Beyond Calculation: Quantitative Literacy and Critical Thinking about Public Issues

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Calls for quantitative literacy tend to focus on matters of calculation, on improving students' abilities to understand mathematical operations and to employ them in practical circumstances. In this paper I argue that quantitative literacy needs to move beyond calculation to understand the social processes that shape the creation and consumption of statistics about public issues. In particular, I examine the nature of the social construction of statistics and discuss how such considerations might be used in teaching quantitative literacy.

Not surprisingly, many of the calls for improving quantitative literacy tend to come from those who teach mathematics. This is important, because mathematics classes center on what I will call *calculation*. I do not use this word as a mathematician might, in a narrow, technical sense; rather, I intend it to encompass all of the practices by which mathematical problems are framed and then solved. Thus, in my view, both someone adding up a column of figures and someone solving an abstract problem through a series of equations are engaged in forms of mathematical reasoning that I am calling calculation. People teach mathematics—and, for the most part, presume that they should teach it—as a series of increasingly complicated forms of calculation. Thus, mathematics instruction is a long march through ever more sophisticated tech-

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niques for framing and solving problems: that is, we first learn to count, then to add, etc., etc., until different individuals top out at algebra, trigonometry, calculus, or whatever.

Because mathematics instruction is organized around principles of calculation, calls for quantitative literacy tend to assume that students are not sufficiently adept as calculators, and that they need to improve their calculating skills, that they either need to beef up their abilities to carry out more sophisticated calculations, or that they need to become better at recognizing how to apply their abstract calculation skills to real-world situations. I do not doubt that both sort of improvements are needed, but this paper argues that key forms of quantitative literacy require moving beyond calculation.

It will already be obvious that I am not a mathematician. I am a sociologist, interested in how and why particular social problems emerge as public issues—why is it that one year public concern focuses on, say, the health risks of breast implants, and then, a few years later, attention shifts to road rage or identity theft. I have written about the role that statistics play in this process, the ways that people use numbers to convince one another that this or that is a big problem (Best, 2001, 2004). Thinking critically about such statistics requires considering both the way those numbers are calculated and the processes by which they are socially constructed. My goal in this paper is to argue that teaching quantitative literacy requires that we confront issues of *construction*, as well as calculation.

What Does It Mean to Say that Numbers Are Socially Constructed?

The term *social construction* attracted faddish attention in recent academic cultural wars; it was invoked as a justification for various relativistic, postmodern positions taken by critical literary theorists, and denounced by those who saw themselves as defending objectivity and science (Boghossian, 2006; Hacking, 1999). Forget all that. The concept of social construction originated in sociology (Berger & Luckmann, 1966), and I will use the term in its narrower, sociological sense.

Humans depend upon language to understand the world, and language is a social phenomenon. We learn language from other people, and that means that all of the meanings we ascribe to the world are understood through those people's—their language's—categories. In this sense, all knowledge is socially constructed.

In particular, numbers are social constructions. Numbers do not exist in nature. Every number is a product of human activity: somebody had to do the

calculations that produced that figure. Somebody had to decide what to count, and how to go about counting. This is not a mundane observation, at least when we encounter numbers about public issues. Understanding those figures requires, not just that we comprehend the calculations that produced them, but also that we appreciate the process of social construction.

Statistics and Public Issues

Let me begin with some examples of the sorts of numbers that regularly appear in discussions of public issues. When activists try to raise concern about some neglected social problem, when the media cover public issues, when political leaders propose new policies to address some concern—these are all occasions when statistics are likely to be invoked:

