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Quantitative Literacy and Civic Virtue

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Abstract

Mathematics educators are occasionally called upon to justify the existence or the offering of quantitative literacy courses. This paper argues that effective quantitative literacy courses have different goals than algebra courses and are legitimate alternatives to algebra courses for non-STEM students. Furthermore, quantitative literacy courses affirm the historic relationship between citizenship and education. In today's world of proliferating news sources, social media, and fake news, quantitative literacy has become an essential component of the long-held ideal of civic virtue.

Keywords

quantitative literacy, critical thinking, citizenship, civic virtue

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Cover Page Footnote

William Briggs is professor emeritus at the University of Colorado at Denver. He is the author of textbooks in quantitative literacy, statistical reasoning, calculus, and problem solving.

Facts are stubborn things; and whatever may be our wishes, our inclination, or the dictates of our passions, they cannot alter the state of facts and evidence.

— John Adams

Introduction

One of the basic lessons we teach in quantitative literacy courses is that polls and surveys must be digested with care. They are susceptible to many sorts of errors that can make them notoriously unreliable and misleading. Nevertheless, when it comes to recent polls about how Americans obtain and evaluate news, the results—even taken with the recommended caution—are unsettling, if not alarming.

The first disturbing trend is the diminishing trust in the news media. A 2018 Gallup/Knight Foundation report found that 88 percent of respondents believe that the news media have a critical or very important role in informing Americans about public affairs. Despite that view, more respondents have a negative (43 percent) than positive (33 percent) view of the job the news media are doing. The same poll found that 66 percent of respondents believe the news media do not do a good job of separating fact from opinion (up from 42 percent in 1984). And at a time when we are awash in news and information from more sources than ever before, 58 percent of respondents say it's more difficult to stay reliably informed because of “the explosion of information sources” (Gallup 2018).

A Pew Research Center poll addressed the role of social media. In that poll, two-thirds of respondents (78 percent of under-age-50 and 55 percent of over-age-50) claimed to get at least some news from social media (largely Facebook, followed by Twitter, YouTube, and Snapchat). However, only five percent claimed to have a lot of trust in social media sources, compared with 20 percent who have a lot of trust in national news organizations (Bialik and Matsa 2017).

Undoubtedly, one of the reasons for the declining trust in the news media is the presence of fake news (defined as “news articles that are intentionally and verifiably false, and could mislead readers” (Alcott and Gentzkow 2017, 213). In a recent Harvard/Harris poll, 65 percent of respondents believed that the mainstream media is filled with fake news (Easley 2017). According to a Pew poll, 64 percent of respondents say made-up news has caused “a great deal of confusion” about the basic facts of current events (Anderson and Rainie 2017). Among the many observations of the Knight Foundation report (Gallup 2018) are that

- 88 percent of respondents say fake news is a very or somewhat serious threat to democracy;

- fewer than half of the respondents claimed they could identify a single news source they believe is objective; and
- 30 percent have shared a story that they knew or later found out was false.

Fake news has also become the subject of scientific inquiry. A recent study in *Science* magazine analyzed twelve years of Twitter data consisting of 126,000 tweets spread by about three million people. The upshot of the study was that false stories (as determined by six independent fact-checking sites) diffused faster and reached more people through Twitter chains than true stories. The authors attributed the difference in part to the “novelty and emotional reactions” of the false stories (Vosoughi et al. 2017).

Another study published in the *Proceedings of the National Academy of Sciences* analyzed six years of data pertaining to the news-sharing habits of 376 million Facebook users following 920 news outlets. The sophisticated analysis determined that the more active users relied on fewer news sources. These active users tended to cluster around those news sources with similar content or outlook. The result, according to the report, is a collection of news-sharing communities (“echo chambers” in the words of the report) that are sharply polarized based on news content and opinion (Schmidt et al. 2017).

Tom Nichols, a conservative international affairs expert (and five-time undefeated *Jeopardy!* champion), has a slightly different perspective on the origins of fake news. In his passionate book, *The Death of Expertise*, he laments the rejection of expertise and the demise of established knowledge. Nichols observes that once a person rejects an accepted fact, he is free to find or create an alternative fact. And then the availability of social media facilitates the spread of that alternative fact. Nichols writes that

the United States is now a country obsessed with the worship of its own ignorance. It’s not just that people don’t know a lot about science or politics or geography. ... The bigger problem is that we’re proud of not knowing things. Americans have reached a point where ignorance, especially of anything related to public policy, is an actual virtue. ... It is a new Declaration of Independence: no longer do we hold *these* truths to be self-evident, we hold *all* truths to be self-evident, even the ones that aren’t true (Nichols 2017, ix-x).

