Public Engagement in Science-related Problems

How is the public to decide on science-related matters?

Suppose a dear relative has become increasingly fragile with age, and you've been called upon to figure out what can be done. You seek out science articles on the subject and find the following headlines:

> **Vitamin D deficiency figures in hip fractures**[1]
>
> **Extra vitamin D and calcium 'a waste of time'**[2]
>
> **Vitamin D can reduce number of falls and fractures in elderly**[3]
>
> **Vitamin D pills for elderly 'increase their risk of falls'**[4]

These, like most science articles in the popular press, begin by reporting the major conclusion in simple terms and then present the credentials of those doing the research. There doesn't seem to be a coherent message in these stories. Maybe examining the sources will help? University of Zurich, Brigham and Women's Hospital in Boston,… they all sound legit. Wait! Maybe some researchers are on the payroll of big corporations that make millions off of vitamins?

No, no need for conspiracy theories. This is just how science works.[5] Experiments ask questions of Nature, but Nature is maddeningly literal, answering not the general question the experimenter intended but a question drenched in specifics. We'd like to devise an experiment to answer the question "Does Vitamin D reduce hip fractures in older women?", but in fact an experiment can assess only the outcomes of certain amounts of Vitamin D, provided under certain conditions, to certain women. Nature's answers are always true. The generalities (made up by humans) are always false. With enough experiments we may approach general understanding, but we'll never achieve it. Experimental science is not math.

Combine how science works with how science reporting works, and you get the whiplash readers commonly experience when reading science news.[6] This is reason enough to find ways for readers to gain access to the specifics -- the experiments that define the results -- containing the truth behind the often vacuous bottom lines.

The stakes are higher than this, however. Conventional science reporting implicitly accepts a view of knowledge that is decidedly non-scientific and relegates the reader to passivity. At root is how the reader should decide conflicting claims: by authority or by observation? If authority is the factor ultimately determining what is to be believed, then the public has no role except to recognize and potentially accept a claim of prerogative. In science, however, there is no authority, except Nature herself. If instead observation holds sway, then anyone, including the public, is invited to judge.

How has the public responded to this invitation (to the extent it exists)? Certainly they have responded differently in many cases from the scientific community. A 2015 report from the Pew Research Center[7] compared the views of 1534 US adults with those of 3748 members of the American Association for the Advancement of Science (AAAS) and found many striking differences. For example, 88% of AAAS respondents agreed that it is "generally safe to eat genetically modified foods", while only 37% of US adults did so. No doubt part of this 51% discrepancy arises from different interpretations of the question. Those in science may tend to interpret the question narrowly (so that it makes sense), limiting it to crops that contain the two classes of genetic modifications that make up nearly 100% of all genetic modification currently

in use.[8] The public may instead interpret the question as referring to genetic modification in ***all*** its conceivable forms.

Different interpretation explains only a small part of the discrepancy. It was once believed by many that providing the public with the scientific information it lacks would bring it in alignment with scientific opinion. This view has been thoroughly discredited.[9] It is not knowledge but ideology[7] and world view[10] that correlates most closely with divergent public opinion, even in matters that can readily be determined empirically beyond dispute.[11] We can't even agree on the weather – the perception of temperature increase in one's own zip code over the preceding three years was significantly correlated with political ideology.[12]

It is a common argument that few people are able to understand the scientific intricacies that underlie genetic modification, climate change, and the many other socially important questions before us, and it is therefore reasonable for them to put their trust in experts to guide their decisions.[13] The public may find trusted experts in their favorite media outlets or in the lab.[14] The choice has become highly polarized. Since 1972, trust in scientists has dropped precipitously, but only amongst those self-identified as "conservative".[15] Much research has been devoted to finding ways the public might regain trust in scientists, for example by showing scientists how to present themselves in a manner that is more likeable and vulnerable.[16] An alternative view is that we shouldn't be focused on imposing the view of science on a recalcitrant public but rather on engaging the public (including the subset that does science for a living) in an inclusive dialog that draws on the component strengths of the participants to advance sound policy.[17] In short, the question at issue is whether the public should focus on ***what*** to believe or on ***who*** to believe.

The Lippmann-Dewey debate: Can the Public be part of the process?

