In recent years, the term quantitative literacy has become a buzzword in the mathematics community. But what does it mean, and is it something that we should incorporate into the high school mathematics classroom? We will define quantitative literacy (QL), discuss how teaching for QL differs from teaching a traditional mathematics course, and provide sources of good QL problems that can be incorporated into the middle school, high school, or college curriculum.

Quantitative literacy has been defined as “the ability to adequately use elementary mathematical tools to interpret and manipulate quantitative data and ideas that arise in an individual’s private, civic, and work life” (Gillman 2004, p. 5). A person who is quantitatively literate has been described as using “habits of mind” when approaching situations or solving problems: “Like reading and writing literacy, quantitative literacy is a habit of mind that is best formed by exposure in many contexts” (Gillman 2004, p. 5). In other words, a quantitatively literate person has developed the intuition and the ability to solve real-life problems using a quantitative perspective.

**THE NEED FOR QUANTITATIVE LITERACY**

Over the past few decades, the average person’s need to be quantitatively literate has become more and more important. For example, would people act differently if they better understood the risks of certain choices, such as the health risks of smoking or of not getting vaccinations? Could the mortgage crisis have been avoided if people understood their finances better? How would debates about issues such as climate change be different if people knew how to interpret scientific data? Unfortunately, most Americans do not have the skills to interpret or evaluate these data appropriately.

A quantitatively literate person must know more than how to apply mathematical concepts and algorithms. A quantitatively literate person has a “predisposition to look at the world through mathematical eyes, to see the benefits (and risks) of thinking quantitatively about commonplace issues, and to approach complex problems with confidence in the value of careful reasoning” (Quantitative Literacy Design Team 2001, p. 2). This means that even students who have studied calculus may, and often do, remain short of quantitative literacy. As Hughes-Hallett (2001) points out, “There are many examples of students with sophisticated mathematics course work in their backgrounds who possess minimal quantitative literacy” (p. 94). Such examples may not be so surprising given that the usual high school curriculum often does not focus on preparing students to understand and articulate quantitative inferences in everyday situations.

Despite the need for quantitative literacy (QL), many Americans, including those who have earned college degrees, are unable or unwilling to reason quantitatively in everyday situations. Although many universities have begun implementing QL requirements for graduation, less than 30 percent
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of Americans graduate from college (U.S. Census Bureau 2010). Non–college graduates also need to develop QL skills to make informed decisions in their lives. As a result, the high school curriculum should reflect this need.

TEACHING FOR QUANTITATIVE LITERACY
Some teachers may ask, “Isn’t teaching for quantitative literacy the same thing as teaching mathematics? Isn’t this what we already do?” Teaching for QL is quite different from teaching traditional mathematics. It is also quite different from teaching another discipline that applies mathematics to that discipline, such as physics or biology. Teaching for QL differs from teaching mathematics in the following four ways: content, context, teaching methodology, and assessment.

Content
The mathematics content typically explored when teaching for QL tends to be elementary mathematics topics such as number sense, measurement, data analysis, and risk and chance. These topics are already found in the high school curriculum and are among the Content Standards recommended by NCTM (2000). The goal of teaching for QL, however, is not to teach these topics but rather to help students understand where and when to use these concepts in everyday life. Thus, when teaching for QL, we focus on real-world problems, such as saving or spending money, remodeling a room in one’s house, or interpreting newspaper articles.

Context
In a traditional mathematics course, teachers often have a mathematical concept that we must teach, and we then try to find a reasonable context in which to situate the topic. For example, if we want to teach the Pythagorean theorem, we try to find situations in which the Pythagorean theorem may be relevant. This approach is the opposite of how we should approach teaching for QL. When teaching for QL, teachers should always start with a real, everyday problem and then explore the mathematical ideas involved in that situation. We should not have specific mathematical content that we must “cover.” If a real-life problem happens to involve the Pythagorean theorem, then we may discuss it when exploring that problem; however, if the Pythagorean theorem does not naturally arise in any of the problems explored, then that particular theorem need not be discussed.

