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Rethinking the Numerate Citizen: Quantitative Literacy and Public Issues

Ander W. Erickson
University of Michigan - Ann Arbor, aweric@umich.edu

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Rethinking the Numerate Citizen: Quantitative Literacy and Public Issues

Abstract

Does a citizen need to possess quantitative literacy in order to make responsible decisions on behalf of the public good? If so, how much is enough? This paper presents an analysis of the quantitative claims made on behalf of ballot measures in order to better delineate the role of quantitative literacy for the citizen. I argue that this role is surprisingly limited due to the contextualized nature of quantitative claims that are encountered outside of a school setting. Instead, rational dependence, or the reasoned dependence on the knowledge of others, is proposed as an educational goal that can supplement quantitative literacy and, in so doing, provide a more realistic plan for informed evaluations of quantitative claims.

Keywords

quantitative literacy, information literacy, social epistemology

Cover Page Footnote

Ander Erickson is a research associate with the Geometry Reasoning and Instructional Practices (GRIP) research group at the University of Michigan. His research interests include information literacy instruction in the mathematics classroom, quantitative literacy and teacher decision-making.

> It seems . . to violate . . any realistic appreciation of the human situation, to think that the problem of ignorance could be solved if people just tried harder to make themselves wise. (Friedman 2006, xxxiii)

> "You have not discovered a potion for remembering, but for reminding, you provide your students with the appearance of wisdom, not with its reality." -Thamus via an ancient tale via Socrates via Plato

Introduction

I want to draw attention to a class of problems. Let's call them *public problems*: questions that are publicly argued, consequential, and relevant to the citizen. Should we be worried about climate change? Is recycling worthwhile? Will the health care reform bill deliver on its promises? Should state sales tax be increased? Should aspartame be banned by the FDA? The citizen is often called upon to take a stand on these issues: whether in the voting booth, by voices in the media, or by members of their social milieu. Many take it for granted that our system of public education should help prepare students to make these decisions. I am going to contest one form that this expectation takes: the idea that students ought to have a basic understanding of the disciplines that inform these public problems. Does the citizen need to know something about biology to have something to say about aspartame? Will mathematical knowledge help an individual have a productive opinion about climate change? In so doing, I will focus upon some of the rhetoric surrounding quantitative literacy, an "everyday understanding of mathematics" (Wilkins 2000), because it has explicitly embraced this expectation as it pertains to the field of mathematics.

The quantitative literacy movement is not simply a push for greater enrollment in mathematics courses; moving mathematics away from a preparatory role for the scientific fields and into a more ecumenical position as a facilitator of everyday action entails a rethinking of the curriculum. Specifically, it is felt that the calculus-oriented mathematical track currently prevalent in our public school system does not provide the type of mathematical knowledge most useful for good citizenship. Lynn Steen, a mathematician and prominent advocate of quantitative literacy, states that "even individuals who have studied trigonometry and calculus often remain largely ignorant of common abuses of data and all too often find themselves unable to comprehend (much less articulate) the nuances of quantitative inferences" (Steen 2001). Indeed, concerns about the ability of the

average citizen to navigate this "data-drenched" society appear well-founded at first glance. It is an established fact that people (even those who are well-educated) make consistent errors when called upon to make quantitative judgments (Kahneman et. al. 1982) and that, by any extant measure, a sizable proportion of the population has a low level of quantitative literacy (Kirsch et. al., 1993; Wilkins, 2000). A typical curricular response to this perceived problem is exemplified by a recently published textbook, *Case Studies for Quantitative Reasoning* (Madison et al. 2009); students are presented with newspaper articles in which the writers employ quantitative arguments and then are asked to evaluate them. In fact, many of the issues addressed in the textbook belong to the category of problems that I sketched out above: fuel-efficiency standards, tax cuts, and the health care crisis, for example.

Where does that leave these public problems? Should they be examined in order to determine the quantitative skills entailed in their apprehension and possible resolution? Does quantitative literacy have a claim on them? I argue the contrary; a generalized feel for numbers that encompasses statistics and probability has no purchase on these issues, and it is misleading to imply otherwise. Stated more broadly, a small amount of disciplinary knowledge does not provide its possessor with any way of evaluating claims that are informed by experts in the subject.[1] Hardwig (1985) nicely captures this state of affairs with his notion of *epistemic dependence*:

> The layman's appeal to the intellectual authority of the expert, his epistemic dependence on the expert, and his intellectual inferiority to the expert (in matters on which the expert is expert) are all expressed by the formula […]: *B* has good reasons to believe *A* has good reasons to believe that *p*. But the layman's epistemic inferiority and dependence can be even more radical – in many such cases, extensive training and special competence may be necessary before *B* could conduct the necessary inquiry. And, lacking this training and competence, *B* may not even be able to understand *A*'s reasons, or, even if he does understand them, he may not be able to appreciate why they are good reasons (338)