What role the public in a technological democratic society ought to play in determining policy is at the heart of a discussion that has roiled since the 1920's, the Lippmann-Dewey debate.[18] Walter Lippmann, one of the most influential journalists of the 20th century, argued in *Public Opinion* (1922) and more pointedly in *The Phantom Public* (1925) that mechanized society had progressed to the point where the layperson could not possibly be sufficiently competent in the substantial issues of the day to exercise a meaningful voice. On the other side was John Dewey, psychologist, patron saint of bottom-up education, and philosopher who championed participatory democracy, and he… agreed! Dewey was effusive in his praise of *Public Opinion*,[19] calling it "*…the most effective indictment of democracy as currently conceived ever penned*." He agreed with Lippmann on the meaning of the term "Public", not merely the bodies within a geographical boundary but individuals brought together by a common recognized problem and called as a group to issue an organized response. He agreed that almost no individuals within a Public could know enough to decide with competence issues of common interest. However, he disagreed with Lippmann's surrender of the public to rule by experts: "*…the difficulty is so fundamental that it can be met, it seems to me, only by a solution more fundamental than [Lippmann] has dared to give.*"[19]

Dewey provided an outline of the solution he envisioned a few years later in *Public and Its Problems* (1927). Two conditions would have to be met in the future, he said, to enable a "democratically organized public" (a term which he spent most of the book explaining) to engage meaningfully in the governance of the society in which it lives. The first requirement is the universal access to fruits of inquiry that must underlie rational governance,[20] free of the "*secrecy, prejudice, bias, misrepresentation, and propaganda*"[21] through which it is routinely filtered. It

was essential that all affected by policy be able to enter the discussion, for while experts are uniquely competent to conduct basic inquiry, their expertise does not extend to framing policy. Dewey offered an image of an expert shoemaker best placed to repair a shoe but helpless without input from the person who wears the shoe and knows where it pinches.[22] Members of the Public need become experts themselves only to the extent of being able to judge how the results of expert inquiry bears on the problem at hand. While he, no less than Lippmann, dismissed the possibility of individuals gaining even this level of expertise in all areas required, the goal could be realized by the "*diffused and seminal intelligence*" of the Public,[23] given the free exchange of ideas required to bind the Public together. Dewey closed his essay, saying "*We lie, as Emerson said, in the lap of an immense intelligence. But that intelligence is dormant and its communications are broken…*"[24]

How to fix the lines of communication? Recognizing that publishing the contents of the Journal of Sociology in the pages of the local newspaper would have little positive effect, Dewey raised his second prerequisite, that news evolve to combine the fruits of inquiry with the art of presentation.[25] "*Artists*", he wrote, "*have always been the true purveyors of news*" by their ability to transform bare fact into human meaning. He left it to our fantasy how this art would take place.

Fleshing out Dewey's vision

Dewey's vision was maddeningly vague. It is difficult to conceive of any scenario possible in the 1920's that could have embodied his views. Today, the possibility seems a bit more tangible, as the internet presents the means of interconnection and availability of information well beyond the imaginations of Dewey and Lippmann. Virtually all recent scientific research exists in digital form, and while much lies behind pay walls, this could change.[26] As for interconnection, however, it is probably unnecessary to point out that thus far the internet has not always proven to be the medium through which disparate views interact amicably. Ideologically opposed views on the web seldom converge on optimal solutions of societal problems. In fact it is a major purveyor of the bunk and hokum decried by Dewey.[27]

A vast increase in the availability of the fruits of inquiry does very little, of course, to engage the Public in its appointed task, any more than a person having difficulty learning to swim in a backyard pool is helped by moving operations to Lake Michigan. Importantly, the internet also makes possible the realization of Dewey's vision of art in service of societal communication. One marriage of art and news that has been proposed is the creation of a news station that brings together intellectuals and comedians to present an entertaining exposition of the news.[28] *Last Week Tonight with John Oliver* offered a meta-example of how this might work.[29]

This and similar ideas may have some merit but in my opinion miss the main point. Dewey and Lippmann both viewed the central problem to be what new public institution could mediate rational decision-making through close contact with the fruits of inquiry -- not possible through the layers imposed by the news media (and by political satire).[27] Lippmann proposed a politically isolated institution that served government decision-makers directly, while Dewey required that its first responsibility was to bring the Public into the process. That institution would mediate two-way exchange between experts and laypeople and facilitate discussion how the findings of research could be applied to policy. Lippmann considered this vision a pipe dream. Is it?

