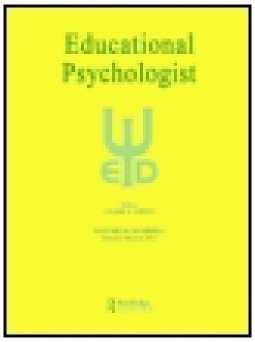


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Noah Weeth Feinstein & David Isaac Waddington

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# Individual truth judgments or purposeful, collective sensemaking? Rethinking science education's response to the post-truth era

Noah Weeth Feinstein[a] and David Isaac Waddington[b]

[a]Department of Curriculum and Instruction, University of Wisconsin—Madison; [b]Department of Education, Concordia University, Montreal, Canada

**ABSTRACT**

Science education is likely to respond to the post-truth era by focusing on how science education can help individuals use scientists' epistemological tools to tell what is true. This strategy, by itself, is inadequate for three reasons. First, science does not actually offer foundational truth, and incautious assertions about scientific truth can make the problems of the post-truth era worse. Second, scientific knowledge offers only part of the solution to personal and policy problems and must be reconstructed in context. Third, people think about and act on science in social context—both *as* members of their social and cultural groups and *with* other members of those groups. Taken together, these arguments suggest that we should be focusing on a different question: How can science education help people work together to make appropriate use of science in social context?

## Introduction

On April 22, 2017, thousands of scientists and self-proclaimed science boosters in the United States joined the first "March for Science." Although scientists have always participated in political activism, this sort of demonstration had no obvious precedent (Appenzeller, 2017; Brulle, 2018). Those who marched in the U.S. were joined by demonstrators in 35 other countries (Science News Staff, 2017). Many protestors targeted particular policies and politicians in their signs and rhetoric, but the organizers of the U.S. March insisted their mission was nonpartisan. In their words, the March embodied a broader concern for the cultural and political status of science:

> Science protects the health of our communities, the safety of our families, the education of our children, the foundation of our economy and jobs, and the future we all want to live in and preserve for coming generations. We speak up now because all of these values are currently at risk. When science is threatened, so is the society that scientists uphold and protect. (Winsor, 2017)

In the year following the March for Science, it was difficult to drive through residential neighborhoods in Madison, Wisconsin, where one of us lives, without encountering a yard sign proclaiming "science is real" alongside other progressive political slogans. Since then, protest signs at climate marches around the world have urged spectators to "Unite Behind the Science," while diverse governments have claimed to be "following the science" in their response to the COVID-19 pandemic). The logical meaning of such slogans is not always clear, but the underlying sentiment is unmistakable: scientific knowledge should not be ignored.

These snapshots from our political moment reveal the profound sense of crisis felt by many people around the world. Science, they believe, has fallen victim to the post-truth era, a social moment "in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (Oxford English Dictionary, 2016). That sense of crisis has filtered down to educational research, where (for example) the theme chosen for the 2019 meeting of the American Educational Research Association was "Leveraging Education Research in a Post-Truth Era." Debates about the post-truth era intensified further in late 2019 and 2020 with the advent of the COVID-19 pandemic. This article, and the thematic set of articles to which it belongs, is not the first and will not be the last devoted to the educational implications of the post-truth era.

Let us not waste a good crisis. As science education gears up to address the post-truth era, not all of the possible responses are good ones, and some of the most intuitive pathways may worsen the problems they are intended to solve. Researchers can help by asking insightful questions and challenging widespread assumptions. This essay poses the questions that we believe will help steer science educators and educational researchers away from counterproductive pathways built on flawed assumptions about the post-truth era and public engagement with science more generally.

CONTACT Noah Weeth Feinstein nfeinstein@wisc.edu Department of Curriculum and Instruction, University of Wisconsin—Madison, 225 N. Mills St., Madison, WI 53704.

## Synopsis of the argument

The body of this essay consists of three arguments. First, science does not actually offer foundational truth; although the *pretty good knowledge* that science *does* offer is valuable, incautious assertions about scientific truth can exacerbate the problems of the post-truth era. Second, people who interact with science in their personal, social, and political lives are usually pursuing scientific knowledge as a means to practical ends, and scientific knowledge only offers part of the solution to their problems. Third, people encounter scientific questions in social context—both *as* members of their social and cultural groups and *with* other members of those groups. Taken together, these arguments indicate that science education should respond to the post-truth era by increasing its emphasis on pedagogies that help people work together to make appropriate use of science in social context.

Throughout the essay, we focus on descriptive/empirical claims about how people interact with science, rather than normative ones. Thus, for example, we are not arguing that people should act *as* and *with* members of their social groups—we are arguing that they *do*. We repeatedly (though not exclusively) use research on climate change to illustrate our points, both because climate change is a crisis of global scale, and because strident disregard for the scientific consensus on climate change (particularly in the United States) is a commonly cited feature of the post-truth era.