- Very often, when people seek to draw attention to some social problem, they offer numeric estimates for the extent of the phenomenon. Usually, these figures support claims that this is a big problem, one that demands attention (e.g., there are two million missing children each year; or one billion birds die annually in the U.S. from flying into windows).
- Polling data is used to describe the public's views about some social issue. Advocates often use such poll results to suggest that there is broad support for their causes (e.g., pro-life activists argue that most Americans are opposed to most abortions, whereas pro-choice advocates insist that the vast majority of Americans oppose ending legal abortion; similarly, both those favoring and opposed to adopting voucher systems for education point to surveys indicating that a majority of the public supports their position).
- Government agencies release statistical indicators (e.g., the crime rate, the unemployment rate, the poverty rate) that track conditions in the U.S. (e.g., in 2006, the U.S. Fish and Wildlife Service reported that total wetlands acreage increased between 1998 and 2004; earlier in 2007, the Census Bureau announced that racial and ethnic minorities now account for one-third of the nation's population).
- Rarely does a week go by without the news media summarizing some new medical research relating to the incidence of various medical problems (e.g., "1 in 5 Students Practice Self-Injury") or lifestyle risks (e.g., eating particular foods, smoking, or drinking alcohol increases or decreases the risks of particular health problems).

Such statistics are intended, not just to inform people, but to shape their attitudes and behaviors. Claims that millions of people are affected by some

social problem can generate widespread concern: thus, claims in the 1980s that there were millions of missing children led to Congress passing new laws, many parents voluntarily having their children fingerprinted, and countless milk cartons displaying blurry pictures of missing kids. Arguments that most people hold particular opinions encourage other people to adopt those views. And stories about dramatic medical breakthroughs can inspire people to change their lifestyles (remember the oat-bran craze?).

However, many of these numbers can not bear close inspection. Particularly when people are first drawing attention to social problems, it is unlikely that anyone can do much more than guess about how many people—let alone birds—might be affected. The very fact that advocates on opposing sides of the abortion and school-voucher debates insist that most Americans sympathize with their positions suggests that their statistics—or at least the impressions they convey—must be flawed. And contradictory news reports that a particular food or beverage is bad—or is it good?—for one's health provide fodder for stand-up comedians' suggestions that scientists may not know what they are talking about.

Or take the recent fuss after the Centers for Disease Control and Prevention (CDC) declared that obesity killed 400,000 Americans in 2003, and warned that the obesity epidemic would soon surpass smoking as the leading cause of preventable deaths. This was followed, about a year later, by a report authored by a different set of CDC scientists that argued that 26,000 would be a more accurate figure for obesity deaths. The realization that public health experts, working at the same federal agency, could not agree on even a ballpark figure for obesity deaths generated a lot of head-scratching, head-shaking commentary in newspaper editorials.

Obviously, we live in a big, complicated world, and it is next to impossible to understand what is going on in that world without resorting to numbers that promise quantitative measures—there are this many, it is increased by this much, and so on. We encounter such numbers every day. They help shape our sense of what is right and wrong with our world. These are not numbers that we calculate, rather, they are figures that we consume. They are calculated and circulated by others, who bring them to our attention in order to inform or influence our thinking.

In my view, students need to learn to think critically about these numbers, and this requires more than having a sense of how those numbers were calculated. Students also need to understand these statistics as the results of social and political, as well as mathematical, processes. And this requires confronting matters of construction.

The Rhetorical Uses of Social Statistics

To begin, we need to appreciate that many of the numbers used to portray social issues are invoked for rhetorical effect. There is a marketplace for social problems, one in which advocates for many different causes compete to first capture public attention, and then convince people to take action. This competition occurs in many arenas: a newspaper's front page can only contain so many stories; a congressional committee can hold a limited number of hearings; and so on (Hilgartner & Bosk, 1988). If one problem surges to the forefront of public attention, others will be shoved aside.

Surviving this competition requires using compelling rhetoric, claims that seem surprising, disturbing, or otherwise worthy of attention. Statistics become one element in making persuasive claims. An arresting number can attract attention. And this, in turn, encourages advocates to use figures that will make their causes seem compelling. They want statistics that can get an issue media coverage, that can arouse members of the public to join the cause, that can force politicians to take action.