Realizing Dewey's vision: Comprehensible fruits of inquiry

One essential realization of Dewey's vision is to use art to make the fruits of inquiry accessible to those outside of science. I will now propose two new resources that may achieve this end. First, a government-sponsored but politically insulated journal should be established – call it the *Journal of Comprehensible Results* (JCR). Its mandate is to publish online translations of ***primary*** research articles from a broad spectrum of scientific disciplines. The articles will usually be written by a science writer (or a student perhaps pursuing that career) with the assistance of one of the authors of the original research article. An article in JCR will have the following characteristics, designed to make the fundamental unit of science – an experiment / result – accessible to all:

1. It can be comprehended by someone with no more scientific background than available through high school.
2. It covers the same ground as the original article and can be seen as the translation of the original into a different language and format.
3. It is written in a nested fashion taking full advantage of web capabilities, so that it can be read in different ways according to the needs and wishes of the reader.
4. It relies much more on graphics and simple lists than would a typical research article, appearing perhaps as much like a presentation as a written article. Figures may be taken from the original article. More often, however, they will be substantially reworked to be comprehensible without deciphering a complex figure legend.
5. It focuses primarily on the experiment(s) and observable result(s). Context is given to make the motivation behind the experiment comprehensible and the connection between experiment and result clear. The point of the new article is the experiment(s) and the result(s). Conclusions drawn in the original article may also appear, but they should not be over-emphasized (as they are in typical news articles).
6. Unlike a conventional research article, it does not provide the experimental detail required to replicate an experiment. Instead it makes the principle of the experiment clear. It may refer as needed to a library of resources developed to explain experimental techniques at a high school level.
7. It may not be cited by an article in a conventional scientific journal in place of the original article.

These considerations should ensure that JCR articles reside in a publication universe separate from that inhabited by conventional scientific articles and do not compete with the original articles for citations. I hope this will quiet concerns of current publishers.

The publication process is designed to ensure that publicly funded research (at least) is available to the public at the time of publication in a comprehensible form. Specifically:

1. Work from any publicly funded project that is published in a peer-reviewed scientific journal must also be published in JCR. This is an extension of the current requirement that publicly funded research be accessible to the public within a year of publication.[30]
2. A submission to JCR must take place simultaneously with a submission to a conventional scientific journal.
3. The submission will be reviewed by a researcher in the field but solely for accuracy of translation from the original article. This limited review will require much less time from

the reviewer than a scientific review (which is the responsibility of the conventional journal). Nonetheless, the reviewer will receive a nominal fee for the review.

4. The submission will be reviewed also by a person outside of science, typically a student. This reviewer will also receive a nominal fee for the review.
5. The review process may instead follow the practices of open review,[26] if the conventional journal follows such practices.
6. The article will appear on the JCR web site available to the world immediately upon acceptance by the conventional journal as a condition of federal funding, regardless of whether that journal imposes an embargo.

The journal and obligations I've described would be cheap, because the journal would be completely online with minimal editorial responsibilities. I'll guess it could be initiated with a government investment of several hundred thousand dollars. Once established, it should pay for itself, through publication fees usually borne by the authors. For authors with grants, the cost will be small, perhaps 10 to 20% of what it costs to publish in a conventional scientific journal. This would amount to less than 0.1% of a typical federal grant. The authors may want to pay a science writer or a student to bear the major burden of translation. Again this should amount to a small fraction of the conventional publication cost. The cost of translating old articles or articles by authors without current funding will probably need to be borne by the journal, and the editor may decide whether the article warrants the cost of translation.

Student participation in the translation should be a highly educational experience, and the National Science Foundation (NSF) may incentivize student involvement. The NSF requires grant submitters to devote part of the application to explain how the proposed work would have societal benefit (called "broader impacts"). I can vouch from my experience reviewing NSF grant proposals that many struggle with this section. Engaging students in translating articles would be an excellent way to meet the broader impacts obligation, and this would provide an incentive for grant holders to bring non-science students into the process of science.

It must be stressed that articles in JCR should not be expected to provide broad insights into scientific questions. Rather they are the raw elements of broad insights that illuminate only when combined with other elements. A news article in the formal or informal media is one vehicle that could combine raw elements. By their timely appearance, JCR articles may be useful to reporters in writing news articles, and I would hope that reporters would form the habit of linking to JCR articles that they draw on.

