant mentioned a paradox that also occurred to me. Some people with very limited formal mathematics instruction, such as market traders in developing countries, are proficient in handling numbers, while many westerners growing up with advanced calculators are not. This suggests that we should pay more attention not just to the pedagogical side of quantitative literacy but also to the changing role of numbers in everyday and professional life.

Two aspects of this changing role have especially interested me. The first is the rhetorical side of numbers, the fact that people use tables and graphs to prove points in which they have emotional or financial stakes. There is surely a message in the failure of organizations such as Long Term Capital and Enron that were packed with quantitatively sophisticated people yet succumbed to self-deception. The second, and the main subject of my own investigations, is the tenuous nature of many vital measurements. Cost-of-living indexes measure shifting breadbaskets of goods, including changing tastes and spending patterns. Television ratings measure a self-selected sample of the population, and the presence of monitoring technology also may change viewer behavior. I think of these problems not so much as obstacles but as opportunities to help students and adults achieve a deeper understanding of measurement and its uses.

—Edward Tenner, Department of English,
Princeton University

Teaching quantitative literacy across the curriculum

Although no clear consensus evolved from the Forum on what it means to be quantitatively literate, it is clear that a citizen should have skills, facility, and understanding in some or all of the areas of arithmetic, data, computers, modeling, statistics, chance, and reasoning that are elaborated in *Mathematics and Democracy:*

- *Arithmetic:* Having facility with simple mental arithmetic; estimating arithmetic calculations; reasoning with proportions; counting by indirection (combinatorics).
- *Data:* Using information conveyed as data, graphs, and charts; drawing inferences from data; recognizing disaggregation as a factor in interpreting data.
- *Computers:* Using spreadsheets, recording data, performing calculations, creating graphic displays, extrapolating, fitting lines or curves to data.
- *Modeling:* Formulating problems, seeking patterns, and drawing conclusions; recognizing interactions in complex systems; understanding linear, exponential, multivariate, and simulation models; understanding the impact of different rates of growth.
- *Statistics:* Understanding the importance of variability; recognizing the differences between correlation and causation, between randomized experiments and observational studies, between finding no effect and finding no statistically significant effect (especially with small samples), and between statistical significance and practical importance (especially with large samples).
- *Chance:* Recognizing that seemingly improbable coincidences are not uncommon; evaluating risks from available evidence; understanding the value of random samples.
- *Reasoning:* Using logical thinking; recognizing levels of rigor in methods of inference; checking hypotheses; exercising caution in making generalizations.

Because these skills defining quantitative literacy have their foundations in mathematics, most participants believed that the primary responsibility for introducing concepts associated with the tools of quantitative literacy lies with mathematics departments; however, most also thought that developing special courses in quantitative literacy would be the wrong approach.

What is needed, instead, is emphasis on QL in many courses and many subjects. There should be no special courses in quantitative literacy. The National Council of Teachers of Mathematics (NCTM) standards should be used, embellished, and built on to ensure that the concepts of quantitative literacy flow throughout the mathematics curriculum in an appropriate manner at all grade levels, thus ensuring that quantitative literacy is neither something new nor a "fad du jour." In addition, the skills of quantitative literacy must be used throughout all subject areas including the language arts, history, geography, and social studies—not only in mathematics and the sciences.

To make this happen, numeracy skills should be taught and modeled in all courses in all content areas that are part of a teacher's degree program. Only in this way will students be exposed to numeracy in both primary and secondary schools in a way that helps them become quantitatively literate across all subject areas. This approach also will help alleviate the fear that is often associated with mathematics-based concepts.

—**William G. Steenken,** General Electric Aircraft Engines (Retired)

Not content, but pedagogy and assessment

Despite the presence of a cross-section of interested and interesting people, the Forum was still, in large part, a mathematics meeting. Granted, the discussion was chiefly on point with regard to quantitative literacy, but to me the unspoken subtext and the dominant culture of the gathering was unmistakably mathematical. The most vivid example I can think of was Daniel Goroff's presentation about a phenomenon of misunderstanding that I used to encounter frequently in political science, a phenomenon that—as I now recognize—I tried to address in QL rather than mathematical terms: getting students to read contingency tables both down and across to make educated guesses about missing data and to draw different policy and personal conclusions. Goroff's use of conditional probability and Bayesian reasoning was far more subtle and sophisticated than anything I used to do, but I am not sure my students ever would have gotten beyond the fearsome notation of conditional probabilities. This kind of disjuncture occurred frequently at the Forum as people talked about QL but did so in the language of mathematics. We may need a new language, more than a new set of concepts, that allows everybody to participate more fully in the conversation.