## The limited scope of educational solutions to the post-truth era

Before we present our central arguments, however, it is important to clarify the limited scope for educational solutions to the post-truth era. "Post-truth" is used and understood in several different ways. In the OED definition quoted above, "post-truth" indicates that emotion, bias, and personal conviction have crowded out rationality and objectivity—and, implicitly, expert evidence and knowledge. This definition reiterates the longstanding perception among many scientists and scientific institutions that public audiences are essentially irrational (Simis et al., 2016; Wynne, 1993). "Post-truth" is also used when prominent politicians casually lie or brazenly disregard evidence, violating the tacit norms of political discourse in which

> politicians generally only bend the truth. When caught lying outright—for example in attempts to escape responsibility for their actions–they provide complex justifications and near-apologies. (Sismondo, 2017, p. 563)

Finally, "post-truth" is often used to describe the spread of false, unsubstantiated, or deliberately deceptive stories through news networks (Waisbord, 2018) and social media channels (Del Vicario et al., 2016).

Scholars and pundits have proposed various causes for these distinct but overlapping manifestations of the post-truth era. Many scholars attribute the post-truth era to technological changes, particularly the rise of social media, that make it faster and easier to spread dubious information (Del Vicario et al., 2016; Vosoughi et al., 2018) by changing when, how, and with whom people share news and discuss politics (Freelon, 2015; Hampton et al., 2017). Others attribute the post-truth era to a broad rejection of expertise and technocratic governance, in which the failure of such governance to fulfill its promises (Fuller, 2017) feeds resentment of elite policy actors (Clarke & Newman, 2017). In this account, distrust of science is linked to declining trust in institutions more generally (Achterberg et al., 2017).[1] Political scientists have argued that political polarization plays a key role in the post-truth era (Anderson & Rainie, 2017) by exaggerating polarization in the news media (Baum & Groeling, 2008; though see Prior, 2013) and making it easier for people to dismiss news that favors their opponents (Ribeiro et al., 2017). Finally, there is the idea that the post-truth era derives from flaws in the public itself. Some blame these flaws on education (Wong, 2018) whereas others argue that new technologies exploit old flaws in human nature (Britt et al., 2019) that make us "selfish, tribal, gullible convenience seekers who put the most trust in that which seems familiar" (Anderson & Rainie, 2017). Of course these theories of the post-truth are not mutually exclusive. Lewandowsky, Ecker, and Cook bundle them together, arguing that

> The post-truth world emerged as a result of societal mega-trends such as a decline in social capital, growing economic inequality, increased polarization, declining trust in science, and an increasingly fractionated media landscape. (2017, p. 353)

Given this causal complexity, we should be wary of the idea that education alone can solve the problem. It is a common neoliberal trope that individuals can and should take on responsibilities that would otherwise fall on institutions (e.g., retirement accounts instead of social security, individual health insurance instead of national health services, sustainable consumption instead of environmental regulation). This argument is often used to deny the need for government regulation and investment (Peck, 2010). If navigating the post-truth era is the responsibility of (properly educated) individuals, why fix the institutions?

Education alone does not offer the long-term solution to the post-truth era. Education cannot regulate social media or prevent foreign disinformation campaigns, it cannot change laws to make policy elites more accountable to citizens, and it cannot eliminate the structural factors (entrenched special interests, gerrymandering, systematic disenfranchisement) that exacerbate political polarization. What education *can* do is help people cope in this

[1]Trust in science is complex. In the United States, for instance, although trust in science and scientists *overall* appears unshaken, a closer look at available data reveals divides along partisan and generational lines (American Academy of Arts and Sciences, 2018; Funk et al., 2019) and a gap between trust in the scientific process, which remains high, and trust in scientific institutions, which is softer (Achterburg et al., 2017). Regardless, public trust in science emphatically does not prevent political leaders from dismissing scientific evidence, nor does it prevent the spread of false or misleading stories. Perhaps most important, the perception of science being attacked need not be true to drive policy response. For the purpose of this paper, we assume that public (and scientist) perceptions of the post-truth era have some face validity—that they reflect real changes in the cultural status of science, even if those changes are more narrowly confined (to certain issues or certain actors) than the broad accounts of the post-truth era imply.

fragmented and chaotic landscape of contested knowledge, in which some of the old institutional supports stand in need of repair or replacement. The real question, of course, is how. As we wait, hope, and advocate for institutional solutions (Kelkar, 2019), how can education, and science education in particular, help people survive and sustain democracy in the post-truth era?