I would only supplement this formulation with two points. First, while the layperson/expert dichotomy may strike an offensive note at first blush, it ought to be noted that we are all essentially in the same boat. That is to say, an expert is only an expert in a highly circumscribed domain and the moment she steps

[1] Any attempt to locate exceptions to this state of affairs is problematic because the non-expert has no a priori means of determining whether a given situation might be an exception without expert knowledge. This bears upon the inclusion of public problems in the curricula. After all, even if we allow that those who picked the problems are disinterested, yet appropriately knowledgeable, parties who have constructed a problem that will allow the students to come to the correct conclusion (we might understand 'correct' to mean the conclusion that they would naturally come to were they to have facility with the material being taught), the problems that they encounter in real life will not be provided in such a manner.

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beyond that limited sphere, her status reverts to that of a layperson. Second, as Siegel (1988) notes, an individual's awareness of their epistemic dependence does not give them leave to relinquish their rationality; it only highlights the non-disciplinary rationality that must guide their decisions instead of a partial disciplinary knowledge that can, at best, provide a sense of false confidence. This other rationality includes assessing whether a given problem falls into a domain in which there exists expertise, determining the identity of pertinent experts, and adjudicating between contradictory expert claims. This work is, of course, complicated by the fact that the individual cannot rely upon disciplinary knowledge to carry out any of these analyses.

I will provide an example that illustrates the consequences of the foregoing theoretical analysis through an examination of the relationship between quantitative literacy and public problems. Specifically, I examined a selection of political arguments found in newspaper editorials in order to better characterize the ways in which quantitative literacy can and cannot aid in their apprehension and evaluation. Two observations are highlighted here: first, understanding the import of the arguments does not require quantitative literacy in any of its forms; second, the contextualized knowledge necessary to evaluate the arguments goes beyond anything that might reasonably be expected of a citizen (i.e., the citizen is epistemically dependent in these situations). These observations lead me to claim that quantitative literacy (however it is defined) is neither necessary nor sufficient for the evaluation of the arguments. What is the alternative for a citizen who wants to make wise decisions respecting public problems? I propose that citizens need to rely upon the testimony of others and that a small amount of disciplinary knowledge will, at best, only confound this activity. This conclusion is probably not of much consequence for the teaching of quantitative literacy, in and of itself. After all, quantitative reasoning features prominently in many domains apart from the evaluation of public problems: job preparation, cultural appreciation, personal finance, etc. On the other hand, I believe that the conclusion has rather large consequences for the curriculum as a whole, especially because it applies equally well to other types of disciplinary knowledge. If discipline-specific instruction fails to provide students with the tools needed to approach public problems, then we must ask ourselves whether the school system has anything to contribute to that domain. I conclude by suggesting that the nondisciplinary rationality described above—finding appropriate sources of expert knowledge—needs to become a site of educational research so that it can eventually take a prominent place in the curriculum.[2] First, however, I will characterize the quantitative

[2] I've referred to this potential construct, the evaluation of expert knowledge, as an adisciplinary component of the curriculum but it may also be characterized as a content-transcendent goal as defined by Norris (1996). Interestingly, the content-transcendent goal that he examines is

literacy movement as an example of a curricular movement that positions itself as a necessary adjunct to good citizenship.

Quantitative Literacy and the Citizen

It has long been recognized that a certain level of mathematical knowledge can provide great affordances in everyday life. This skill set, mathematical in nature but not synonymous with the mathematics taught in school, has been termed numeracy in the United Kingdom and quantitative literacy (QL) in the United States (Chiswick et. al. 2003; Steen 2001; Kennedy 2001). Multiple constructs frustrate any attempt to provide a consistent definition of QL and to reconcile this with related terms that have appeared in the literature including mathematical literacy and statistical literacy (Kilpatrick 2001; Gal 2002). A taxonomy of these constructs would take me too far afield, so I will simply employ the working definition provided by Wilkins (2000):

> The term quantitative literacy is defined as an everyday understanding of mathematics. More explicitly, quantitative literacy includes a knowledge of mathematical content embedded in a contextual framework that promotes an understanding and appreciation of the nature, development, and social impact of its applications. Furthermore, it includes a capacity for reasoning and utility and is further supported by a feeling that one is able to function in a quantitative situation. (1)

An important commonality between this definition and others is the contextual nature of the mathematical problems attended to by QL. This generalized mathematical/statistical knowledge implies comfort with quantitative arguments and enables its possessor to engage in quantitative reasoning (Shavelson, 2008).[3]

Many disagreements exist about the place of quantitative literacy in the curriculum and whether it deserves the prominence advocated by some of its proponents. This debate will be elided, however, because my present purpose is only to establish that some see a connection between QL and good citizenship: this connection between disciplinary knowledge and broader public problems is implicit in much of our educational system and is made explicit in the writings on QL. The proposed connection between quantitative literacy and democratic citizenship features prominently in *Mathematics and Democracy* (Steen 2001), a

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'intellectual independence': a goal that is, as formulated by Munby (1977), directly opposed to the concern of this paper.

