Introduction

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Quantitative Literacy is one of those things about which we say "I know it when I see it", but is difficult to describe precisely and concisely. It includes numeracy (an understanding of numbers and magnitude); some geometric, algebraic and algorithmic skills; some problem solving ability; an understanding of probability and statistics; and the ability to quickly capture information, summarize it, and make a decision.

The working definition I find most convenient is the following, extracted from the bylaws of the MAA's SIGMAA on Quantitative Literacy. (There are alternatives provided in the various essays included in this volume and in related works.)

Quantitative literacy (QL) can be described as the ability to adequately use elementary mathematical tools to interpret and manipulate quantitative data and ideas that arise in individuals' private, civic, and work lives. As with reading and writing literacy, quantitative literacy is a habit of mind that is best formed by exposure in many contexts.

As mathematicians, it is very tempting to say that being quantitatively literate is equivalent to being more proficient at mathematics, and therefore the solution to developing quantitatively literate citizens is to have them study more mathematics. But this is inherently a poor solution since mathematics is fundamentally about developing and understanding deeper abstractions and connections. Mathematics uses many tools and techniques that, to put it bluntly, do not have much value in the daily world of our fellow citizens. A quantitatively literate citizen will be able to use fairly elementary mathematical tools in sophisticated manners in a wide variety of contexts.

While developing a quantitatively literate citizenry is the responsibility of a much larger community, it is the obligation of the collegiate level mathematics community to take leadership in (a) identifying the prerequisite mathematical skills for QL, (b) finding innovative ways of developing and implementing QL curricula, (c) assisting colleagues in other disciplines to infuse appropriate QL experiences into their courses, and (d) stimulating the national dialogue concerning QL.

With this perspective in mind, the purpose of this volume is to present a wide sampling of the specific efforts being made on campuses across the country to achieve our common goal of having a quantitatively literate citizenry.

As you read these essays, you will see the difficulties these colleges and universities have grappled with to define quantitative literacy within their own communities and to implement appropriate curricula. You will also see a wide range of solutions that result because of differing pressures created by the student population being served, the definition that the community accepts, and the pre-existing curricula.

The volume begins with a series of essays that help to develop and set the context for the curricular programs that follow. The first essays by **Sons** and **Ganter** lay the historical framework for the current attention being given to quantitative literacy. In particular, Sons' essay describes the context of quantitative literacy over the past two decades, while Ganter's essay describes the current initiative to make quantitative literacy a priority. The essay by **Briggs** helps to bring these ideas into immediate application when he describes ten problems that every college graduate should be able to solve.

The majority of this volume consists of examples of institutions working to implement quantitative literacy curricula. All of these writers have been asked to speak about issues concerning student placement, program history, curriculum content, and program assessment; individual writers have chosen to focus on different elements of this list. Because quantitative literacy is inherently part of the general education curriculum and of interest to many other individuals on their campuses, they have also been asked to describe input from individuals outside of the mathematics department and the relationship of their program to the overall general education curriculum.

Each program can be compared with the model described in *Quantitative Reasoning: A Complement to the Standards*, published by the MAA in 1995. This volume makes it very clear that any specific quantitative literacy program must be responsive to the local conditions of an institution including its mission, its student clientele, its history and its resources.

However, with this understanding, the volume is able to describe the general form of a complete quantitative literacy program. Such a program would include an appropriate placement exam so that students are able to move efficiently to a course in which they will succeed and which will support their academic interests. The program may very well have a remedial component for those students who are not prepared for the collegiate level work being offered at their institution. The core of the program is a two-tiered system consisting of a "foundations" course usually taken during the first or second year and "infusion" or applied courses taken in the latter years of undergraduate study. It is anticipated that the foundation course or courses would usually, but not necessarily, be offered by the mathematics department. The courses in the second tier of the program would be offered by disciplines outside of

mathematics (frequently within the students' majors) which would utilize the foundational skills previously developed to address problems of interest to the students in context.

These essays are organized into three sections. The first describes programs that have significant components outside of the mathematics department. **Bressoud** describes a program unique to his institution's mission. **Diefenderfer, Doan & Saloway**, **Taylor**, **Fink & Nordmoe**, and **Hartzler & Leoni** describe programs in which quantitative experiences are embedded in a wide range of courses throughout the institution. **Bukowski**, **Coe & Ziesler, Haines & Jordan**, **Gordon & Winn**, **Johnson**, **Kantrowitz & O'Neill,** and **Mast & Pawlak** describe programs in which a finite set of specific courses satisfy the quantitative literacy requirement.

The third section of the volume describes courses explicitly designed to satisfy a quantitative literacy requirement. These essays include those by **Ellington & Haver, Jabon, Jimenez & Zack, Sevilla & Somers,** and **Sons**. It is interesting to read how different institutions have resolved issues of curriculum, staffing, and placement.