## Two directions for science education

We are convinced that science education can play a constructive role in the post-truth era, but believe that it is also possible that the field's well-intentioned but mis-directed efforts could make things worse. Indeed, we fear that science educators and science education researchers will respond to the challenges of the post-truth era by "doubling down" on well-established approaches that are poorly suited to the task at hand.

There is a longstanding tension between what might be called internalist and contextual approaches to science education. The internalist approach focuses on key scientific findings and idealized features of scientific work—the internal workings of science. Whether it deploys a heavily simplified scientific method or a more nuanced set of scientific practices, the basic claim of the internalist approach is that knowing science and "thinking like a scientist" will help people solve their personal and policy problems (e.g., Osborne, 2014). In contrast, the contextual approach starts with the personal or policy problem, bringing in science as a set of tools and explanations that, under some circumstances, provide part of the solution (e.g., Pedretti & Nazir, 2011). While the internalist approach keeps scientific work in the foreground, the contextual approach emphasizes the important but complicated relationship between science and other domains of life.

Neither approach is new. The internalist approach tends to dominate in education policy (especially in the United States), but teachers may in practice employ both. With respect to the post-truth era, though, they offer starkly different prescriptions. An internalist response to the post-truth era would focus on making a stronger case for the superiority of scientific practices and the robust nature of scientific findings. A contextual response would focus on clarifying the relationship between science and daily life, examining when and how science can be useful.

Science education's response to the post-truth era will also be shaped by the tension between individualistic and sociocultural approaches to education. The former focuses on individual knowledge and defines critical outcomes in terms of individual understanding and performance (e.g., Alonzo & Gotwals, 2012), whereas the latter emphasizes collective meaning-making and the use of cultural tools to achieve shared goals (e.g., Bang et al., 2012; Warren et al., 2001). Sociocultural approaches are increasingly accepted, particularly when they adopt the internalist emphasis on scientific practice (e.g., scientific argumentation), but individualistic approaches remain dominant; there is no clearer indication of this than the almost exclusively individualist focus of educational assessment.

Individualist and sociocultural approaches also differ markedly in their prescriptions for the post-truth era. An individualist response would attempt to inoculate students with accurate conceptual understandings and strong individual judgment. A sociocultural approach would attempt to develop and improve shared sense-making practices, in which students learned to work with others to make best use of scientific knowledge.

Given how science education has historically reacted to the bogeymen of pseudoscience, we fear that the field will respond to the post-truth era by returning to old narratives that focus on scientific reasoning and correct scientific conceptions (e.g., Darner, 2019) rather than the genuinely complex relationship between science and social problems. From this internalist and individualist perspective, the key question of the post-truth era is: How can science education help individuals use scientists' epistemological tools to tell what is true? For reasons we discuss below, we believe that this question is the wrong one, and that contextual and sociocultural approaches to science education offer better tools for responding to the post-truth era.

Anticipating a vigorous defense of internalist and individual approaches, we wish to clarify that we do *not* believe that contextual and sociocultural approaches should be used exclusively. We favor a pluralist, pragmatic strategy that combines the best elements of different educational approaches in context-appropriate ways. In this essay, however, we focus almost entirely on the flaws of internalist/individualist approaches and the compensatory strengths of contextual/sociocultural approaches. This is because internalism and individualism represent a deeply entrenched *status quo*. Individualism, especially, is still the implicit conceptual and methodological foundation of most of what we do in western education systems. We do not need to emphasize the importance of individual reasoning and scientific practices because there are plenty of other people doing just that, and there is little chance that contextual and sociocultural approaches would suddenly crowd them out of the classroom. Indeed, given the dominance of internalist and individualist strategies, we believe that their proponents should face a heavier burden of proof. Put bluntly, we have been investing the vast majority of our attention and resources in internalist and individualist approaches all along. If they have not sufficiently mitigated the post-truth era so far, why should we have confidence that their slightly modified successors will do better?

## What sort of truth does science offer?

Science education, as a field, is characterized by ambivalence about scientific truth. On one hand, the tentativeness and fallibility of scientific knowledge is widely acknowledged among researchers (e.g., Lederman & O'Malley, 1990). On the other, tentativeness and fallibility are typically deployed in classroom settings to explain how one scientific idea replaces another, not how science informs personal and civic life. The fallibility of scientific knowledge tends to fade from view when research focuses on public misconceptions and "science denial" (Berkman & Plutzer, 2011; Darner, 2019; Eve & Dunn, 1990; Moore, 2008). Meanwhile, U.S. national standards continue to advance the idea that science provides reliable answers to important social questions (Feinstein & Kirchgasler, 2015), while students and teachers continue to perceive science as the domain of correct and incorrect answers (e.g., Furtak, 2006).

