Science Literacy in Controversial Contexts: An Epistemic Balancing Act

Aviv J. Sharon, Technion – Israel Institute of Technology, a.sharon@technion.ac.il
Ayelet Baram-Tsabari, Technion – Israel Institute of Technology, ayelet@technion.ac.il

Abstract: "Science literacy" is considered important for thinking and deciding about everyday personal and social issues relating to science, including controversial topics, such as anthropogenic climate change. In recent years, science literacy has been conceptualized as the ability to access and make sense of scientific expertise in the time and in the context of need. Recently, evidence has shown that when people attempt to make sense of controversial issues, their processing of scientific information is biased by their existing ideologies and worldviews. This is considered the culprit of persistent controversy about scientific findings, such as the findings that indicate anthropogenic climate change. Here, we propose an implication to this evidence: To promote science literacy, educators should promote an "epistemic balancing act" in the science classroom, avoiding both credulity and hyper-skepticism. Implications for educational policy are discussed.

Introduction

Individuals and groups often make decisions with scientific components. For example, voters go to the ballots and consider whether, in fact, the climate is changing, and if so, what should be done to mitigate the changes. For decades, scholars have been discussing what "scientific literacy" (SL) people need to make such decisions. Despite efforts to promote SL through science education, concerns about the usefulness of science education in everyday life persist (e.g., Aikenhead, 2006).

Here, we briefly review theoretical and empirical notions of SL and maintain that people often refuse to accept valid scientific findings that challenge their beliefs, values and interests. e.g., regarding anthropogenic climate change. We argue that as part of SL, laypeople must be taught to perform an "epistemic balancing act" when interacting with scientific expertise: They must avoid both credulity on one hand and hyper-skepticism in the other. We relate this "balancing act" to the epistemic virtue of open-mindedness.

Theoretical notions of science literacy

Although the body of literature on SL is immense, there is no general agreement on the definition or constituent parts of this construct. Alongside the diversity, there is some common ground. A committee of the US National Academies of Sciences, Engineering and Medicine (2016b) (hereafter NASEM) identified seven commonly hypothesized aspects of SL on the individual level: (1) foundational literacies, such as numeracy and textual literacy; (2) content knowledge, such as scientific terms, concepts and facts; (3) understanding of scientific practices, such as collecting and analyzing data and peer review; (4) identifying and judging appropriate scientific expertise; (5) epistemic knowledge, i.e., understanding how scientific claims are supported by scientific procedures; (6) cultural understanding of science and (7) dispositions and habits of mind, such as inquisitiveness and open-mindedness. Aspects 2, 3 and 5 are found in the PISA 2015 conceptual framework for SL as "content knowledge", "procedural knowledge" and "epistemic knowledge" (OECD, 2016).

The competent outsider: An evidence-based notion of SL

Several studies provide a modest base of evidence about lay reasoning with and about science in everyday settings, and some preliminary clues into the capabilities this reasoning requires. Feinstein (2011) suggested that to be considered "science literate," people must be able to *identify* when science is useful for their own needs and interests and to "*interact* with sources of scientific expertise in ways that help them achieve their own goals", or, in other words, be "*competent outsiders* with respect to science" (p. 180, emphasis by authors). By analogy, the "competent outsider" is like a competent water-drawer, who can identify when water might be useful (e.g., when one is thirsty), and then find an appropriate well. The science literate person can then use the well's pulley system to draw needed amounts of water, and then brew tea, launder clothes, etc.

Open-mindedness and the competent outsider

Scientific propositions on socially controversial topics, such as global warming, can threaten beliefs, values and interests, posing a difficulty to defer to scientific expertise. A recent consensus report on science communication

emphasized the role of motivated reasoning in interpreting scientific findings, especially when "individuals feel their values, identity, or interests are threatened" (National Academies of Sciences Engineering and Medicine, 2016a, p. 47).

One may expect schooling to help alleviate this problem. However, unfortunately, the available evidence suggests the opposite: In several contexts, scientific knowledge polarizes attitudes towards scientific facts. Thus, belief in human-caused climate change interacts with science knowledge and numeracy by individuals' political affiliations and cultural world-views: Among US adults who subscribe to an egalitarian, communitarian world-view, belief in human-caused climate change grows with scientific knowledge and numeracy. However, among US adults who subscribe to an individualistic, hierarchical world-view, belief in human-caused climate change *declines* with science knowledge. Science knowledge has been observed to contribute to polarization about private gun possession and hydraulic fracturing, but not nanotechnology or genetically modified food. This polarization contributes to persistent controversy on these topics (Kahan, 2017).

Building upon Feinstein's notion of the "competent outsider," Hendriks, Kienhues, & Bromme (2016) argued that to establish shared understanding, "trust is critical for 'insiders' as well as 'outsiders'" (p. 144). Their notion of "epistemic trust" for "outsiders" entails both willingness to be dependent on appropriate sources of scientific knowledge and vigilance towards being misinformed. We propose to add a complementary claim: Just as epistemic trust is necessary to rely on scientific knowledge claims, open-mindedness (part of NASEM aspect 7) is needed for "outsiders" to begin assessing such claims in the first place.

This approach is reflected in Taylor's (2016) conceptualization of open-mindedness as a "virtue that is a mean between the opposing vices of closed-mindedness and credulity" (p. 609). She suggests that this virtue requires one to have (1) intellectual humility (the ability and willingness to judge one's own fallibility); (2) intellectual courage (the willingness to take risks in the pursuit of knowledge despite threats to one's identity); and (3) intellectual diligence (the willingness to persist in pursuing knowledge and understanding). Thus, we propose viewing science literacy in controversial contexts as an "epistemic balancing act": Outsiders must be able to avoid erring both on the side of credulity and on the side of closed-mindedness.

This claim has important policymaking consequences. The Framework for K-12 Science Education states that scientists and citizens must "make evaluative judgments about the validity of science-related media reports" and have "[t]he knowledge and ability to detect 'bad science'" (National Research Council, 2012, p. 71). The Framework even cites Ben Goldacre's popular book, “Bad Science” (Goldacre, 2009). Although a critical stance is often appropriate, missing from this part of the document, and others like it, is an apt reference to identification of "good"– yet counter-attitudinal – scientific knowledge as well.

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