The final section addresses issues that don't neatly fit into the other two. Most of this section of the volume consists of a series of essays that focus on placement, advising, assessment, and remediation. However, essays by **Al-Hasan** and **Maher** are included which describe current efforts to establish a quantitative literacy program. While their campuses are very different, their essays reveal similar issues involved in this process: effective placement, student interests, involving other departments, and adapting current courses to serve this purpose. The essay by **Muir** speaks directly to placement and advising, while the essay by **Lichtman** presents some interesting insights into the effect of high school preparation on placement. **Gillman** and **Çömez & Martin** speak to the problem of assessment.

Many of the essays speak to particular issues. The essays by **Bressoud, Gordon & Winn,** and **Mast & Pawlak** address the manner in which the quantitative literacy program is particularly tied to their institutional missions. In addition, the **Gordon & Winn** and **Çömez & Martin** papers demonstrate that the level of quantitative proficiency expected of students can vary by institutional mission.

Not only does the essay by **Hartzler & Leoni** describe a quantitative literacy program at a community college, but it also describes the amount of time and energy required to prepare faculty to include QL topics in their courses. **Bressoud** and **Diefenderfer, Doan & Salowey** address this same issue in their essays. Similarly, **Ellington & Haver** and **Sons** address the same issue of preparing TA's, part-time faculty, and regular faculty in the mathematics department to teach QL specific courses.

The issue of faculty development, both within the department and among the faculty of the institution more generally, leads naturally to the related topic of pedagogy. This is described specifically in several essays (**Jimenez & Zack**, **Sevilla & Sommers**) and implied in many others. As you read these essays, you will see that either explicitly or implicitly, they say that the student is expected to be actively engaged in his or her learning experience by reading, writing, working in groups, collecting and manipulating data, and interpreting answers.

The use of student centered pedagogy as described in many of these essays reflects another belief implicit in all of these essays. This is the belief that learning is an integrated experience. We cannot effectively teach our students in compartmentalized courses, but each course should be connected to others either formally in the curriculum or more simply through explicit recognition by instructors that material in one course in one discipline can, and will be, used in other courses in other disciplines.

Although the programs and courses described in this volume only represent a sample of what is happening in the community, some trends do seem to be apparent. For example, the approach that an institution takes to address the quantitative literacy of its students seems to depend significantly on the size and type of institution.

Smaller, more liberal arts oriented schools tend to develop more extensive infusion based models for their programs which involve many faculty and courses outside of quantitative intensive disciplines. Mid-sized or small comprehensive schools tend to use traditionally quantitative courses outside of the mathematics department, as well as courses within the department, to teach quantitative reasoning. Large schools tend to rely almost exclusively on the mathematics department to provide appropriate courses, with very little effort to infuse quantitative material into courses outside of the quantitative intensive disciplines. There are many reasonable explanations for these tendencies, but it does indicate how far we are from the model described in *Quantitative Reasoning* in which students have many opportunities to develop the "habit of mind" required to be quantitatively literate citizens.

The essays do indicate that there is a consensus on the mathematical skills necessary to be quantitatively literate. These include elementary logic, the basic mathematics of financial interest, descriptive statistics, finite probability, an elementary understanding of rates of change, the ability to model problems with linear and exponential models, estimation and approximation, and general problem solving. In addition, the essays suggest that many of our students enter college with minimal mastery of these skills and their applications. The goal of quantitative literacy is to raise student mastery of these skills and their use, but a very significant gap in the literature is an articulated statement of standards for what "mastery" means.

There seems to be consensus that students do not master this set of skills, nor develop the habit of utilizing them to solve problems, in a traditional college algebra course. It is generally assumed that students completing a calculus course, statistics course, or finite mathematics course do achieve these two goals, but the evidence is not provided in these essays; possibly because the set of standards has not been articulated as of yet.

The "liberal arts mathematics" courses and textbooks deserve particular attention here. While many of them are intentionally designed to foster quantitative literacy, it seems that many truly wonderful courses and books are not so designed. For example, it is unclear if a course that teaches the "great ideas" of mathematics to help students appreciate the "beauty and wonder" of mathematics advances a student's quantitative literacy.

Even with the concerns that have been raised in the last several paragraphs, this collection of essays suggest that we have moved a long way in the past ten years in our understanding of quantitative literacy, our ability to implement effective programs to promote it, and the interest in many types of institutions across the country to address the issue.

As a closing remark, I would like to say thank you to Joan Steffen, and the MAA *Notes* Editorial Board without whose help compiling and editing these essays would have been much more difficult and time consuming.