There was clear consensus on the problem but a lot of trouble pinning it down in terms of definitions. I fully agree with the many comments that a further search for definition is not profitable. What we need are many concrete examples—of failures to understand and their consequences and of real and effective programs that can increase competence. For external audiences, for instance, we need a strong, short statement that contains concrete (quantitative) evidence of the failure to master QL and what it may be costing us as a society. For disciplinary audiences, we need very concrete identification of the latent (and perhaps even unrecognized) QL content in their subject areas. Everybody can easily agree on the "it" in terms of examples, but going much farther at the conceptual level just leaves people confused.

Different audiences need very different messages. The policy community needs a very short statement concerning what QL is (defined by example), why it is important (demonstrated in terms of concrete evidence of shortfalls and their consequences in lost productivity and quality of life), and what might be done about it (a concerted policy effort aimed, probably, at points of transition between high school and college and between education and the world of work). The K–12 mathematics community needs a different message—already in part delivered by the NCTM standards—but probably more focused on pedagogy. The postsecondary nonmathematics community needs a message that identifies common QL threads in what it is doing, together with an urge to make common cause in working together and working with mathematics. Finally, the postsecondary mathematics community needs a message that affirms that QL is not an attack on mathematics per se but a discussion about the ways mathematics is taught and applied. (There were, for instance, too many needless arguments for and against algebra.)

In many ways, the real Forum conversation was more about pedagogy and assessment than about content. This is important first because much QL writing leads with content, which inevitably leads in turn to unproductive fights about what content is "in" and what is "out." I find myself more and more persuaded that one barrier to achieving quantitative literacy is, as Alan Schoenfeld noted in *Mathematics and Democracy,* the way mathematics is taught in the early school grades, especially how abstractions are introduced and contextually anchored. Second, as Grant Wiggins argued in one of the Forum's background essays, fixing assignments and tests may be far more important than fixing syllabi (Wiggins, see pp. 121–143).

Finally, I found myself more convinced than ever that the dynamics—and therefore the levers—for change are quite different in K–12 and higher education. Top-down methods, largely led by the mathematics community, will work in K–12—employing organizations such as NCTM and the Mathematical Association of America (MAA). Other teachers and disciplines can help, but in K–12 the movement needs to be led by the mathematics community. This in part is because, as a number of Forum speakers

pointed out, many K–12 teachers outside mathematics are not themselves quantitatively literate.

I am not at all convinced that the same is true for higher education. Here, I think the movement has to be led largely from outside mathematics—relying on practitioners in client disciplines who really understand and practice QL to make common cause. Of course, needs will be different in the sciences and engineering (algebra/calculus-based disciplines) and the social sciences and business (statistics and applied numeracy-based disciplines). I never thought I would say this, but one approach in higher education might be to empower client disciplines to teach their own quantitative courses in greater numbers (which, of course, already happens in statistics), leaving mathematics departments to the business of educating the few who want to take the traditional path.

—Peter Ewell, Partner, National Center for Higher Education Management Systems

Confronting external impediments to QL

The task of improving the quantitative literacy of all students seems daunting. The more we talked at the Forum, the more the task grew. Thinking about the work that needs to be done in the early grades, in high school, and then in college made it clear that a coordinated effort is needed. Students at every level, and their teachers, need to recognize that quantitative literacy is important and that it is valued. Students learn what they are taught; therefore, faculty at every level must teach the QL practices we claim to value.

Because it is what I know best, I think most about the tasks facing high school teachers. High school curricula are determined to a great extent by outside forces. College admissions processes that place the greatest value on the highest-level mathematics course (e.g., Advanced Placement) do not always help teachers teach what would be best for their students. College placement tests and procedures that value very traditional mathematics hurt students who have been taught a mathematics curriculum that has a strong emphasis on quantitative literacy, and therefore discourage teachers from moving toward a quantitative literacy focus in their teaching. The NCTM standards-based course of study, which supports quantitative literacy, does not always seem to be valued by college faculty. Therefore, students prepared in a standards-based mathematics program may be hurt in the transition to college courses. Parents' views of what is important and administrators' responses both to parents and to colleges also have an effect on what teachers are allowed to do. Until a quantitative literacy-based curriculum is valued by these outside forces, high school teachers will not be able to do what is best for all students.