This need not be a cynical process; the point is not that these advocates are lying. To be sure, there may be occasions when people deliberately fabricate data, or when they intentionally use deceptive practices. But this sort of dishonesty probably cannot account for most—let alone all—of the dubious numbers presented about public issues. Advocates are often quite sincere: they believe they have identified what is in fact a big problem that has been shamefully neglected. It is therefore often easy for them to uncritically presume that their big number—which they may acknowledge is not much more than an educated guess—must be more-or-less accurate. But sincerity is no guarantee of accuracy. There have been heavily publicized numeric estimates for social problems that proved to be off by one, two, even three orders of magnitude.

Similarly, because apparently minor differences in how survey questions are worded can lead to very different results, it is often possible for advocates on opposing sides of an issue to argue that public opinion supports their position. Again, this need not be a cynical ploy, although when advocates report the results of polls they commissioned, their claims warrant especially careful examination. Still, people who hold strong views often spend a lot of time talking to others who share their concerns; it is easy for them to become convinced that—yes—most people agree with them.

Advocates become invested in their causes. This is by no means limited to having a financial interest in an issue's outcome; they may also stand to gain or lose influence and social status, depending upon what happens. Often, too, they come to have an emotional stake in their claims. If an "obesity epidemic" poses

a serious threat to the nation's health, then the CDC and other public health officials—to say nothing of pharmaceutical manufacturers and other firms that sell weight-loss products—stand to gain (Oliver 2006). We should not be too quick to assume that the competing estimates for obesity-related deaths emanating from CDC simply reflect different calculation choices; the agency's leadership has a considerable stake in maximizing concern about the obesity threat.

The media also compete in the social problems marketplace. Their preference for important, dramatic stories means that they are drawn to claims that seem to present evidence for surprising conclusions (Two million children go missing each year! Research shows that eating oatmeal can cut your risk of heart disease!). Moreover, they are not under much obligation to check the numbers they report. So long as some researchers report that oat bran reduces health risks, a story about that research is accurate, regardless of whether oat bran actually has the beneficial effects claimed. Like advocates for competing causes, politicians, and even researchers, the media stand to benefit by promoting the sorts of large, compelling numbers that they consider newsworthy.

Of course it helps that many of the advocates estimating the scope of social problems, like many of those in the media reporting on those estimates, have problems with innumeracy (Paulos, 1988). They may want to promote accurate numbers, they may even believe that their numbers are accurate, yet they also may have trouble assessing accuracy, so that—even with the best intentions—badly flawed numbers get into circulation. Many people seem to subscribe to the innumerate notion that all big numbers are essentially equal ("A million, a billion—hey, they're all big numbers, what's the difference?"). Further, there is a widespread tendency to equate numbers with facts. Once a figure has attracted public attention, people feel free to repeat it. After all, a number suggests that somebody must have counted something—it must be true.

What about Authoritative Numbers?

It is, of course, easy to have doubts about statistics promoted by interested parties. The tobacco industry's critiques of research on the link between smoking and disease stand as a model of self-serving statistical hocus-pocus, and we can suspect that corporations generally will put forward numbers consistent with their interests. Similarly, we should anticipate that activists engaged in promoting various political and social causes will tend to use figures that advance their views. And there are many claims and counterclaims that this or that media outlet is "biased" and guilty of selective coverage. When I warn that statistics are socially constructed, these sorts of questionable sources for numbers may be the first thing that comes to mind.

But social construction can shape statistics in many other ways. To repeat: we need to consider how processes of social construction shape all statistics. Even apparently authoritative, objective figures need to be approached with care. Consider two examples involving problematic statistics produced by authoritative sources: the first a report summarizing the findings of an exhaustive, technically sophisticated government survey, the other a research report published in a major medical journal.

On March 30, 2006, Secretary of the Interior Gale Norton released a Fish and Wildlife Service report showing "a net gain in America's … wetlands for the first time since the Service began compiling data in 1954." Secretary Norton was quoted as saying: "This report, prepared as part of President Bush's initiative to stem the loss of wetlands, is good news…. Although the overall state of our wetlands in still precarious, this report suggests that nationwide efforts to curb losses and restore wetlands habitats are on the right track" ("Secretaries Norton and Johanns," 2006, p. 1). This report quickly attracted criticism from conservationists, who pointed out that the apparent increase was due solely to the adoption of a new, more generous definition of wetlands, one that included golf-course water hazards and other man-made water areas (Barringer, 2006). (The report showed that acreage covered by swamps, marshes, and other natural wetlands had actually declined, and carefully noted that "This report does not assess the quality or condition of the nation's wetlands" (Dahl, 2006, p. 15).)