[3] Shavelson (2008) acknowledges the difficulty of defining quantitative reasoning and ends up triangulating via three approaches (psychometric, cognitive, and situationist). His verdict is that a situationist (informed by the cognitive perspective) definition is the most compelling. I believe that his working definition squares well with Wilkin's; the assessment measures, in any case, are very consistent with the quantitative problems that I will be dealing with in this paper.

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volume edited by Steen and authored by a number of noted mathematicians and educators. The collection offers a multi-faceted definition of quantitative literacy: encompassing everything from culture to education to personal finance to work. While most of these categories would have equal applicability to the citizen of any country, the title of the book foregrounds the connection between QL and democratic participation. As Steen states in the introduction, "virtually every major public issue -- from health care to social security, from international economics to welfare reform -- depends on data, projections, inferences, and the kind of systematic thinking that is at the heart of quantitative literacy." (ibid 14) This claim is echoed throughout the accompanying essays (Cohen 2001; Ewell 2001; Schoenfeld 2001) and, indeed, throughout much of the literature that pertains to quantitative literacy (Sweet et. al. 2006; Weist et. al. 2007). I provide a few examples in order to communicate the tenor of these remarks:

> If individuals lack the ability to think numerically they cannot participate fully in civic life thereby bringing into question the very basis of government of, by, and for the people. (Orrill 2001)
>
> Our multitudes of numerical indicators summarize the complex economic, political, and social health of the country, and citizens need to be able to decode and decipher this modern-day 'political arithmetic.' (Cohen 2003)
>
> In the Unites States many people have come to recognize the critical role of an everyday understanding and appreciation of mathematics as an important characteristic of a well-informed citizen. (Wilkins 2000)

Given this valorization of quantitative literacy, we may well wonder what research has to tell us about the subject. There are models of quantitative literacy and its cousin statistical literacy (Steen 2001; Gal 2002; Watson 2003), analyses of circumstantial evidence that are used to ascertain historical levels of quantitative literacy (A'Hearn et. al. 2006), examinations of correlations between quantitative literacy and labor market outcomes (Green et. al. 2000; Chiswick et. al. 2003), the development of instruments to measure quantitative literacy (Wilkins 2000, 2009), and there are a number of studies that explore the manner in which numeracy may contribute to informed healthcare decisions (Hamm et. al. 2003). Lacking, in all of this, is any theoretical articulation of the role it may play in civic participation. The authors of *Mathematics and Democracy* provide a number of conjectured applications:

> Understanding how resampling and statistical estimates can improve the accuracy of a census.
>
> Understanding how different voting procedures can influence the results of elections.
>
> Analyzing economic and demographic data to support or oppose policy proposals.
>
> Understanding quantitative arguments made in voter information pamphlets (e.g., about

> school budgets or tax proposals). (Steen 2001, 10-11)

More hypothetical scenarios are offered by contributors to the collection. Schoenfeld (2001) says that "literate citizenship calls for making a plethora of informed decisions -- about interest rates, about situations that are inherently probabilistic, about the nonsense spewed by politicians" (53). Ellis (2001) suggests that citizens may find themselves "analyzing data to support or oppose a local government proposal" (63). This rhetoric, combined with the extant quantitative literacy curricula with its focus on the analysis of public issues as portrayed in the media, strongly implies that a citizen needs some mathematical background in order to make an informed decision with respect to public problems.

In the following section, I provide a limited example of the role of QL in political argumentation through an analysis of newspaper editorials pertaining to a number of recent ballot measures. I will put forward two observations about the role of QL in public debate, along with supporting evidence. The import of my argument will be that the preceding characterization of QL's role rests upon a fundamental misunderstanding of work that goes into examining public problems; a misunderstanding that simultaneously disempowers the uneducated and grants too much power to the educated. It is telling that a contributor to *Math and Democracy* speaks of Dewey's "popular enlightenment" (Orrill 2001) as a necessary component of a "vital democracy" and worries that innumeracy (i.e., quantitative illiteracy) puts us in danger of a "regress to pre-enlightenment conditions" (xvi). It has been argued that Enlightenment thinkers such as Descartes and Kant "provide us with a romantic ideal which is thoroughly unrealistic and which, in practice, results in less rational belief and judgement" (Hardwig 1985, 340). Kant demanded that we have the courage to use our own understanding but this edict, productive as it may be within a discipline and for personal matters, impoverishes the individual's analysis of public problems.

