

# The Many Faces of Quantitative Literacy

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Quantitative literacy (QL), the ability to understand and use numbers and data analyses in everyday life, is everybody's orphan (Madison 2001). Despite every person's need for QL, in the discipline-dominated K–16 education system in the United States there is neither an academic home nor an administrative promoter for this crucial competency. Needs for QL extend across the traditional American guarantees of life, liberty, and the pursuit of happiness. Health concerns increasingly are immersed in risk analysis and probabilities; government decisions and political arguments are steeped in uses and misuses of quantitative data; and consumer issues, sports, and investments frequently are reported in terms of averages, rates of change, and changes in rates of change.

To better understand quantitative literacy and the educational challenge it presents, the National Council on Education and the Disciplines (NCED) initiated a national examination of issues surrounding QL education, especially in the context of school and college studies. As a starting point, NCED published *Mathematics and Democracy: The Case for Quantitative Literacy* (Steen 2001), consisting of a case statement on numeracy in contemporary society and 12 responses. To expand the conversation about QL, NCED subsequently sponsored a national Forum, *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges*, held at the National Academy of Sciences in Washington, D.C., on December 1–2, 2001. This volume represents the proceedings of this Forum and includes papers commissioned as background for the Forum, essays presented at the Forum, and selected reactions to the Forum.

## Part I: Background Papers

To help interpret the implications of quantitative literacy in preparation for the national Forum, NCED commissioned several thought papers, as opposed to research treatises, on various aspects of QL. Initial drafts of these papers were read by two external reviewers prior to preparation of a second draft. These second drafts, along with *Mathematics and Democracy*, provided the foundation for the Forum. Following discussions at the Forum, several authors revised their papers yet again. The first section of this volume includes edited versions of these post-Forum revisions plus two additional papers written after the Forum that are complementary to the commissioned works.

### NEED FOR WORK AND LEARNING

Four of these papers focus on the need for quantitative literacy, particularly in the context of citizenship and work, while eight address components of QL education: curriculum, pedagogy, articulation, and assessment. Of the eight, four deal directly with curriculum and four consider policy issues involving curricular relationships and assessment. Although thoroughly grounded in the realities of U.S. education, these papers explore a variety of paths to the goal of imbuing students with quantitative habits of mind in addition to conveying facts and procedures. As with all such

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explorations, differences in terminology and emphases emerge, revealing both the intellectual richness and the complexity of this challenging issue.

The need for quantitative literacy is both personal and societal. Although personal needs are addressed to some extent in all the papers, four focus especially on the societal issues of citizenship and work. Two of these view QL and the workplace from very different perspectives. Linda Rosen (with Lindsay Weil and Claus von Zastrow) addresses QL from the standpoint of the National Alliance for Business, offering views from the business world concerning the need for QL education and the educational responses that have been made by businesses. Because QL is a nontraditional newcomer to education, the business response to it is predicted to be conservative. Arnold Packer, a pragmatic economist, approaches QL from the perspective of what mathematics everyone should know and be able to do. His approach is to evaluate skills in terms of their frequency of use and economic value in the workforce.

The third paper addressing societal issues, by historian Patricia Cline Cohen, views the need for QL from a historical perspective. She details how the U.S. government has relied on and promoted QL from the inception of constitutional rule in 1789. The fourth paper, by Anthony Carnevale and Donna Desrochers, analyzes the current need for QL education. The authors consider both the demands of democratic processes and the requirements of the current and future workforce.

### **CURRICULUM ISSUES**

Four thought papers look specifically at the mathematics curriculum and its role in general education. Deborah Hughes Hallett, Jan de Lange, and Lynn Arthur Steen address various aspects of that curriculum, including some that often are classified under the rubric of statistics. Hughes Hallett writes of the college experience while de Lange offers an international perspective. Steen argues for a mathematics curriculum in grades 6 to 12 that would expand the current narrow focus on algebraic symbol manipulation. Finally, Randall Richardson and William McCallum discuss how to extend college QL education beyond mathematics courses to develop authentic contexts for mathematical concepts in other disciplines.

### **POLICY CHALLENGES**

Policy challenges in various QL areas—articulation, assessment, relation to mathematics, and core curriculum—are the subjects of the final four thought papers. Michael Kirst addresses the complex political and policy issues surrounding articulation, that is, how QL education is affected by the decision making and transitions from secondary to higher education. Bernard Madison looks at articulation from within mathematics and analyzes features of the

current system of school and college mathematics that weaken QL education. Grant Wiggins discusses the unusual demands of assessing QL that are created by its contextual nature. Finally, Richard Scheaffer, aided by five statistics colleagues, positions many of the ideas in the other papers in the context of statistics education.