When teaching for QL, we should explore authentic situations that students may face in everyday life. These situations may vary from school to school. Therefore, the contexts that we choose to incorporate in our classrooms should be selected in part on the makeup of the class. Regardless of which problems we choose, they should mirror the complexity of real-life situations and not be simplified to provide “nice” answers. Problems in everyday situations generally do not have “nice” answers, and altering problems so that they do removes the authenticity from the problems.
Teaching Methodology
To help students develop the habits of mind necessary to be quantitatively literate, teaching QL ought to be different from teaching a typical mathematics course. “In the real world, problems do not come neatly packaged with methods of solution attached; our job is to figure out how to approach them” (Schoenfeld 2001, p. 53). Thus, students in a QL course cannot first be taught to follow algorithms or be shown how to do a problem and then be asked to do multiple similar problems. Such pedagogical methods may be suitable for teaching students new mathematical content, but they do not help students develop appropriate habits of mind that will enable them to use this knowledge in real-life situations. Rather, students should explore situations and be provided new mathematical content only as needed for the situation.

Assessment
Assessment of QL skills may also look quite different from assessment of traditional mathematical content knowledge. For example, when we teach for QL, many problems may be open-ended; there may not be one “right” answer. If we ask students to consider whether it would be cost-effective for their family to trade in a family car for a brand-new hybrid car, answers may vary depending on each family’s situation. More important than a final answer is the reasoning students use to obtain their answer. Further, when we teach for QL, after class discussions it may be appropriate to allow students to revise their work to incorporate some factors that they may not have considered within their original solution. For example, in the family car problem, some students may not have considered the increased costs of car insurance for a new car.

Another typical form of assessment for QL is to ask students to keep a regular journal about the quantitative occurrences in their everyday lives. Keeping such journals will help students develop an awareness of the quantitative matters in situations that they face. This technique also helps students develop habits of mind because they regularly try to find the quantitative aspects to situations in their lives. Further, keeping a journal is a way of expanding classroom walls. Rather than thinking only about mathematics during their mathematics class or when completing their homework, students now begin to think about mathematics throughout their everyday experiences. Having students give presentations based on their journal entries is often useful, allowing them to share the quantitative experiences they face in their daily activities.

Sources of Quantitative Literacy Problems
Although teaching for QL differs from teaching mathematics in the ways described here, the easiest way to help students develop QL skills is by incorporating QL problems into current mathematics classes. Descriptions of four sources of good QL problems follow.

Magazines and Newspapers
Graphically rich magazine or newspaper articles serve as an excellent source of QL problems. Even a small portion of a page may stimulate discussion about important current mathematical ideas, concepts, or conventions. Such articles provide problems of varied complexity—from five-minute warm-up discussions to investigations that can span several class meetings. Short claims or statements found in a local or school newspaper might not require much preparation on the teacher’s part and will allow for improvised discussion of mathematical topics that arise from contexts relevant to students’ lives.

Consider the following example from the Central Michigan University newspaper:

A photograph of a cheering crowd at a stadium (see fig. 1) appeared with this caption: “Nearly 19,732 fans packed into Kelly/Shorts Stadium for the CMU home opener.”

Asking students to make sense of the caption can inspire an exchange that includes number sense, rounding, and approximation:

• How many can “nearly 19,732” be? Ninety-five can be nearly 100, but what number is “nearly 19,732”? Do decimals make sense here?
• What are some ways of presenting the information in a more meaningful way?
• What other words besides “nearly” can indicate estimated numbers?

Even articles that do not reflect what students are currently doing and experiencing can still be relevant to their lives. Problems of social justice or environmental issues might be distant to students’ current interests, yet exposure to discussions of
such issues from a quantitative perspective may help shape opinions, attitudes, and habits of mind. We have found that *National Geographic*, *Time*, and *Newsweek* magazines are rich sources of problems.

**Student Journals**

Another source of QL problems is students’ journal entries. Journals on the quantitative occurrences in students’ everyday lives also provide great insights into the mathematics that students deal with. Student presentations of journal entries can inspire a worthy discussion.

Following is one example from a student’s presentation:

My two roommates and I take turns paying the rent, utilities, and some other common expenses. For example, last month I paid the rent ($250), Angie paid for utilities ($78), and Cara paid for my birthday cake at Pie’s Company ($16). We also ordered a pizza (Cara paid $20, and I contributed $3) and bought a new bookshelf ($63), which was paid for by Angie. At the end of each month, we try to figure out who owes money to whom and how much. Is there a spreadsheet formula we can use to see right away who needs to write a check to whom and for how much?

A similar journal entry could be used to help students in your class learn to write algebraic equations while also solving a relevant, real-life problem.

**Mathematics Textbooks**

Mathematics textbooks can be a third source of good QL problems. Although most textbooks’ “real-world” problems are not very realistic or relevant to students’ lives, with a little work many can be altered to produce good QL problems.