An Example: The Role of Numbers in Political Discourse

Public problems are not always up for a vote, but I have restricted this example to political argumentation that is centered on votable issues, as it is much easier to delineate a discourse when it is tied to a ballot measure or a candidate. In particular, I draw from the website Ballotpedia; an inventory of current and historical ballot measures that also contains links to pertinent newspaper endorsements. My focus is on the 17 ballot measures that were under consideration during 2009, and the 79 accompanying editorials. I read every

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endorsement (pro and con) listed in Ballotpedia and noted every appearance of a number.

The point of my immediate argument is that quantitative reasoning, as it features in political argumentation, is extremely limited. It is easy to see why one might imagine the contrary. By my count, the third Obama-McCain debate as presented in a transcript published by the *Los Angeles Times* in 2008, contains at least 19 separate claims that contain a numerical component. I also found that over half of the statewide ballot measures that were voted upon in 2009 were centered on quantitative issues (largely taxation and financing); and it is certainly true that the average citizen, as mentioned earlier, does not have a lot of quantitative knowledge. It would seem to follow that the danger of voter error looms large in electoral politics. If numbers pervade political discourse and voters are not very good with numbers then mistakes ought to abound. So here is the question that I must answer: How can numbers be talked about, yet not reasoned about?

In answer to this question, I am presenting two observations that collectively describe the role of numbers in the political arguments that I examined. First, the reader simply does not need facility with numbers (or statistics or probability) to understand the recommendations or conclusions provided by the disputant. This probably will not come as any surprise; it would take a rather poor editorialist to leave their reader in the dark about their views on a subject. Second, while the conclusions of these arguments may be transparent, this is hardly the case for the arguments themselves. The arguments' claims exist within contexts that present a barrier to analysis that no reasonable level of QL can overcome. This opacity cannot be put down to disingenuousness on the part of the authors because, as I will attempt to demonstrate, it is a feature of the topics under discussion. Thus, the reader must rely upon experts in the field in question. Crucially, even if some of the arguments did not require this deeper contextual knowledge, readers do not have any *a priori* means of determining whether the argument in front of them falls into that category and so they, again, must rely upon expert knowledge. Taken together, these findings suggest that the ability to engage in quantitative reasoning, while possibly of great importance in other domains, is not a prerequisite for civic participation. Indeed, it is fortunate that this is the case because a generalized ability to do mathematics "in context" would not be sufficient for any substantive analysis of the numbers employed in political discourse.

1. Citizens can understand the import of arguments without employing quantitative reasoning.

> Maine towns collectively raise about $4 billion a year from all sources, and the reduction in auto excise tax provided by this measure would cut that by an

> estimated 2 percent. (*Morning Sentinel* February 21 2009)

This point may best be served by looking at a potential exception. In the editorial quoted above, written in favor of a measure that would reduce Maine's auto excise tax, I might feel called upon to actually calculate 2% of $4 billion, a task that could prove intimidating to anybody lacking a minimal level of QL. As it turns out, I do not need to go the trouble. The author does not tell me that 2% of $4 billion is $80 million (the actual estimated reduction is $83 million) but I am told that it is "not an inconsiderable sum of money" and reassured that local governments may be able to recover the shortfall through careful financial planning. Notably, an ability to find percentages confirms that the amount is considerable but it does not provide me with any way of evaluating the latter claim: a statement that lies at the heart of the argument.

Numbers are usually introduced into these editorials in a manner that does not suggest a need for any mathematical work at all. A bond is proposed in Ohio that will allow the state to borrow and spend $200 million on veterans. Is $200 million unreasonable or reasonable? There is no math that can answer that question without additional context. As it stands, every argument in favor of the bond mentioned the $200 million, but not a single one of them said anything about what the number meant (*Toledo Free Press* 2009; *The Columbus Dispatch* 2009; *Akron Beacon Journal* 2009). Instead, they appealed to the importance of helping veterans. There was one argument against the measure (*Mansfield News Journal* 2009) which also brought up the $200 million, but it simply said that the state could not afford the price-tag and did not provide a rationale. Here is a typical example from another measure on the Maine ballot,

> The $71 million bond devotes $55 million to state highways and bridges, $8 million to port and ferry improvements, $4 million to railroad upgrades, $3.6 million for aviation work and $400,000 for the Acadia Gateway project in Trenton. (*Bangor Daily News* October 23 2009)

I do not want to belabor an obvious point; these numbers are all presented to the reader but the only math involved would be a trivial confirmation that the breakdown described does indeed add up to $71 million. Perhaps it would be better to talk about why these numbers appear in the argument at all. It would appear patronizing for the *Bangor Daily News* to simply say, "a bond issue was proposed by the Governor and the House Majority Speaker, the amount seems appropriate, and so we recommend that you vote in favor". But are the numbers included because the paper thinks that more than a vanishingly small percentage of their readership would have anything to say about the reasonableness of spending $3.6 million on aviation work or $400,000 on the project in Trenton?