The relationship between science and truth is well-trodden territory. It has been explored at length by philosophers, social scientists, and scientists themselves. There is surprising consensus on one point: Science does not reveal foundational, ultimate truth, at least not in the permanent, unchanging sense that we normally associate with the word (for one summary of the many lines of work that contribute to this conclusion, see Longino, 2002). This point seems abstract and technical, but it has real consequences for how science is discussed and taken up in civic and personal life.

If science doesn't produce absolute truth, what does it produce? Here there is less consensus, but a reasonable starting place is that science produces *pretty good knowledge*: Powerful but limited insights that help us act in and understand the world (Waddington & Weeth Feinstein, 2016). In other words, science does not tell the foundational story of how the world really is, but it does give us some useful conceptual tools for action in the world. It may not offer the answers that policy-makers want, but it nonetheless has strengths that render it useful when crafting policy and making decisions (Funtowicz & Strand, 2007).

Readers might quibble with the distinction between truth, on one hand, and pretty good knowledge, on the other, arguing that the limitations of science are implicitly embedded in some uses of the word truth, or that science deserves the word truth because it is "more true" than the alternatives. But there is a consequential difference between claiming truth (with the implication of certain proof) and claiming pretty good knowledge. Overweening scientific claims to truth and accuracy have contributed to science's own crisis of legitimacy by creating expectations of certainty that science cannot satisfy (Saltelli & Funtowicz, 2017). The gap between public expectations of truth and the reality of scientific knowledge can be exploited by "merchants of doubt" who turn the inescapably uncertain nature of scientific knowledge into political scandal (Oreskes & Conway, 2011). In contrast, acknowledging value positions and doubt may make scientists more credible in public debates (Jensen, 2008; Yamamoto, 2012).

Climate change research offers clear examples of how scientific knowledge can develop nuanced language for conveying certainty and confidence. The Intergovernmental Panel on Climate Change (IPCC) has been particularly innovative. For its Fifth Assessment Report, an updated summary of climate research, the IPCC disseminated a technical framework for contributors to use in discussing their own research results, particularly when discussing scientific certainty with non-scientist audiences (Mastrandrea et al., 2011). This framework built on years of discussion and prior attempts to standardize terminology (Adler & Hirsch Hadorn, 2014; Giles, 2002). Although the IPCC process differs from standard scientific publication practices, this example vividly illustrates how climate science, beset by very public challenges, responded with more careful qualification rather than more strident claims to the truth.

## Does science provide solutions to personal and civic problems?

Conversations about the post-truth era often focus on what people *believe*, but the anxiety that animates these conversations is often driven by what people *do*. We, as educators, are interested in rich and accurate understandings of the climate system—but we, as humans, are more upset when people support policies that produce social and environmental catastrophe. When thinking about how science education might respond to the post-truth era, it is important to avoid the common misconception that scientific knowledge offers solutions to the problems of personal, social, or civic life, and that more accurate scientific knowledge will necessarily lead to a particular course of action.

The problems of personal, social, and civic life rarely map directly onto scientific questions (NASEM, 2016). For a mother seeking new therapies for her autistic son (Feinstein, 2014), town councilors discussing methane leaks at their local landfill (Layton et al., 1993), sheep farmers dealing with radioactive contamination from Chernobyl (Wynne, 1992), or environmental justice activists fighting for protection from industrial carcinogens (Allen, 2003), questions such as whom to believe and what to do next are shaped by cultural, historical, and political context. When scientific knowledge enters their considerations "in unpredictable ways that are shaped by personal motivations and cultural context" (Feinstein, 2011, p. 177), it must be reconstructed, tailored, and adapted to make sense in the lives of the people who encounter it (Irwin & Wynne, 1996). Even then, its relationship to action is attenuated by social norms, structural context, and other sources of information (Kollmuss & Agyeman, 2002; Stern, 2000). Thus, even when commuters know (and care) about the carbon intensiveness of driving, their transportation choices are constrained by the availability, affordability, and safety of public transit as well as the time structure of their work and family responsibilities. Even when farmers know (and care) about the climate implications of different crops, their choices are still governed by their knowledge of cropping systems, their investment in equipment and infrastructure, and the merciless logic of supply chains and commodity markets. The pretty good knowledge produced by science is often useful and even necessary, but in these and many other circumstances, it is only part of the picture.