Nichols indicts social media (including Google and Wikipedia) for conferring the title *expert* on anyone who has an opinion on a subject. He notes that self-appointed experts appear not only in politics and public policy, but in law, medicine, and other disciplines in which there is an accepted path of training and certification.

We seem to be in a perilous situation. Americans say they need the news media as a vital means to be well-informed citizens. And yet their trust in the news media is at an all-time low. The situation is aggravated by the proliferation of news sources with social media playing an increasingly prevalent role. Then, as some

inexplicable consequence of these factors, fake news has emerged and spread like an epidemic.

The existence of fake news has made the essential process of filtering and evaluating news stories more challenging than ever. The ability to separate facts from opinions requires new levels of skepticism and analysis. The poet Archibald MacLeish was appointed head of the new Office of Facts and Figures by Franklin Roosevelt in 1941; the office was created to defend against the Nazi propaganda war. MacLeish noted that, “The strategy of truth is not ... devoid of strategy. It is not enough, in this war of hoaxes and perpetuated lies, to be merely honest. It is necessary also to be wise” (cited in Lepore 2017, 37).

What is today’s version of MacLeish’s strategy of truth? How do we restore the primacy of truth? Unbiased fact-checking sites offer a short-term solution, but it’s unlikely that Factcheck.org, Politifact, Snopes and other reputable sites can keep up with the expanding flood of fake news. Another recent article in *Science* suggests an obvious solution.

Another, longer-run, approach [to detecting fake news] seeks to improve individual evaluation of the quality of information sources through education. There has been a proliferation of efforts to inject training of critical information skills into primary and secondary schools. ... There is a great need for rigorous program evaluation of different educational interventions (Lazer et al. 2018, 1094).

And of all available “educational interventions,” surely one of the most effective is that collection of mathematical, logical, and cognitive skills called *quantitative literacy*. As we show, these skills empower individuals to distinguish authentic and fake news, make informed decisions, and formulate justifiable positions on social, economic, and political issues—in other words, to be functional and thoughtful citizens.

Quantitative Literacy

Several decades ago, a movement called *core curriculum* swept American colleges and universities. The admirable idea was that upon graduation, all undergraduates should be familiar with a common, minimum collection of skills and knowledge areas. One component of the core curriculum was additional exposure to mathematics. For many colleges and universities, there was a simple way to satisfy the mathematics requirement of the core: require all students to take a traditional algebra course—the same course required for students in STEM (science, technology, engineering, and mathematics) majors. For STEM majors, this requirement was hardly a hurdle. However, for non-STEM students (largely liberal arts students) this solution was often disastrous.

Non-STEM students had likely already taken algebra in high school and many of them had not prospered. More importantly, a typical algebra course for calculus-

bound students, contains very little useful material that non-STEM students can use in their future course work, in their careers, and in their lives as productive citizens. Slowly, many mathematics departments across the country realized that, by herding all students into algebra courses, they were not serving the quantitative needs of a majority of their students. Clearly, special courses for non-STEM students were needed.

As a result of this realization, a bewildering variety of courses began to appear, under names such as *Math Appreciation* or *Math for Liberal Arts Students*. In many cases, these were conflicted courses, caught between the need for demonstrating adequate rigor and the need to present topics of use to non-STEM students. Over many years, out of the deliberations of many curriculum committees, it's fair to say that a viable approach has emerged for providing non-STEM students with a relevant and meaningful mathematical experience; that approach goes under the name *quantitative literacy* or *quantitative reasoning*.

An effective quantitative literacy course is a legitimate alternative to an algebra course once one realizes that it has a different purpose than an algebra course and it emphasizes different skills. An algebra course is content-driven: it is a tick-list of skills that prepare students for calculus and other STEM topics. By contrast, a quantitative literacy course is context-driven: it starts with a list of topics and problems that are relevant to the courses, careers, and lives of non-STEM students. That list of applications then determines the skills and ideas that appear in the course.