—Jo Ann Lutz, North Carolina School of Mathematics and Science, and College Board Trustee

Learning mathematics by using mathematics

Clearly, our first priority must be to improve the quality of mathematics instruction. Evidence from the High Schools That Work (HSTW) network shows a dramatic change in mathematics courses taken by career-oriented students over the past 12 years. In 1988, only 25 percent of these students took three mathematics credits (including two or more of Algebra I, Algebra II, and Geometry), while in 2000, 85 percent had reached this standard, with 80 percent completing geometry and nearly 70 percent completing Algebra II. During this time the average mathematics scores of these students increased from the low 280s on a NAEP-based examination to over 300. In 2000, only 4 percent had a mathematics score below 250.

Interestingly, female students take more, and more advanced, mathematics courses than male students, while young men still have slightly higher mathematics test scores. (The achievement gap is diminishing.) Although male students take fewer and easier mathematics courses than females, males tend to be enrolled in vocational programs in which they make greater use of mathematics to complete authentic assignments and are much more likely to be given joint assignments from their mathematics and vocational teachers. Extensive classroom visits show that much of the instruction in mathematics classrooms is designed to teach students how to follow procedures. In too many classrooms, teachers simply skip the reading problems in their texts, some of which are actually rather decent problems. Students need to take courses in other areas to see mathematics used, and when they do it is noticeable in their test scores.

Thus the first priority: to support mathematics teachers in assigning real-world problems that will help students understand mathematical concepts and engage in mathematical reasoning. Such support is crucial politically as well as pedagogically, because if we do not see the expected improvement in achievement as students are required to take more mathematics courses, mathematics teachers will come under increasing criticism. We need a major initiative to help mathematics teachers teach in ways that engage students in using mathematics to do real things in various contexts.

A second priority, clearly articulated at the Forum, is to emphasize quantitative literacy across the curriculum. This may mean developing individuals in both the middle grades and high schools to become "QL coaches" to devise learning experiences within nonmathematical disciplines that are quantitative in nature and that improve students' understanding of those disciplines. A QL coach would help integrate quantitative analysis throughout the curriculum. The focus of coaching has to be on empowering teachers to use quantitative literacy—not to teach mathematics but to advance students' learning and understanding in their own disciplines. If teachers interpret QL to mean that they are now to teach mathematics in addition to their own disciplines, they will simply turn off.

We have known for a long time at HSTW sites that science, vocational, and technical arts teachers who devise learning experiences that require students to draw on mathematical knowledge produce students with consistently higher mathematics achievement and much better performance on problem-solving items on a NAEP-based examination. Yet too many high school students study science or technical courses devoid of mathematics. Only about one-third are in classes in which they frequently have to use mathematics to complete authentic tasks. In too many cases, only the best students do mathematics while the rest simply do what they are told. Science, vocational, and technical arts teachers need special help devising learning experiences with a mathematical base, using instructional strategies through which they hold all students accountable for doing quantitative analysis, and developing assessments to determine whether students are able to apply essential mathematical concepts to typical problems they will encounter in diverse careers. Physical education, social studies, and art teachers also can use quantitative literacy to enhance student learning in those disciplines. Most of these teachers could benefit from a QL coach.

Third, if we want to change how mathematics is taught, we must change the nature of the questions that are asked on various examinations. Most state and end-of-course examinations and even the ACT and SAT mathematics examinations have very few questions that focus on the ability of students to reason and think with mathematics to solve authentic real-world problems. In too many instances, mathematics examinations encourage teachers to teach the wrong way. They encourage teachers to cover the material, teach students the procedures, and hope that students will remember them long enough to pass the examination. The emphasis of the examinations, and thus of teaching, is not on deep understanding of mathematical concepts or on advancing students' reasoning skills. Moreover, there are no consequences for failure to show improvement over time.

Fourth, changes need to be made in mathematics texts to include more real-world problems that can be used to teach quantitative literacy. Moreover, textbook publishers should provide more coordination between mathematics and science textbooks to align mathematics concepts and the quantitative literacy potential of science. In visiting hundreds of schools and high school classrooms over the past 15 years, it has been my observation that more than any other teachers in high school, mathematics teachers depend on textbooks. Therefore, without quality text materials to give students opportunities to use mathematics in a variety of challenging contexts, QL simply will not happen.