Climate change offers numerous examples of people framing their personal, social, and civic decisions in decidedly nonscientific terms. As much as we might like them to do so (Wynes & Nicholas, 2017), people rarely base their childbearing decisions on climate change. On a civic scale, sea level projections make a compelling case for relocating coastal communities, but the problem of "managed retreat" (Hino et al., 2017) is profoundly entangled with local culture and community values, and neither the obstacles to relocation nor the cost of relocating can be adequately summarized in scientific terms (Adger et al., 2013). At a policy level, Hoffman (2011) describes how climate change skeptics see climate science as duplicitous cover for partisan political goals:

> For skeptics, climate change is inextricably tied to a belief that climate science and climate policy is a covert way for liberal environmentalists and the government to interfere in the market and diminish citizens' personal freedom … skeptics believe "the issue isn't the issue" and "the environmental agenda seeks to use the state to create scarcity as a means to exert their will, and the state's authority, over your lives." (Hoffman, 2011, p. 79)

Climate science is relevant to reproductive decisions, managed retreat, and energy policy, and scientific knowledge can shape how people think about these challenges (Ranney & Clark, 2016)—but in none of these cases do the people involved see their situations entirely (or even primarily) in terms of climate science (Moser, 2014).

None of this is particularly controversial from the perspective of people who study environmental or health behavior. Yet education researchers often adopt a naïve rationalist position, proceeding as if people framed decisions in terms of science and made choices based on their scientific knowledge or lack thereof. One might surmise that we do this because science educators believe in the liberatory and prophylactic power of scientific knowledge (a longstanding cultural value), because it is what we already know how to do (it is our historical strength) or because our education systems are hemmed in by high-stakes, knowledge-centric assessment schemes (our structural and institutional context). Thus, unaware of the irony, we dismiss strong evidence about public engagement with science to preserve our commitment to naïve rationalism—and we do so because we are constrained by cultural, historical, and structural factors.

## How does social context shape judgment and action?

If science doesn't offer truth, and scientific knowledge plays a limited role in solving personal and policy problems, it makes sense for science education to shift some attention away from judging scientific truths and toward purposeful, contextualized sensemaking in which scientific knowledge informs questions and decisions that are framed in non-scientific terms. But who, exactly, is doing the sensemaking? As we have noted above, many science educators and education researchers conceptualize civic action in terms of individuals taking action based on their (individual) knowledge. This is not, strictly speaking, a "wrong" mode of analysis. As is the case with all social problems, thinking about reasoning and action from the standpoint of the individual can help illuminate important aspects of the situation, as well as potential solutions. However, science educators tend to neglect two ways in which judgment and action in civic contexts are profoundly social. First, people encounter science *as* members of social and cultural groups, interpreting and responding to it in ways that reflect the attitudes, values, and propensities of those groups. Second, people encounter science *with* members of their social and cultural groups, seeking out science through existing networks, drawing on the people they know to help them understand it, and acting in ways that are constrained and enabled by their communities.

Multiple distinct lines of research converge on the finding that cultural, political, and social identities shape peoples' interpretation of scientific findings. Much of this work comes from research on risk, health, and the environment, domains in which people often interact with science. In each of these domains, different aspects of identity interact with historical and cultural context to shape how people make sense of these interactions. For example, African-Americans have lower trust in medical systems and medical research because of a "legacy of racial discrimination in medical research and the health care system" (Boulware et al., 2003, p. 358). Women in many different societies express greater environmental concern than men (Stern et al., 1993), but their sense of vulnerability to environmental risks may depend on the level of gender equity in their national context (Olofsson & Rashid, 2011).

Within these broader framing conditions, Dan Kahan's cultural cognition laboratory has used both descriptive and experimental methods to show how identity, values, and worldview cause people to evaluate scientific evidence in ways that are "congenial to their values" (Kahan et al., 2011, p. 147), and to accept or dismiss risks based on whether those risks call their worldviews into question (e.g., Kahan et al., 2007). Writing with education in mind, Kahan demonstrates that attitudes about climate change are *more* polarized among people with more schooling (Kahan et al., 2012), and that (in the United States at least) beliefs about climate change tell us less about scientific reasoning capacity than "latent cultural affiliation" (Kahan, 2017; see also McCright et al., 2016, for a contrasting theoretical perspective that arrives at similar conclusions).

Kahan's quantitative results converge with the conclusions of older qualitative research from sociology, anthropology, and education. Sociologists, in particular, have repeatedly demonstrated that public engagement with science is shaped by social identity, historical context, and power relations. In Wynne's classic study of radioactive fallout in England's Lake District (Wynne, 1992), farmers' historical and contemporary relationships with the nearby nuclear power plant informed how they interacted with government scientists, and their response to scientific guidance reflected their own sense of disempowerment—what Wynne later called reflexive dependence (Wynne, 1996). Other studies show how identity influences the interpretation of science in contexts such as AIDS (Epstein, 1996), autism (Silverman, 2011), and, of course, climate change (Hoffman, 2011).