This example raises at least three sorts of interpretative questions. The first involves matters of technical calculation (the application of sophisticated technologies such as aerial and satellite imagery, geospatial analysis, and computerized mapping to measure areas defined as wetlands). The report discusses these methods in some detail. The second seems to straddle the boundary between calculation and construction: What should count as wetlands? Clearly, it is possible to disagree about the appropriate definition, as evidenced by the debate between the Administration and its environmentalist critics, although of Secretary Norton's readiness to claim that total wetlands acreage had increased, while ignoring the fact that the change was wholly due to redefining what counted, seems pretty shifty. Meanwhile, the third moves completely outside the domain of mathematical calculation: Why was the definition changed? Was the Bush Administration deliberately trying to use the broader definition of wetlands to conceal ongoing environmental degradation? Or is there some more innocent explanation? Understanding the change in wetlands acreage requires thinking critically about more than matters of pure calculation.

Or take a second example, also from 2006, when an article published in the journal *Pediatrics* attracted a good deal of press coverage. CNN.com

("Study: 1 in 5," 2006), for instance, used the headline: "Study: 1 in 5 Students Practice Self-Injury." Researchers (Whitlock, Eckenrode, & Silverman, 2006) invited 8,300 randomly selected students at two Ivy League universities to participate in an Internet-based survey; they received 2,875 usable responses (a 34.6 percent response rate). Of the respondents, 490 (17%—rounded up to one in five in many news stories, although the percentage is, of course, closer to one in six) reported having practiced some sort self-injurious behavior (SIB). The most common SIB was "severely scratched or pinched with fingernails or objects to the point that bleeding occurred or marks remained on the skin" (Whitlock, Eckenrode, & Silverman, 2006, p. 1943). Only 46 (i.e., 9.4 percent of those reporting SIB, which is to say 1.6 percent of the respondents) reported having inflicted an injury severe enough that it "should have been treated by a medical professional."

This study—and the resulting media coverage—offer a nice example of what happens when medical journals issue press releases (Shell, 1998). Journals presumably hope to raise their public standing by drawing attention to the important work published in their pages. Knowing that the press is unlikely to browse through each new issue without prompting, they issue news releases heralding newsworthy articles. This encourages accentuating the most striking aspects of the research (for instance, highlighting—even exaggerating—the substantial fraction of students practicing any sort of SIB, rather than drawing attention to the tiny percentage inflicting serious injuries). We might further suspect that an editor's decision to publish or reject a paper might sometimes be affected by the work's perceived potential for attracting media coverage. Once again, calculation is not at issue; however, interpreting the statistic presented in the media requires understanding something about the social process by which numbers find their way into our daily newspaper.

These examples remind us that government agencies, researchers, editors of scholarly journals, and other authorities have agendas, too. If obesity can be recognized as a huge public-health hazard, then the CDC can reasonably request more funding to deal with this problem. Even the most professional researchers would like to see their work appear in the best journals, and receive attention in the popular media. Such considerations can easily affect choices among ways of calculating and presenting data, so as to make the results seem as important or interesting—as competitive—as possible.

Implications for Teaching Quantitative Literacy

All of this has significant implications for teaching quantitative literacy. Evaluating the sorts of numbers—and the claims that such numeric evidence

is used to support—that appear in news reports about public issues requires a broader set of critical thinking skills than mastering calculation. It also requires understanding something about the social construction of social statistics—about competition among advocates for different public issues, about the rhetorical role statistics can play in supporting advocates' claims, about the ways numbers are produced, about the assumptions and methods required to reach those numbers, about the limitations inherent in these processes, about the likely motivations and possible biases of the people who generate numbers, about ways the media make decisions to report or ignore numbers. That is, if quantitative literacy refers to a set of skills that can allow people to comfortably understand and critically examine the numbers they will encounter in their lives, including, in particular, figures that appear in discussions of public issues, then quantitative literacy instruction needs to extend beyond matters of calculation, to also encompass issues of construction.