Most of the numbers encountered in the editorials were entirely extrinsic to the arguments at hand:

> State officials predict if I-1033 passes, it would reduce state funds by $5.9 billion by 2015. Counties would lose about $694 million, with cities taking a $2.1 billion hit […] We maintain our state government spends too much of our money and without outside pressure and laws such as I-1033, those running our governments will continue to turn towards higher taxes to fund ever-expanding programs. (*The Chronicle* October 19 2009)

> The initiative would effectively anchor state revenues to the spending limits of this current recession and would prevent the state from digging itself out of this budgetary hole. The State Office of Financial Management predicts the initiative would reduce the state budget by $5.9 billion by 2015. (*Yakima Herald-Republic* October 11 2009)

These two editorials come down on different sides of Initiative 1033, but the same numbers appear in both arguments. This highlights the extrinsic role of the numbers involved. The information provided is relevant to a potential voting decision (there surely exist upper and lower bounds to a debatable budget cut, e.g., nobody would argue over a .001% or 99% cut) but voters are not being asked to do anything with the numbers that would bring to bear any QL that they possess. Two questions arise: What, then, is the role of quantitative reasoning in electoral politics? What about the thoughtful voter who wants to question the claims made by these editorials, might they need a certain level of QL? These are the questions to which I'll be turning in the next section.

2. Citizens cannot determine whether an argument is likely to be sound without recourse to the opinions of others.

> We understand that some people enjoy gambling, and that many, including those from Mahoning Valley, travel out of state now to gamble. Casino proponents tell us that Ohio is losing $1 billion a year to such outward migration and that Issue 3 will put an end to that.
>
> Do the math.
>
> But the numbers don't add up. For one thing, as anyone from this area familiar with gambling patterns can tell you, not everyone goes to West Virginia or has started going to Pittsburgh to gamble will automatically switch to one of the four Ohio casinos permitted under Issue 3. Some who are going to Atlantic City, Las Vegas, Detroit or Niagara Falls to gamble may go, instead, to Cleveland, Columbus, Toledo or Cincinnati, but not all. Those dollars leaving Ohio are not the target of would-be operators of Issue 3 casinos. If they captured every gambling dollar leaving the state, $1 billion isn't enough to provide the jobs and taxes that Issue 3 proponents promise. (*Youngstown Vindicator* 2009)

This argument, against a measure that would legalize gambling in four Ohio cities, entreats the reader to "do the math." But the reader does not need to, and indeed cannot, do any math based upon the information provided by the editorial

itself. Instead, the author informs us that the gambling dollars spent outside of Ohio are not sufficient to account for the promised job-growth and implies that the advocates of the measure are counting on an increase in gambling by the citizens of the state; a compelling argument against the measure for any reader who is comfortable with the taxation of extant gambling, but who does not want the practice encouraged. The argument can be taken at face value but a deeper inquiry into the situation may demand a level of QL that is not required by the editorial itself. After all, job growth and tax revenue estimates must be the product of math-intensive studies and any analysis of these studies would surely require a high level of QL. While a thorough inquiry into the knowledge necessary to engage in this type of investigation is far beyond the scope of my current study, I have done some preliminary work in this direction and the implications of my findings run directly counter to the rationale behind the development of QL for democratic citizenship. It is asserted that modern society is awash with data (Steen 2001) and that the quantitative reasoning associated with the analysis of this data is characterized by "heavy context dependency" (Shavelson 2008, 9), but the accuracy of their premises undermines their conclusions. In fact, the very first well-defined problem that arose in my analysis of the argument printed above was strikingly similar to the type of QL assessment item that Shavelson champions. Nevertheless, it is precisely the abundance of data and the multiplicity of contexts within which it resides that argue against the existence of a generalized ability that can be of use in tackling these problems. As I'll demonstrate below, even the most straightforward of issues demands a mathematical and, more importantly, contextual knowledge that it would be unreasonable to expect any citizen to possess.