Finally, one of the points made by many Forum participants was that if quantitative literacy is not viewed as something for all students, it will lead to further tracking in mathematics, which these participants saw as undesirable. This is certainly a valid point, but I fear that by stressing this distinction the quantitative literacy movement runs the risk of being interpreted as saying that what we are now doing is not working. We cannot simply overthrow one system and substitute another. We must develop mathematics course sequences that are appropriate for all students and that offer a suitable balance between the more procedural emphases that now are taught to too many students and a QL-like emphasis that engages students in using mathematics to do real things in contexts that have meaning for them.

—Gene Bottoms, Director, High Schools That Work, Southern Regional Education Board (SREB)

Do not focus on the distinctions between mathematics and quantitative literacy

Advocates for the skills, abilities, knowledge, and mind-set embodied in quantitative literacy, particularly those advocates outside the mathematics community, can have a strong influence on improving mathematics instruction and student learning. Many within the mathematics community are taking big steps toward revising the mathematics curriculum in the directions called for under the QL banner. Reports from mathematics professional organizations—the NCTM at the school level and the MAA and the American Statistical Association (ASA) at the college level—call for such changes. The mathematics curriculum projects at the elementary, middle, and high school levels supported by the National Science Foundation infuse quantitative literacy into the K–12 mathematics curriculum. Changes at the college level are taking place under banners such as "calculus reform," "alternatives to college algebra," or, in many mathematics departments, "quantitative literacy."

Those of us committed to this work at our own institutions very much need the help of advocates outside the mathematics community:

- We need to know that what we are doing matters in a broader world; anything that catches the eye of administrators would be very useful.
- We need assistance and encouragement in urging disciplines outside mathematics to work together with us in promoting quantitative literacy.
- Perhaps most critically, we need support to include quantitative literacy on high-stakes tests, particularly on the mathematics portions of the tests many states are requiring for high school graduation and the new grade-level tests now being mandated at the national level.

All of this said, I think it is a big mistake to focus on the distinctions between mathematics and quantitative literacy, as was sometimes the case at the Forum and in *Mathematics and Democracy.* Such artificial distinctions let mathematicians and the broader mathematics community off the hook. In my opinion, the abilities and mind-set described as quantitative literacy are central to mathematics (definitely including research mathematics) as well as to effective teaching and learning of mathematics. Many in positions of influence, however, would prefer to keep all students focused on technical manipulation skills in the elementary algebra, formal geometry, intermediate algebra, college algebra, and pre-calculus courses that are studied by masses of students today, students who have no intention of entering fields that require calculus.

If we make distinctions that can be translated as "quantitative literacy is not mathematics," we run the risk of giving ammunition to those who oppose reforming the mathematics curriculum and instruction in ways encouraged by quantitative literacy advocates. The chance that leadership in implementing quantitative literacy programs will come from anywhere but the mathematics community is slight to nonexistent. States require testing of mathematics, language arts, and often social science and science. The chances of adding a fifth test on quantitative literacy are nonexistent. The federal government now requires states to test mathematics at every grade level between three and eight. There is no possibility of adding an additional test on quantitative literacy. Mathematics is taught to all students from kindergarten through at least grade 10. An additional "quantitative literacy" subject will not be added to the curriculum. Large numbers of colleges and universities require mathematics course work of all their students. Some may replace a mathematics requirement by a quantitative literacy requirement, but very few would add a quantitative literacy requirement on top of a mathematics requirement. Finally, colleges and universities provide support to departments of mathematics; they will not support or fund new departments of quantitative literacy.

In short, leadership for quantitative literacy needs to come from mathematical sciences departments (mathematics and statistics) at both the school and college levels and mathematicians must take the lead if wide-scale change is to occur. Support from outside the mathematics community would be very useful; however, if quantitative literacy is viewed as not a central part of mathematics, it will be much more difficult to direct the energy and resources of mathematicians and mathematical sciences departments toward this important effort.

—William Haver, Mathematics Department,
Virginia Commonwealth University

QL is the sophisticated use of elementary mathematics

I was struck most at the Forum by the need to continue educating faculty about the concept of quantitative literacy. Even among the group of people who were interested enough to spend a weekend discussing QL, there was no common understanding of the term. Conversations kept slipping between QL and mathematics as if they were one and the same, and the mathematicians seemed to be the ones most often conflating the concepts. In addition to assuming that QL was the same as mathematics (without even a nod in the direction of context or applicability), very often concepts that should be learning outcomes or capacities were immediately turned into mathematics courses.