Consider the following textbook problem:

A phone company charges 40¢ per long-distance call plus 20¢ per minute. Find the cost of an 18-minute long-distance phone call. (Smith et al. 2001)

High school students today most frequently use cell phones. The problem above, which models a pay-as-you-go plan, can be revised into the following QL problem:

Consider your current cell phone usage (or your ideal usage, if you do not have a cell phone).

Using the Internet, find two different cell phone plans—one pay-as-you-go plan and one contract plan. Determine which plan would make the most sense for you and argue mathematically why this plan is the best for your needs.

By using the adapted problem rather than the textbook problem, teachers can still cover the same mathematical content, but now they have also incorporated quantitative reasoning skills into the problem.

**Students’ Decisions**

A final source of good QL problems is simply the types of decisions that many high school students consider in their everyday lives, such as whether to purchase a car, how to redecorate their bedroom, how to interpret nutritional labels, and so on.

Even games can be sources of quantitative reasoning problems. Many students play Facebook games, such as *Zoo World*™, *Café World*™, and *FarmVille*™. These games can require decision making that uses quantitative reasoning, and teachers can create problems based on decisions in these games. For example, in *Zoo World*, players earn money according to the size and value of their zoo (bigger and more expensive zoos earn more money) and can use this money to buy animals and objects to increase their zoo’s value. Because daily profits increase with each purchase, students can be asked to make decisions about what is a better buy and how long it will take to pay off each purchase. The game can help students learn to use quantitative reasoning in financial decision making.

Remember, however, that decision making in real life does not rely exclusively on quantitative or logical reasoning. Emotions, impulse, values, or prejudice all play a role in decision making, frequently overshadowing quantitative reasoning. A single right or uniform answer to a problem is rare, as can be seen in the following example:

Jorge commutes to work, driving a total of 250 miles per week. His current car is fully paid off, but it is getting old. He spends about $1800 per year for repairs, and the car gets only 18 mpg. Jorge is thinking about buying a new hybrid that will cost $25,000 but would be maintenance free over the next five years and gets 54 mpg. Compare the overall costs of owning these two cars. (Bennett and Briggs 2010)

This problem undoubtedly entails quantitative reasoning: Assuming that the average price of gas will be $3 per gallon, the initial investment in the hybrid car will be paid off in less than eight years. However, decisions in real life are often much more complicated.

Consider the question: “If you were in Jorge’s situation, would you buy a new hybrid car?” Answers are more likely to vary now. Some sample answers that we received from students follow:
• “Yes, I would buy the car as it will pay for itself in eight years.”
• “Definitely yes, because it is our obligation to behave responsibly and take good care of our environment.”
• “No, how could I ever sell my fifteen-year-old Subaru that my dad gave me five years ago? I am going to drive it until it breaks down completely one day.”
• “I do not know because … I would need a loan, which will add to the cost of a new car … I guess that the insurance premium on a new hybrid will be much higher than on the old car, but I am not sure how big the difference would be…..”

Quantitative literacy and the habits of mind of a quantitatively literate person are not limited to the ability to find answers to questions such as that about Jorge. They represent a much broader ability to identify and interpret quantitative information around us and an inclination to take quantitative arguments and reasoning into consideration when making a decision, even if a final decision is eventually informed by factors unrelated to quantitative arguments and reasoning.

FURTHER IDEAS FOR TEACHING QUANTITATIVE LITERACY
We have described some sources of good problems that could be used to integrate QL into mathematics courses. To give students a more solid background in QL, teachers and administrators could also develop a semester- or year-long course in quantitative literacy. Although this course may not be a traditional college preparatory course, it should not be constructed as a watered-down mathematics course. In reality, the content of such a course may be more important for college success than the content of a traditional mathematics course.

Another less obvious place to include activities that promote quantitative literacy is in cross-disciplinary classes. Science, history, and even English teachers should work with mathematics teachers to incorporate QL activities into their classrooms. For example, a civics teacher could pose the following problem:

Whether or not you support war, it has a financial cost. Consider how much money the U.S. government has spent on the Iraq war. How many government-funded college scholarships could have been awarded with this same amount of money? (Eric Gutstein, personal communication)

When teachers model quantitative literacy across the curriculum, students will be more likely to value and acquire quantitative literacy skills themselves (Hughes-Hallett 2001). Further, by encountering QL problems in multiple disciplines, students will be more likely to develop the habits of mind necessary to become truly quantitatively literate adults.

REFERENCES


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