Looking back at the *Vindicator*'s editorial, I see that we need to have a fair estimate of potential job growth and tax revenue associated with the measure. These numbers can then be compared with the estimated $1 billion in lost revenue associated with out-of-state gambling. An investigative report produced by the local NBC news informed me that the estimated job growth figure is 34,000, sourced from a report produced by the University of Cincinnati Economics Center for Education and Research (2009). My perusal of Ballotpedia had already led me to a report by the Public Policy Analysis Group (2009), based at Hiram College, which asserted that no jobs would be created by Issue 3. Deciding upon a reasonable estimate for job growth is a necessary, but certainly not sufficient, step towards evaluating the claim in the *Youngstown Vindicator*. Nevertheless, an attempt at comparing these two reports provides a good example of the type of work entailed in responsible citizenship as advocated by Steen and others. The first report consists of almost fifty pages of analysis, and a critique of their numbers would require specialized knowledge about the calculation of economic multipliers and the assessment of labor market participation. Furthermore, the

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projections are based on "the developers' operations *pro forma* and The Innovation Group's recently published 'Ohio Statewide Casino Market Assessment'" (2), reports that would need to be examined if one were to assess the validity of their findings. The Hiram report is shorter, but its point-by-point examination of the claims made by supporters of Issue 3 does not consist of any new research; instead it employs the findings of eleven other studies. These vary in scope from an analysis of the social externalities of casinos to a presentation of the risk factors associated with pathological gambling. The claim of zero job growth, in particular, is based on testimony by E.L. Grinols, an economist who has developed "a rigorously grounded formulation of the costs and benefits associated with the introduction of an industry such as casino gambling that imposes cost on society in the form of real-resource-using harmful externalities" (Grinols et. al. 2001, 144). I began examining Grinols' work and eventually, around the time he transformed his four-component cost-benefit equation into a seven-component differential form, decided that it was not accessible to anybody with no more than a reasonable level of QL.

So where does this example leave us? I do not mean to suggest that political arguments as presented in public venues are incomplete, or that the studies that inform these arguments are too obscure. The implications of this example have to do with the nature of argumentation about public problems. I have already shown how numbers can pervade the public discourse without an attendant demand for quantitative reasoning. This last analysis suggests that much of the quantitative reasoning involved in policy matters is out of reach for even the most mathematically-minded citizen. Suppose, after all, that I were capable of evaluating any number of the reports and papers that were encountered above. There could, nevertheless, be problematic premises that would never occur to me (there are, for example, economists who contest Grinols' cost-benefit model). Because I do not know what I do not know, and because this state of affairs holds true for any public problem that one might care to name, I have no choice but to ask a knowledgeable expert (or to ask somebody whom I trust and whom I can count on to ask an expert for me). Therein lies the crux of the problem. After all, the expert can either provide me with their assessment of the situation or information that will allow me to make up my own mind. Suppose they do the latter; what will it mean if I come to a different conclusion than the expert? It probably means that I am incorrect (since the expert came to a different conclusion with the same information) and if we entertain the possibly that I am in the right, then the only reasonable way to adjudicate the disagreement will be via the intervention of even more experts.

And there is no reason to believe that a small (or even moderate) amount of disciplinary knowledge (let us say I majored in Economics) will change the nature of the situation. After all, as demonstrated by the Ohio casino issue, even experts'

opinions can be wildly divergent. Lee Shulman's (1974) investigation of medical practice puts the issue in sharp relief. He examined, along with his associates, the procedures that experienced physicians used when attempting to diagnose a patient, and came to two conclusions that are relevant to the present argument. First, the diagnostic process recommended by medical textbooks bore little relation to the process actually employed by the physicians themselves. Second, the researchers were not able to make any generalizations about the diagnostic accuracy of even the most well-regarded physicians because their skills were too domain-dependent. It is the existence of this "wisdom of practice," as Shulman (1987) would later call it, that gives lie to the idea that a small amount of pertinent knowledge can inform decisions about complex public problems. So how can responsible citizens proceed? This is the situation that Hardwig (1985) calls epistemic dependence and, as I stated at the outset, it calls for a nondisciplinary approach to the assessment of expert opinions.