Knowing who someone is and what culture(s) they belong to can tell you a lot about how they will interpret science. People do not leave their cultural identities at the door when they encounter science, just as scientists themselves pose questions and interpret evidence in ways that are shaped by their own cultural perspectives. With respect to the post-truth era, we must recognize that

> the human being whom we fasten upon as individual *par excellence* is moved and regulated by his associations with others; what he does and what the consequences of his behavior are, what his experience consists of, cannot even be described, much less accounted for, in isolation. (Dewey, 1927/1954, p. 188)

If we wish to change how people grapple with scientific knowledge, we must understand their social and cultural positionality.

It is tempting to respond to the influence of culture and identity by trying to filter them out—treating them as corrupting influences that both teachers and students must understand and eschew in order to better simulate scientific rationality. There are three problems with this strategy. First, there is no such thing as a culture-free perspective. What is typically presented as "filtering out" the corrupting influence of culture and identity is, in practice, substituting one cultural standpoint for another (Harding, 1992). Second, culture and identity are constantly reinforced by ongoing social interactions. When an educator attempts to shift students' cultural perspective, she is working against the contemporaneous influence of the sociocultural worlds they inhabit (Aikenhead, 2006). Finally, attempting to filter out social and cultural perspectives assumes that these perspectives are detrimental to sensemaking, when in practice they can be powerful and constructive resources (e.g., González et al., 2006).

People do not just encounter science *as* members of social and cultural groups, they encounter science *with* those groups. This idea is now commonplace in educational research. Generations of learning theorists and empirical researchers have described the social origins of individual thought (e.g., Vygotsky, 1980), the cultural nature of human development (Rogoff, 2003), and the central importance of communities for learning (Lave & Wenger, 1991). These ideas can and should shape how science education envisions public engagement with science in the post-truth era.

In 2016, a consensus panel from the National Academies of Sciences, Engineering, and Medicine (2016) highlighted the positive outcomes of community engagement with science, reporting that

> science literacy can be expressed in a collective manner—i.e., resources are distributed and organized in such a way that the varying abilities of community members work in concert to contribute to their overall well-being. Science literacy in a community does not require that each individual attain a particular threshold of knowledge, skills, and abilities; rather, it is a matter of that community having sufficient shared capability necessary to address a science-related issue. (NASEM, 2016, p. 6)

In some cases, people encounter science *with* their communities by coordinating action around well-defined, shared goals. Research on social movements compellingly illustrates how activism offers a powerful context for collective sensemaking around science (Casas-Cortés et al., 2008; Choudry, 2015; Epstein, 1996). Jamison (2010) provides one interesting account of collective science literacy in climate change social movements, describing how coalitions of scientists and laypeople leveraged each other's understanding in the pursuit of political change, while also repeatedly intervening in climate change science to the extent that they "affected and influenced the making of climate change knowledge." Of course, collective engagement with science can also produce the social phenomena that are sometimes branded "anti-science," and are frequently cited as examples of the post-truth era. For example, McCright and Dunlap (2003) describe how established political groups coordinated with social movement actors to dispute the emerging scientific consensus on climate change, inserting new narratives of doubt and creating epistemological cover for political opposition to climate change policies.

Whether the results are inspiring or troubling, social movements and related forms of collective action have a disproportionate impact on policy and political discourse. For the impending socio-ecological crisis of climate change, it is difficult to imagine any widespread social change that does not involve social movements. If science educators want to improve public capacity to make appropriate use of science in civic decision-making, it makes sense to prepare people for the collective sense-making that takes place in these overtly social contexts.

Focusing only on activism, though, distracts from more common activities where the subtle nature of collective sensemaking makes its importance easier to miss. For example, we are accustomed to thinking about actions like voting or choosing to read a news article in terms of individual judgment, but in both cases what appears to be individual action is meaningfully social. When people vote, their votes reflect the political discussions they have had, the political events they have attended, and the political messaging targeted at them by people who share their group affiliation (e.g., Fieldhouse & Cutts, 2018; Wyatt et al., 2000). The choice and interpretation of a news article is equally social. Political and cultural affiliation affects where people get their news (Prior, 2013), social networks (both on and offline) affect what stories they see (Schmidt et al., 2017), and social interaction with the people around them, people who are likely to share their values, reinforces shared perspectives and makes some interpretations more likely than others (Robinson & Levy, 1986).

The social systems that constrain and facilitate sensemaking are equally present when that sensemaking involves science. People learn (or fail to learn) about science and health through their social networks (Southwell, 2013), and exposure to science news predicts interpersonal conversations about science (Southwell & Torres, 2006). With respect to climate change, for example, it will surprise none of our readers to learn that social media platforms both reinforce strong partisan sentiments and give rise to conflict when people encounter those whose views they oppose (Williams et al., 2015).