The following brief list of skills and topics gives a taste of the richness of an effective quantitative literacy course.

- An awareness of logical and formal fallacies is needed to detect the deceptions of advertising, propaganda, and political campaigns.
- An understanding of the natural world, social sciences, and economic systems requires number sense and ability to make estimates and numerical comparisons.
- A familiarity with financial management skills (house and student loans, investments) or the finances of the federal government requires basic algebra.
- Understanding the risks of gambling and lotteries requires an introduction to probability.
- Statistical reasoning, interpreting graphical displays, and using spreadsheets are needed to interpret the data and statistics that permeate our lives (polls, surveys, data analysis, designing experiments).
- Simple mathematical modeling, for example, to appreciate the power of exponential growth, calls on algebra and the use calculators.

- Political topics such as apportionment, redistricting, and voting require new concepts and basic calculations.

And the list goes on as students discover that mathematics can be uncovered in art, music, psychology, marketing, nursing and medicine, and every other academic discipline.

Hopefully, those examples give a workable notion of quantitative literacy. If not, the following definition covers its many aspects.

Quantitative literacy is a collection of mathematical, logical, and cognitive skills that includes using elementary logic in everyday thinking, interpreting data, reasoning with numerical information, formulating decisions based on quantitative evidence, and appreciating the role that these skills play in the life of a reflective, constructive citizen.

Quantitative literacy is more than mathematics. One implicit component of quantitative literacy that runs through every course is *critical thinking*. We shouldn't work too hard at a definition of this elusive term, except to say that it captures the logical and cognitive sides of quantitative literacy.

The American philosopher John Dewey identified a key component of critical thinking when he said,

to maintain the state of doubt and to carry on systematic and protracted inquiry — these are the essentials of thinking. ... Reflective thinking, in short, means judgment suspended during further inquiry; and suspense is likely to be somewhat painful (Dewey 1910, 14).

Dewey's warning about patience and avoiding a rush to judgement is particularly salient when it comes to assessing the news. A recent poll showed that 42 percent of respondents impatiently classified an accurate news report to be fake news if it did not conform to their opinion on the subject (Gallup 2018). Among other mindsets, critical thinking requires deliberation and discipline.

The revered astronomer and writer Carl Sagan provided critical thinkers with his ten-point Baloney Detection Kit. Among the advice given there is the observation that

arguments from authority carry little weight — “authorities” have made mistakes in the past. They will do so again in the future. Perhaps a better way to say it is that in science there are no authorities; at most, there are experts. (Sagan 1996, 210).

Sagan's admonition to question authority is another aspect of critical thinking and an antidote for fake news: like food, it's advisable to know the sources of the news you consume.

Research in cognitive psychology over several decades also has a bearing on critical thinking and should be considered a component of quantitative literacy. Much of this research either originates with or reaffirms the work of the Israeli psychologists Amos Tversky and Daniel Kahneman. (Tversky died at the age of 59 in 1996. Kahneman received the Nobel Prize in economics in 2002.) Their work relied on surveys and imaginative experiments that were designed to investigate

how people make decisions, assess risk, and frequently fall victim to fallacies and flaws in thinking. In short, their work was an exploration of critical thinking (Lewis 2017, Plous 1993).

The research of Tversky and Kahneman gave currency to ideas such as *confirmation bias* (the tendency to seek and cite only the evidence that supports what you already believe), *availability heuristic* (making decisions based on easily recalled or imagined events and facts), the *representativeness heuristic* (the tendency to replace a situation of interest by an apparently similar situation), *anchoring* (the often erroneous adjustment of an estimate or opinion based on given information). It also provided insight into the curious misunderstandings of randomness.

It's difficult to mention Tversky and Kahneman without giving examples of their experiments and the often unexpected results. One of their most famous survey questions now goes by the name of the Linda problem.

Linda is 31 years old, single, outspoken, and very bright. As a student, she majored in philosophy and was deeply concerned with issues of discrimination and social justice. She also participated in antinuclear demonstrations. Which is most likely?

- Linda is a bank teller.
- Linda is a bank teller and is active in the feminist movement.