## **Part II: Forum Essays**

The Forum program stimulated a wide-ranging discussion of the nature of QL; the relationships of QL to mathematics, statistics, and other disciplines; the consequences of innumeracy; possible improvements in QL education; and policy issues related to QL education. Perspectives expanded well beyond those presented in the background papers but continued to echo the themes of need and challenge. Varied voices spoke from broad and experienced viewpoints. For example, program participants included the presidents of major mathematical sciences professional organizations such as the American Mathematical Society (AMS), American Mathematical Association of Two-Year Colleges (AMATYC), American Statistical Association (ASA), Mathematical Association of America (MAA), and National Council of Teachers of Mathematics (NCTM).

### **NEED FOR WORK AND LEARNING**

Stronger mathematical education of teachers is central to QL in the view of National Academy of Science member Roger Howe. J. T. Sutcliffe, a high school mathematics teacher, not only supports stronger teacher education but also points to the constraints under which teachers work. Science dean and biologist David Brakke echoes the need for K–12 teacher education in QL but expands that in a call for colleges to continue and extend QL education. NCTM President Johnny Lott points to flaws in the K–16 mathematics curriculum that weaken QL education for all students, including future teachers.

Retired General Electric engineer William Steenken writes about the importance of QL to industry while Arnold Packer expands on his background paper, exhorting mathematicians to recognize the need for practical mathematical knowledge. Former astronaut and astronomer George Nelson discusses the nature of QL and compares it to science literacy.

### **POLICY PERSPECTIVES**

Although most participants at the Forum felt that education for QL should extend beyond mathematics and statistics, Jan Somerville cites policy issues surrounding college and university mathematics that impede progress toward a more useful mathematics education. She challenges mathematicians to take QL as a responsibility and to address more forcefully problems in mathematics education. Margaret Cozzens reinforces Somerville's views by identifying higher education policies and practices that hinder QL

education. Judith Rizzo points to the need for stronger curricula and better prepared teachers, observing that our standards show that we already are strongly committed to QL. Sadie Bragg describes the special role of two-year colleges in general education and emphasizes how institutional policies can impact basic learning. In an essay addressing the importance of national networks, Susan Ganter discusses past and current successes of networks in mathematics curricular reform.

### INTERNATIONAL PERSPECTIVES

In addition to the background paper by Jan de Lange, this volume contains a group of essays by authors from Brazil, Denmark, France, Great Britain, and the Netherlands, offering views of QL in those countries. Lynn Steen writes in his introduction to this section that “these glimpses of how mathematics educators in other nations are coming to terms with the new demands of numeracy, mathematics, and citizenship open a window on approaches that move well beyond those normally considered in U.S. curriculum discussions.”

### FORUM REFLECTIONS AND OBSERVATIONS

Three presentations at the Forum provided reflections on the central issues. Jeanne Narum opened the Forum with an analysis of the task ahead and, citing her experience with Project Kaleidoscope, urged collaboration in addressing QL. In a luncheon presentation, Rita Colwell, director of the National Science Foundation, challenged Forum attendees to produce national standards for QL and assessments that measure our progress toward attainment of QL goals. AMS President Hyman Bass, in his closing remarks, cautioned against major curricular changes until QL is better understood.

Although regrettably not recorded in the pages of this volume, Daniel Kennedy’s hilarious monologue on “Why Johnny STILL Can’t Add” entertained Forum participants after the midpoint dinner. For a brief respite, QL was replaced by a sterling example of “high humor” literacy.

The reflections at the end of this volume probably provide the best summary of Forum discussions. This is what various selected participants from a wide variety of backgrounds took away with them. Two themes dominate: (1) the relationship of QL to mathematics and statistics and (2) the perceived difficulty of improving QL education. AMATYC President Philip Mahler ties these two themes together, concluding that the difficulty in improving QL education requires that it must be extended beyond mathematics and statistics.

Gene Bottoms and Andrea Leskes focus on the need to improve school mathematics. Leskes suggests that viewing QL as sophisticated uses of elementary mathematics could allow schools to con-

centrate on improved understanding of elementary mathematics while colleges address more complicated uses. William Haver cautions that too much emphasis on how QL and mathematics differ could let mathematicians off the educational hook. Russell Edgerton acknowledges that the QL discussions made him more aware of the need for a curriculum that contributes to general learning goals. Peter Ewell muses about the struggle to define QL, the dominance of mathematics in Forum discussions, and the need for different messages for different audiences. Rob Cole worries about the narrowness of disciplinary thinking.

Jo Ann Lutz and Mary Jane Schmitt both speak of how the challenge of QL seemed to become more daunting as the Forum unfolded. Schmitt also points to the expansion of focus from education in grades 11 to 14 to “pre-K through grey.” Don Small urges development of experimental QL education programs and suggests that reforming college algebra could provide a strong base for QL in colleges. Stephen Maurer, even though temporarily discouraged by the difficult task of QL education, left the Forum with a plan of action for Swarthmore. Edward Tenner notes the split between the experimentalist views of Small and Maurer and the more conservative view that QL is a long-term systemic challenge.