Realizing Dewey's vision: Promoting discussion of research results and policy implications

The second resource is a proposed website modeled in some ways after Wikipedia, with the aim of engaging a Public in the consideration of science-related issues, drawing on experimental results . I'll call the resource for now *Public Science* (or PubSci). Although administered by JCR, it will be functionally independent, and as with Wikipedia, topics and content will be provided by volunteer editors. PubSci will have important differences from Wikipedia:

1. As with Wikipedia, anyone can edit a topic. I would hope that editors are drawn from the ranks of interested amateurs and those whose profession is science. Unlike Wikipedia, PubSci will ask all editors to identify themselves by their actual names.
2. As with Wikipedia, claims of fact will require references, but unlike Wikipedia, PubSci will accept references only from amongst the following sources: (1) unretracted, peer

reviewed, primary research articles (preferably JCR articles, when available), (2) peer-reviewed review articles that consider primary research articles, and (3) official sources of primary quantitative data.

3. Original research is OK, so long as it is based on acceptable sources as described above. Claims or opinions without acceptable citations are not OK and should be removed by editors.
4. Editors will accept the conventions of the scientific community, in particular the presumption that all results presented in peer reviewed articles are given in good faith until proven otherwise.
5. As with Wikipedia, there will be a talk page associated with each content page. Unlike Wikipedia, the talk page may be used to discuss the direct merits of the content.

Realizing Dewey's vision: Intended outcomes

1. A database of JCR articles, offering primary research results that a motivated layperson has a good chance of understanding
2. A firm basis on which reporters and others can create meaningful narratives from specific findings.
3. A resource that enables reporters to take on a new role: helping their readers come to their own conclusions, by pointing them to relevant primary research results that they can understand.
4. An inclusive forum for discussion of topics with scientific content. I would hope that the rules of the game would sidestep the interminable harangues on what is or isn't junk science or fringe theories. Anything with peer-reviewed primary results has a seat at the table, but not otherwise.

I must confess doubt that any of these are likely outcomes in the short term. After all, if a popular talk show host can dismiss fact checking as another means to sell an ideological position,[31] then I suppose strict adherence to evidence in primary research articles might be subject to a similar objection. Creating a new role for news reporters also seems like a tall order. And then the greatest challenge – I know full well how difficult it is to get even a captive audience of undergraduates to grapple with the distinction between experimental results and conclusions, perhaps the most basic concept in science. Should we imagine that a Public might somehow make this leap?

But that is exactly the task that must be accomplished for there to be a grounded interaction between the Public and experts that is multidirectional. Dewey appreciated the magnitude of the problem, calling science "*…a highly specialized language, more difficult to learn than any natural language.*"[32] Lippmann could not conceive bridging this gap. Others have proposed partial solutions, preparing students to critically evaluate science presented in the media[9] and to interact within communities, amongst themselves and with scientists.[18]

I think these approaches do not measure up to the task of ensuring that the Public "*…have the ability to judge of the bearing of the knowledge supplied by others upon common concerns.*"[21] Making these judgments requires that the Public has the ability to navigate the thickets of conflicting conclusions, and this means gaining access to the core of science, the experimental result. Dewey allowed that this could be achieved, writing, "*It is, indeed, conceivable that sometime methods of instruction will be devised which will enable laymen to read and hear*

scientific material with comprehension, even when they do not themselves use the apparatus which is science…. But that time is in the future."[32] The future may be now, and this leads me to suggest what I consider the most significant possible outcome:

5. An educational tool that may help secondary and college students understand by direct contact the nature of an experimental result and that may promote the habit of approaching problems as a community.

A Public that has absorbed these lessons (and managed to avoid the common lesson of K12 education that science rests on authority) may participate in the governance of a democratic technological society. Individuals will have a wide range of partial expertise in the scope of scientific issues, according to their interests, but the collective intelligence of the Public may stand a chance of meeting the challenge.

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[11] The great majority of one world view subscribe to the statement that "…most expert scientists agree [that] global temperatures are increasing", while the great majority of an opposing world view do not agree.[5] Armed with only a high school-level understanding of science, one can go to PubMed (a publicly available database that indexes articles in about 26,000 scientific journals), search for a term like "global climate change", and assess from a sampling of the article abstracts whether the authors of the resulting articles accept the reality of climate change. These authors may be right or wrong in their beliefs, but determining the level of support in scientific publications should not be in dispute.

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