I found the suggestion that quantitative literacy involves the sophisticated use of relatively elementary mathematics to be illuminating and useful. With this interpretation, it becomes clearer how teaching elementary mathematical concepts could be part of the high school curriculum (to make sure students have a solid foundation in the concepts applied in an introductory manner), while the responsibility for ensuring their sophisticated use would devolve to the colleges. (A possible parallel in writing—which may not hold up to greater scrutiny — is to master basic grammar and organization by the end of secondary school through writing about relevant, albeit elementary issues, and then employ these skills to write well about complex issues from many fields in college.)

Should a commitment to quantitative literacy replace, supplement, or transform the mathematics curriculum? This seemed to

be one of the basic questions asked at the Forum, one that, I believe, is best addressed by clarifying the goals for learning. Do we want students to have "experienced" algebra, geometry, probability, and statistics (is the experience the goal?), or to be able to "use" the tools of these fields in a variety of ways, both in formal college study and in life?

A second basic question concerned the home of QL: in the mathematics department (preferably one that commits to teaching the practical nature of mathematics), in the social sciences (as many suggested), or in an interdisciplinary unit? If the college contribution to QL is, indeed, increasingly sophisticated use of elementary concepts, a "through the disciplines" approach seems entirely appropriate.

A third basic question concerned expected level of ability. At the elementary end, we heard about people who could not understand orders of magnitude or appropriate precision; then we moved through the intermediate level of finding patterns in numerical data to the higher end of appropriately using quantitative concepts in science and other fields. Clearly the first is a societal problem, but the solution probably lies in grades 6 to 9. I did not sense agreement as to whether the higher levels also were cause for major concern about QL, although the corporate sector seemed to suggest that they were.

—**Andrea Leskes,** Association of American Colleges and Universities

Do not underestimate arithmetic

QL is as much an attitude as a set of skills. We know that one thing that makes a person who is good at mathematics different from one who is not is the belief that tackling a problem that involves mathematics is worth the effort and that eventually, somehow, an answer will be obtained. QL is about sharing computational and analytical skills for social purposes.

QL must include a recognition that numeric computation is not a trivial precursor to algebra but a difficult skill on its own. Even when supported by technology, computation is not easy. Two-thirds of our population has never really mastered computational skills. Arithmetic is hard and data analysis is even harder.

QL needs a different title. Anything with computation, mathematics, or statistics is problematic. QL will not thrive when viewed as a part of mathematics or statistics. It must be viewed as a pursuit in its own right. Perhaps we need a larger concept that might be called Full Literacy, or Whole Literacy, or 3M Literacy (literacy for the third millennium)—something to suggest, inclusively, reading, writing, document literacy, data analysis, and computational literacy.

QL needs to recognize that there are different levels of literacy. A passive literacy is one target. An active literacy is another, more ambitious one. Many argue that literacy is by nature more passive than an active use of skills. Active use may be—dare we say it—what distinguishes mathematics and statistics from quantitative literacy.

—**Philip Mahler,** Middlesex Community College; President, American Mathematical Association of Two-Year Colleges

Support faculty, develop examples, and fix admissions tests

A year or two ago, I thought I had a reasonable understanding of quantitative literacy based on general knowledge and discussions at my college; however, this Forum made me aware that there is much more to it than I had at first suspected. First, there is a lot more mathematics to it than just good number sense. I really like Lynn Steen's phrase "sophisticated use of elementary mathematics." Second, as an educational and societal problem, it is much more urgent than I realized.

The Forum added both clarity and passion to our understanding of QL. Some railed against the usual suspects—many of which we have all heard before. We listened to impassioned pleading ranging from "let's stop talking and do something" to "it's too early to do anything because we haven't defined what we are talking about." In an important way, I found the Forum discouraging because it showed that the problem is even harder than I thought and because we ourselves do not seem to have QL in focus.

At the precollege level, it is not clear how much QL differs from various aspects of the NCTM Standards, but it is clear that there is a lot of overlap. Probably the best way to make progress on getting QL into the schools is to make progress on serious and broad implementation of those Standards. (Reaching out to other subjects such as natural and social science will help, but these courses cannot carry the primary load.) In college, the best way to learn QL is to have it show up in regular courses in the various disciplines. Enticing faculty to put more QL into their courses by offering them course development and revision grants is one good approach. (It is much less clear what to do at the college level for the great majority of institutions that must teach a lot of precollege mathematics.) In any event, it seems clear that QL, like writing, is something we can never finish learning, so it needs to be emphasized at all levels of the curriculum.