## Many Faces and Common Themes

*Mathematics and Democracy* lays the groundwork for all the papers, essays, and reflections, providing common terminology, general definitions, and examples of quantitative literacy. Nevertheless, the thought papers and Forum proceedings exhibit considerable wrestling with the meaning of QL and offer a variety of interpretations and terminology. Some talk about mathematics and mathematical literacy as proxies for quantitative literacy while others draw finer distinctions between mathematics, mathematical literacy, numeracy, and QL. Many of the reflections on the Forum recognize that although a general understanding of QL is critical, precision in definition is unnecessary. The faces of quantitative literacy revealed in this volume create a mosaic of complex issues confronting a U.S. education system unaccustomed to dealing with competencies cutting across all academic disciplines and almost all aspects of everyday life. Yet these competencies are crucial for citizens living in a twenty-first-century democracy.

Common themes do run through many of the contributions to this volume. One is the need for better articulation and synergy between the components of the K–16 education system and between education and the rapidly changing political and economic environment. Kirst and Madison focus largely on articulation between school and college; Kirst analyzes political and policy issues while Madison aims specifically at circumstances within mathematics. Somerville and Lott both point to difficulties stu-

dents face in the transition from school to college mathematics. Haver and Small suggest specific ways in which college mathematics can ease some of those difficulties. Lutz cautions that current messages from colleges keep schools from emphasizing QL, and Maurer points to admission tests as an example of one such message. Other commentators address the need for different kinds of articulation.

Carnevale and Desrochers, Rosen, and Packer discuss the need for articulation between mathematics education and the workplace. Steenken expands on this need from the perspective of an engineer in industry. Hughes Hallett, de Lange, Scheaffer, and Richardson and McCallum all address the need for articulation between teaching mathematical and statistical concepts and using authentic contexts drawn from a variety of real-world sources. Further, they argue for the effectiveness of articulation between various college disciplines (Hughes Hallett calls this a “friendly conspiracy”) in teaching the use of mathematics and statistics in numerous contexts. Cole and Edgerton expand on the need for QL to be a multidisciplinary effort. Leskes echoes the goal of teaching QL across the disciplines.

Closely aligned to the articulation theme is the complexity of the education system responsible for teaching quantitative literacy. The discussions in this volume point to numerous pressures within and on this system that make change difficult. Kirst speaks of the “Babel of assessments” facing students as they move through the mathematics curriculum. Madison describes the complex and overlapping system of mathematics at the boundary between school and college. In a Forum reflection, Schmitt observes that QL education should extend well beyond school and college to a host of adult education venues in the media, workplace, and community.

Wiggins writes about the difficulty of finding authentic contextual assessments. Steen discusses the formidable forces that shape the K–12 mathematics curriculum. Bottoms outlines five challenges for improving QL in the schools, including changing testing and textbooks and avoiding increased tracking. Cohen chronicles the historical development of QL and the forces that were in play in earlier eras. De Lange illustrates the difficulty of deciding what mathematics is important for QL and emphasizes the need for much closer ties between the curriculum and the culture in which it is taught. Tenner hypothesizes that only a minority of college faculty are potentially strong QL teachers and that they need to be convinced that QL is an intellectual challenge.

Rosen and Packer address the complex needs of a major component of U.S. culture, the workplace, and show how those needs are or are not being met by mathematics and quantitative education. Scheaffer confronts the doubly complex task of explaining how the relatively new and poorly understood discipline of statistics and statistics education fit into the haze of QL education.

Aside from the discussion—albeit mostly academic—about the need for a better definition of QL, the Forum papers and essays clearly point to two other needs:

1. Systematic evidence to support the call for stronger QL education; and
2. Clear descriptions of the levels of QL and of strategies for how they can be assessed.

Numerous anecdotes and the results of national and international tests point to low levels of QL, even among U.S. college graduates. Most people are familiar with this deficiency, but stronger evidence is needed about the consequences for society and for individuals. Although there is widespread agreement that a basic level of quantitative literacy should result from K–12 education and that levels of QL should continue to rise throughout higher education, neither the levels of QL nor assessments for these levels are yet identified in a form that commands widespread support.

Neither the background papers nor the Forum essays and reflections answer all the questions about the need for QL and how best to achieve it. They do, however, present valuable and informed views on quantitative literacy from a variety of perspectives. Together with *Mathematics and Democracy*, these views form a solid basis for furthering the national conversation on how to achieve quantitative literacy for all. As Peter Ewell observed, the Forum was helpful in “stirring the pot, which was exactly what was intended. The question now is how to keep the thing cooking without boiling over.”

## References

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