The quantitative literacy movement seems to be composed largely of mathematicians and mathematics educators who have become skeptical about the practical value of traditional math instruction. They seem to view themselves—and are probably viewed by many mainstream mathematicians—as renegades who have ventured well outside the realm of what mathematicians recognize as mathematics. My point is that they have not gone far enough; that quantitative literacy requires some distinctly non-mathematical—that is, more than calculation-based—skills.

Because mathematics instruction emphases calculation, when it does introduce critical thinking, it tends to do so in a half-hearted, limited fashion. For example, statistics courses may make brief, tangential references to the problem of "bias." This is a convenient term, because it is ambiguous. On the one hand, statisticians use "bias" as part of the vocabulary of calculation: a sample drawn in some less than random manner is considered "biased"—what we might consider a technical, mathematical use of the term. But statistics teachers also may warn their students that some people with, say, an ideological agenda—a "bias"—may deliberately choose samples, word survey questions, or use other techniques to insure the sorts of results they favor. Thus, having an ideological bias becomes simply another form of bias in the mathematical sense. While this does offer a way of fitting ideology (and other social factors) within a mathematical framework (in that both sorts of bias skew the results of calculations), it does not go very far in preparing students to think critically about numbers, beyond offering an vague injunction to watch out for sources of bias.

While I am ill-qualified to advise primary, middle-school, and secondary educators on how to teach, let me offer one example of the sorts of lessons that

might bring construction into the quantitative literacy classroom. When I teach social problems to lower-division college students, I give a couple people a brief homework assignment. One is to locate information from pro-life sources about surveys of Americans' attitudes toward abortion; the other, of course, is to do the same thing using pro-choice sources. They invariably come to the next class armed with contradictory claims that most Americans support the position of their respective groups. This engenders a nice discussion about the ways pollsters measure abortion attitudes, about alternative ways different people can interpret the same data, and so on.

I can imagine many similar ways to get students thinking critically about social statistics. The Census Bureau announces that nonwhite minorities now make up a third of the U.S. population. What does that mean? Does it matter that a substantial share of those being counted as minorities consider themselves white? What accounts for the bureau's eagerness to reclassify people formerly considered white as minorities? A typical newspaper front page contains social, economic, or political statistics that offers similar fodder for quantitative literacy lessons that incorporate matters of both calculation and construction.

But Will It Work?

In short, I envision quantitative literacy as going beyond calculation. However, I realize that, even if others find my argument convincing, it is likely to prove very difficult to incorporate this goal in quantitative literacy programs, because the people who teach math—who are, after all, the folks most interested in quantitative literacy, and the ones who will doubtless wind up teaching this material—have been trained to teach calculation, and they tend to define the problem of quantitative literacy in terms of people being insufficiently adept at calculation. They are likely to see the sorts of issues I have raising as, at most, peripheral to increasing quantitative literacy.

Ideally, of course, critical thinking lessons ought to be taught across the curriculum. We can imagine quantitative literacy lessons being taught in all sorts of classes. Couldn't students learn how to read—and ask questions about—say, news reports about new medical findings in science classes, or health classes, or social studies classes? Certainly this would be desirable, but getting the cause of quantitative literacy to spread beyond math classrooms obviously poses its own challenges. Those teaching other subjects will want to focus on what they see as the important content in their own subjects; they may doubt their qualifications or ability to venture into mathematical terrain; they may insist that teaching quantitative literacy is the job of math teachers; and so on.

In short, it seems to me the cause of quantitative literacy faces two challenges: first, recognizing that quantitative literacy must encompass more than matters of calculation; and, second, finding ways to integrate quantitative literacy—and critical thinking more generally—into the curriculum.

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