Most important, it does not do colleges and universities much good to provide QL reinforcement at the higher levels if schools do not get the message that we are expecting students to have basic QL at entrance. I am not sure statements by colleges about admissions expectations have much effect, but I am sure that standardized admissions tests do have an influence. These must change. Those calling for improved education (e.g., business groups) must be made aware of what these improvements need to be. State governments and education administrators at all levels have to understand the issue and get behind it. This is a long haul.

Do we have to agree on a definition of QL? No. But without some agreement it is too easy to slip into thinking that QL means to everyone else just what we think it is. We should assume that everyone we speak to in hopes of alerting them to the QL problem also has an idea about QL but that their idea is probably different from ours. Thus we have our work cut out just to ensure that others really hear us.

In pure mathematics, definitions make more sense with concrete examples; so much more so with an amorphous topic such as QL. What I would really like to see are several carefully laid out examples of QL problem tasks (or classroom activities) at various educational levels—especially examples that are different from what already is being done under the banner of the NCTM standards, or reformed calculus, or introductory statistics, or discrete mathematics. I then will have a clearer idea of what I have to change and what I have to try to sell (if I still want to sell it) to my colleagues and my community.

Even without full clarity on a definition or ready examples of QL problems, there is much that I can do on my own campus:

- I can seek internal money for grants to faculty to develop QL components in their courses.
- I can talk to my department to make sure that people who teach pre-calculus have some appreciation of the QL issues and urge them to put more QL aspects into this course.
- I can talk to teachers and the curriculum specialists in our local school district (where I have sometimes been a mathematics consultant) to see how aware they are of QL issues.
- I can do some more reading and Web exploring to deepen my personal insights into QL.

—**Stephen B. Maurer,** Associate Provost for Information Technology and Professor of Mathematics, Swarthmore College

Numeracy from cradle to grave

As the quantitative literacy movement grows, it is critical that it be inclusive of populations as well as of contexts. Who are we thinking about when we say people need to be quantitatively literate? And when and where will folks need to learn and use quantitative reasoning?

What struck me at the Forum is that both of these dimensions expanded considerably as the discussions proceeded. We started out with an explicit focus on adolescents in grades 11 to 14, but by the end of the Forum there seemed to be tacit agreement that we were really talking about "pre-K through gray." Moreover, although the focus primarily remained on topics from statistics and data analysis, it soon became apparent that quantitative reasoning matters in almost every discipline and in every adult role: worker, citizen, and family member.

In other words, in the two days of the Forum we went from:

	School Mathematics	Other Disciplines
High school		
College		

to

	School Mathematics	Other Disciplines	At Work	In the Community
Pre-K–5				
Middle school				
High school				
College				
Adult workforce and citizenry				

This expansion requires many groups to shoulder the responsibility for helping to create a more quantitatively literate populace. The usual suspects—high school and four-year college mathematics educators—are joined by faculty from other disciplines as well as by elementary educators on one side and, on the other, by community college and adult basic education teachers as well as a host of informal education venues for adults such as the media, the

workplace, and the community. All of which bring my crowd into the QL loop.

We teach adults returning to study. Each year over four million adults enroll in adult basic education, literacy, GED, or high school equivalency programs. (One of every seven high school diplomas awarded each year is a GED.) It is essential that the content and pedagogy of courses for adults be critically reviewed so that they reflect what is most important for adults in their roles at work, in the community, and at home, as well as for further learning. At present, these courses generally put more stress on traditional arithmetic (decontextualized computation and one-step word problems) than on reasoning and decision making using real data and focusing on real-life issues. On behalf of adult educators, I hope the continuing discussions about quantitative literacy will include us and the populations we teach because it keeps us focused on what is really important for adults.

As a member of the Adult Literacy and Lifeskills (ALL) survey numeracy team, my colleagues and I have spent three years thinking hard about just what it means when we say we are looking at the distribution of numeracy skills in the adult population within and across countries. What is the range of skills to be assessed and what are the most critical concepts? The issues raised at the QL Forum resonated with the ALL team discussions and will help us in our work.

—Mary Jane Schmitt, TERC, Cambridge, MA