Anyone who has posed this question in a classroom knows the response that Tversky and Kahneman saw repeatedly in their studies. They discovered that upwards of 90 percent of respondents believed the second description of Linda is more likely (an example of the representativeness heuristic). In fact, the first description is more likely because it includes the second description.

Another example exposes how we assess risk. The prototype problem asks which of two options you would choose:

A: A certain *gain* of \$100

B: A coin flip in which a head gives you \$200 and a tail gives you \$0.

Although both options have the same expected gain of \$100 (a nice example of expected value), respondents in Tversky and Kahneman's experiments favored option A by large margins.

Posing the flip-side question, we now ask which of the following options you would choose:

A: A certain *loss* of \$100

B: A coin flip in which you lose \$0 with a head and you lose \$200 with a tail.

The expected loss is \$100 with both options, but large majorities of respondents selected option B. Combining these results, we conclude, as verified by many similar experiments, that humans tend to be risk-averse when the choice involves gains and risk-seeking when the choice involves losses.

The lessons of Tversky, Kahneman, and other cognitive psychologists shed light on our critical thinking and decision-making skills. These lessons are still remarkably unrecognized at a time when they are needed more than ever before.

Civic Virtue

Strong critical thinking skills and quantitatively literacy are needed if we are to avoid drowning in the tidal wave of news and information that emanates from both conventional and social media sources. And certainly, navigating the news, evaluating quantitative information, and making sound decisions are part of what it means to be a responsible and engaged citizen. Combining these observations, we can conclude that effective citizenship relies on quantitative literacy.

The connection between education and citizenship has a long history. The ancient Greeks believed that a healthy democracy requires virtuous, well-educated citizens. The term *paideia* (often attributed to Isocrates, ca. 400 BCE) is variously interpreted to mean the process of educating people to be productive citizens.

The same theme is expressed in the writings of the Roman statesman Cicero, Enlightenment philosophers such as Rousseau, and founders of the American government. Thomas Jefferson, writing in 1787 from Paris to a delegate of the Continental Congress, said that engaged citizens must have

full information of their affairs thro' the channel of the public papers, and to contrive that those papers should penetrate the whole mass of the people. The basis of our governments being the opinion of the people, the very first object should be to keep that right (Founders 2018).

In a lighter vein, the American educator and champion of public schools Horace Mann famously observed that

a republican form of government, without intelligence in the people, must be, on a vast scale, what a mad-house, without superintendent or keepers, would be on a small one (cited in Reich 2018, 176).

Franklin Delano Roosevelt asserted “that the schools make worthy citizens is the most important responsibility placed on them” (cited in Crittenden 2002, 83).

This line of thinking has led to the notion of *civic virtue*: a collection of attitudes, knowledge, and skills that enable citizens to contribute to the stable working of government and the welfare of society. Civic virtue has always included the basic knowledge once learned in civics courses: the branches of government, the ways laws are made and enforced, and so forth. However, today, in a world soaked with quantitative information and conflicting news reports—all delivered through multiple media sources—civic virtue necessarily includes critical thinking and quantitative literacy.

In the report *The Role of Civic Education*, the authors assert that, “The intellectual skills essential for informed, effective, and responsible citizenship sometimes are called critical thinking skills” (Branson 1998). In his recent book *The Common Good*, former Labor Secretary Robert Reich mourns that civic duty and commitment to the collective welfare of the nation have been replaced by a “whatever-it-takes” attitude in both personal dealings and politics. He notes that “truth itself is a common good,” and writes

Democracy depends on citizens who are able to recognize the truth, analyze and weigh alternatives, and civilly debate their future, just as it depends on citizens who have an equal voice and equal stake in it. Without an educated populace, a common good cannot even be discerned. ... When education is viewed as a private investment yielding private returns, there is no reason why anyone other than the “investor” should pay for it. But when understood as a public good underlying our democracy, all of us have a responsibility to ensure that it is of high quality, and available to all (Reich 2018, 33).

There could be no clearer statement of the alliance between citizenship and education. An enduring democracy relies on engaged, well-educated citizens endowed with civic virtue. Today, we need an enlarged concept of civic virtue that accommodates a complex, rapidly changing world. Civic virtue must include the fundamental skills of critical thinking and quantitative literacy. And the schools, colleges, and universities of this country must embrace this vital educational challenge.

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