The social nature of scientific sensemaking is neither intrinsically good nor inevitably bad, but once you look for it, it is difficult to miss. With respect to the problems of the post-truth era, this does *not* mean that all science education should attempt to replicate the social complexity of life outside of school. It *does* mean that teaching people to filter out their own internal biases in artificially isolated academic contexts is unlikely to be fruitful, because that isolation ends when the exercise ends. Teaching students to work productively and wisely in complex social contexts is both epistemically sound and pragmatically important.

## What does this mean for education?

Earlier, we predicted that science education would respond to the challenges of the post-truth era by gravitating toward an internalist, individualist framing of the problem that focuses on the following question: How can science education help individuals use scientists' epistemological tools to tell what is true? We then argued that science offers pretty good knowledge, rather than foundational, ultimate truth; that scientific knowledge becomes useful when it is integrated with other sources of information and reconstructed in context; and that people invariably interact with science both *as* and *with* members of their social and cultural groups. Taken together, these three arguments suggest that we should be focusing on a different question, one that aligns with a contextual, sociocultural approach: How can science education help people work together to make appropriate use of science in social context?

Perhaps the most important thing our field can do is replace an old way of thinking about social context, in which social influences corrupt a pure scientific rationality, with a newer one that accepts the social nature of sensemaking and embraces the idea that social situations can be structured to produce epistemologically stronger and more useful outcomes (Longino, 2002). Although science has an important role to play in social sensemaking, it is not a disinterested or objective one, it does not offer the only useful account of reality, and its epistemological strategies are not necessarily well-suited for socially situated problem solving. Social and cultural groups can undoubtedly distort sensemaking in troubling ways, but they also provide valuable information (e.g., Feinstein, 2014; Southwell, 2013), including information that reflects the real experience of marginalized groups (e.g., Boulware et al., 2003; Allen, 2003). Science education should account for the cultural and political nature of collective sensemaking, while also being more deliberate and sophisticated in structuring dialogue to grapple with contradictory worldviews, extreme positions, competing frames, and sociocultural positionality. As a field, we should aim to support students as they move from being passive participants in sensemaking scenarios whose rules are chosen by others (Miller et al., 2018) to being active shapers of the social contexts in which they encounter science, empowered actors who can set up, seek out, and work well within a wide range of collective sensemaking situations. In short, for science to be an important part of civic discourse, civic discourse—including its more pluralistic, creative, and chaotic forms—must become an important part of science education.

Making the challenges of civic discourse central to science education would require a substantial rebalancing of educational priorities. In most national contexts, the policy regimes that govern formal education are unlikely to embrace this change, at least not in a timely manner. Yet, in the absence of wholesale policy change, it is still possible to push science education in a useful direction by introducing pedagogies and materials that helps students (and adults) work together to make appropriate use of science in social context. Within tightly constrained formal education systems, the best choice may be to refine, adapt and deploy existing tools that lend themselves to the challenge, taking advantage of whatever leeway is available within standards and assessment systems. Outside of formal education, the possibility for transformative innovation is greater, but implementing such innovations on a large social scale is likely to remain difficult.

Science teachers have access to a wide range of educational tools—tools developed in the contextual tradition of formal science education—that can be used to help students "recognize the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help them achieve their own goals" (Feinstein, 2011, p. 180). These tools include pedagogical strategies such as socio-scientific issue discussion (Åkerblom & Lindahl, 2017) and place-based education (Buxton, 2010), as well as curricula like the UK's 21st Century Science (Millar, 2006). It may also be possible to modify contemporary pedagogical strategies that were developed with the internalist goal of replicating scientific practices but have a clear emphasis on social interaction. For example, current work on scientific argumentation (e.g., McNeill & Berland, 2017) focuses on the epistemological practices of scientists, but could potentially be adapted to shed light on the (ab)uses of evidence and collective construction of meaning in contexts where science informs personal and policy decisions. These approaches are worthwhile and necessary components of science education in the post-truth era, but more research is needed to identify pedagogical practices that integrate civic discourse with scientific evidence and that build students' capacity to engage in robust and rigorous collective sensemaking (Braaten & Windschitl, 2011; Warren et al., 2001) across a wide range of social environments, including online environments (Greenhow & Askari, 2017). Of course, any such innovations must be supported with powerful professional development if they are to have any effect at all.

Some national contexts undoubtedly offer more space for teaching that goes beyond internalist and individualist approaches. Canada is a particularly interesting case. Earlier policy frameworks emphasized "Science, Technology, Society, and Environment," encouraging the development of curricula and pedagogies that addressed the roles of science in social life (Pedretti & Nazir, 2011), and some strong critics of internalist and individualist approaches made substantial headway in changing state curricula (Désautels, 2015).