Many issues immediately spring to mind: How does one locate experts in a field without possessing the same expertise? How much weight should be given to *ad hominems* (e.g., conflicts of interest, dangerous pride, and political pressure)? How does one sort out competing expert claims? The proliferation of these questions is precisely why the educational community cannot afford to ignore this activity, why it needs to be made an explicit object of research, and why it needs to take a central place in the curriculum. After all, we engage in this type of decision-making all the time and I would judge that we actually do it fairly well in many circumstances. One need look no further than the trust that we put in the FDA to see how this type of thinking undergirds our society. Claims have been made, for example, about the dangers of aspartame, an artificial sweetener that pervades our food supply. The reported problems were serious enough that no responsible parent would allow their child to consume the product if they entertained any real notion that the claims were true. While many people may not have encountered the accusations in the first place (it began as an e-mail that was widely circulated about ten years ago), many others have; and, for the most part, they have felt comfortable dismissing the rumors as fallacious (Gorman 1999). Now, one may safely assume that a vast majority of those people had no scientific basis on which to judge the claims about aspartame. Instead, they judged—correctly by most accounts—that the e-mail was a hoax, and trusted that the FDA was correct in deeming the substance safe for consumption. Furthermore, we might note that this trust in the FDA, while probably based in part on the assumed good-will of the government, must largely indicate a trust in the organization's competence in carrying out its job; this despite the fact that very few people would be able to say how the FDA would actually go about determining the effects of aspartame. I present this as a single example of the many ways in which we engage in this type of expert evaluation despite its lack of prominence in the

curriculum. I will conclude with a consideration of some of the implications of this approach.

Knowledge of Others

> "You seem to consider not whether a thing is or is not true, but who the speaker is and from what country the tale comes." -Socrates

The need to rely upon the knowledge of others is an ineluctable feature of reality and nothing to be decried. There are certain domains for which the knowledge of others ought to take precedence over one's own knowledge. I have attempted to demonstrate that publicly-decided issues constitute one such domain. All of this implies that evaluation of the knowledge of others ought to take on a central role in the curriculum. But this cannot happen until we have a better understanding of the way in which people carry out these evaluations and the way in which they ought to be carried out. We have an incredibly rich data source for this type of investigation: namely every appeal to an authority and every attempt to characterize experts.[4] Of course, any examination of textual evidence would need to be supplemented by interviews and observations of people in action. I have hope for both types of empirical research because my guess is that people are actually rather good at making these sorts of judgments. The primary goal, and difficulty, would be the construction of a theoretical framework for this type of activity, something that could inform the prescriptions that would, in turn, inform curriculum. This work ought to be informed by those philosophers engaged in social epistemology, "the study of the social dimensions of knowledge" (Goldman 2006, 1). Indeed, Alvin Goldman (2002), the renowned epistemologist, has proposed the question "What kinds of education could substantially improve the ability of novices to appraise expertise?" (160) as one of the practical challenges facing the field.

A focus on drawing information from expert sources may sound abhorrent to some, as reliance on the word of others can sound suspiciously like indoctrination. Green (1964) gives voice to this concern when he says that "it takes no great powers of insight to see that in proportion as the conversation of instruction is less and less characterized by argument, reasons, objections, explanations, and so forth […] it more closely resembles what we call indoctrination." Unfortunately, this perspective cannot take us very far; after all, as Renoir wrote, "the terrible thing about this world is that everybody has his reasons" (Thompson & LoBianco, 1994). In other words, all Green asks is that the teacher present explanations,

[4] Shulman used "peer-nominated" physicians for his study on physicians' decision-making. One might say that this is evidence for one implicit theory for the determination of expertise: ask others who belong in the same field.

reasons, objections and arguments for what they believe, a bar that can be hit by just about anybody. A focus on expert knowledge, on the other hand, forces the student to survey the intellectual terrain that they are working within. There are other educational goals that could be seen as being in conflict with a focus on expert knowledge. The construct of "intellectual independence," for example, had currency for quite some time in the science education field. The term was coined by Munby (1977), who said that "an individual can be said to be intellectually independent when he has all the resources necessary for judging the truth of a knowledge claim independently of other people" (6). I will not be the first to critique Munby's position, but let me just note that this vision of intellectual independence, as he proceeds to implement it, maintains the teacher in a position of authority and simply requires that reasons be given for claims. This is most likely a productive practice in a science classroom, but I would argue that intellectual independence would be better realized by providing access to competing authorities along with the means to evaluate them.

Green (1964) also distinguishes between training and teaching: the former enables the learner to do something while the latter is in the service of the search for truth. I would like to make a further distinction. First, let us discard 'truth' as a rather loaded term and replace it with 'knowledge,' as that can be theoretical and actively contested. Now I'll say that teaching can take multiple forms: a student can be trained to engage in the pursuit of knowledge or a student can be taught how to access the knowledge that has already been created. While the line between these two modes is not firm, I will conjecture that many problems arise from their conflation. Students are taught to argue a point and, as a part of this, they learn how to analyze arguments. This may be functional on an informal level, or when somebody is contributing to a growing discipline. However, there is no symmetry between the creation of a valid argument in a classroom and the assessment of a political problem. The latter requires the student, or the citizen, to access disciplinary knowledge and, as outlined above, the work involved in doing this is entirely based upon the evaluation of expert sources and doesn't involve an examination of the validity of individual claims.

There are, however, current efforts to help students make wise decisions informed by disciplinary knowledge; some of this work suggests that there is still a role for some manner of disciplinary literacy. For example, the possession of financial literacy has been shown to be linked to better financial outcomes (de Bassa Scheresbert 2013) and greater success in the development of small businesses (Dahmen and Rodríguez 2014). Further, critical analysis of how numbers are used and misused by the media requires a level of quantitative literacy as demonstrated by Orcutt and Turner (1993) in their account of the way that statistical information was represented in order to construct overblown claims about the crack epidemic of the 1980s. These arguments and others like them

suggest that there exist many circumstances, e.g., making personalized decisions about finances or health, where the possession of quantitative literacy supports decision-making even as it may interact with the expertise of others.

I am also cognizant that my argument, as it has been presented so far, may be conjuring up the specter of a technocratic government in which all decisions must be made by scientists and others with technical expertise in pertinent fields. So how do we address this concern? First of all, I've already noted that the scope of expertise is extremely limited—an expert in one domain is a layperson in all others. Second, even within a given domain, experts have to rely upon others; Hardwig (1985), for example, cites articles in particle physics that involve over fifty authors. With this in mind, it may make more sense to speak of knowledge as something that is communally held rather than possessed by a single person. Even the renowned physician, who exhibits her diagnostic acumen in the course of a one-on-one session with a desperate patient, enjoys her status only because of her contact with and support from other respected practitioners in the field. In short, we cannot talk about rule of the experts because we simply cannot speak of experts as a monolithic group. That said, this appraisal of our situation serves to highlight certain ethical imperatives that should be of importance to those who attempt to theorize education. Namely, it is incumbent upon anyone with expert knowledge to teach those who want to learn, on the one hand, and to open up their considerations to peers, on the other. It is not clear, though, that those same experts should make an effort to open up their considerations to those who are not in a position to evaluate them. This does not mean that information or deliberations ought to be hidden from view. It simply means that nothing is served by sharing these deliberations with people other than those who have a commensurate amount of knowledge or those who want to learn from them. All of these considerations are, fortunately, embodied in the ethos of modern academia.

Conclusion

Quantitative literacy, scientific literacy and all the other disciplinary literacies do not present a viable means of accessing the products of human learning as they pertain to a large class of important problems. I demonstrated this through an analysis of quantitative literacy and its role in the assessment of political arguments. These political problems, as I defined them at the outset, don't exhaust the types of problems whose solutions fall outside the realm of basic disciplinary learning. However large that domain may end up being, it won't be productively addressed by current curriculum until we can begin to talk about the manner in which we can and should evaluate authorities. It is, at the moment, a practice that occurs in the interstices of our education. The practical knowledge about this fundamental evaluative process is embodied in our actions and beliefs, but it has

yet to be examined and given the official status that it deserves.

The Internet provides us with a wonderful opportunity for research in this vein. Resources used to be spread across the world, in people and libraries and archives. We are now provided with instant access to written information and more efficient means of accessing the knowledgeable experts themselves. In fact, the absence of a central resource like the Internet may be one of the reasons for the lack of a prominent research tradition in this domain. New means for fact-checking information and carrying out debates are being developed—a fluidity that lends even more importance to the subject. I do not, however, want to give the impression that this emphasis on the evaluation of expert knowledge is simply a form of media literacy. The focus would need to be on the interaction between the individual and the knowledge collectively held by our society; the media within which that interaction occurs would have to take a secondary, albeit very important, role.

In conclusion, I would like to make two points. First of all, the poverty of a disciplinary approach to public issues can be witnessed first-hand. Simply take a controversial public problem like health care reform or immigration policy or trade regulations, and list out the various pieces of disciplinary knowledge that a citizen would need in order to evaluate the issue on her own (or in order to evaluate somebody else's evaluation). It should become quickly apparent that requirements of this sort can serve only to further differentiate access to the political process, an end that ought to be embraced if the premises underlying the quantitative literacy rhetoric are to be believed. I hope I have established, however, that there is nothing to be served by allowing students to think that they can, or should, rationally evaluate the issue on their own if only they had the necessary background knowledge. And there is everything to be gained by helping students realize that they depend upon others and by providing them with tools to help them navigate the cacophony of voices that they will encounter in the real world. Second, I want to stress that an acknowledgment of our individual limitations ought to be seen as empowering. When it is allowed that we can (and should) cede judgments to experts, we are broadening our world in an essential way. This attitude empowers individuals to make more decisions of consequence and brings them into contact with the greatest of human accomplishments in all its plurality.

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