More recently, a nationwide emphasis on the legacy of colonialism and the displacement of Indigenous knowledge has provided another powerful challenge to the internalist assumptions of science education. Researchers and teachers in Western Canada (Aikenhead, 2002, 2006; Lemaigre, 2000) have developed cross-cultural science curricula that integrate Western scientific knowledge with Indigenous knowledge such that Indigenous traditions of knowing and experiencing are more valued and less displaced. This work, as well as that of others who are integrating nonscientific ways of seeing into the sciences classroom (Blades, 2001, 2016), aligns well with the 20th century philosophical insight that science is not the sole, foundational truth about experience, but rather one key intellectual tool among others (Dewey, 1925).

It is reasonable to ask whether this strategy opens the door to an overly pluralistic "anything goes" approach. Particularly in the current post-truth context, some may worry that deprecating science to the level of pretty good knowledge and acknowledging the value of nonscientific points of view will create space for discourses like climate denialism to proliferate. Even a view as marginal as the Flat Earth hypothesis might appear to be countenanced by such a pluralist stance.

Our response here is twofold. First, as a matter of practice, the curriculum allows us to pick and choose which sorts of discourses we are willing to legitimate in the science classroom. Giving science a humbler position as pretty good knowledge does not preclude designating some pseudoscientific knowledge as "really bad" and excluding it from the outset. Unlike some nonscientific points of view (e.g., indigenous knowledge), Flat Earth and most of the anti-vaccinationist discourses have pretentions to scientific credibility which fall apart when under internalist scrutiny. Here, internalist approaches that explain the particular robustness of scientific practice are obviously valuable, which is why we do not suggest abandoning them. But the internalist tonic does not cure all of our post-truth ills. As Robert Proctor points out, much of science that tobacco companies sponsored in their efforts to fend off regulation was of excellent quality from an internalist standpoint (Proctor, 1995). The same is likely to be true for at least some climate denialist science.

This is why the second aspect of our response to the "anything goes" critique is to emphasize the importance of thinking through socially significant issues on pragmatic grounds—not primarily in terms of whether knowledge claims meet internalist criteria, but rather in terms of whether and how well they seem to work, as well as whose interests they serve. We readily acknowledge that people will adopt—and communities will coalesce around—beliefs that are not in accord with the current state of scientific evidence. In our view, this can sometimes be fine. An array of nonscientific views (religious viewpoints, indigenous viewpoints, everyday wisdom viewpoints, etc.) often guide practical action better than science does, and some of these can co-exist peacefully with non-chauvinist approaches to science. Some beliefs, however, are not just nonscientific, but actively science-discrepant. Some of these have little social significance (e.g., belief in ghosts), but some are deeply troubling, as the oft-cited examples of vaccine avoidance and climate skepticism reveal.

What makes these instances troubling, from our perspective, is not so much their scientific wrongness but rather their social consequences. Accordingly, our stance here is a pragmatist one. We believe that focusing on action and its consequences, and on the social context of knowledge production, are more effective strategies for protecting society from the negative consequences of science-discrepant beliefs. Rather than attempting to rebut those beliefs based *solely* on a detailed consideration of evidence and epistemological warrants (an approach that has achieved strikingly limited success in the public arena), science education might draw attention to the possible consequences. What if you don't take action on climate change and it turns out to be real? How bad is measles really? Furthermore, by drawing attention to the social and institutional origins of knowledge claims, such as who is paying for a particular piece of research, science education opens up a contextualist mode of analysis that—as we have discussed above—can be exceptionally useful in judging the trustworthiness of claims. Once again, we wish to be clear that we do not advocate these strategies to the exclusion of internalist approaches that emphasize, for example, the epistemic grounds that scientists use to evaluate claims in their particular fields of research. But we do think that internalist approaches should be complemented by consideration of the social context and consequences of urgent practical and policy decisions.

This is not, historically, an area of strength for science education, but another field within formal education—social studies education—possesses greater expertise in the cultivation of constructive dialogue focused on civic and policy action (e.g., McAvoy & Hess, 2013). Rather than re-inventing the wheel, science educators and researchers should borrow from and collaborate with social studies educators and researchers (Feinstein & Kirchgasler, 2015). This partnership could take a modest form, such as borrowing controversial issue discussion techniques from social studies educators (Hess, 2009), or it could take a more robust form, such as extended cross-curricular collaborations on important social issues. In some contexts, there may be more curricular flexibility in the social studies, which raises the possibility that enhancing social studies materials and expanding the capacity of social studies teachers to address scientific topics might be another power strategy for integrating science and civic discourse.

Informal science education offers a very different set of possibilities. Science museums have been holding policy forums and public deliberation exercises for many years, and some envision an important social role for museums as facilitators of science-related civic discourse (Bandelli & Konijn, 2020; Bell, 2009). This type of programing appears to have educational value for participating adults (Davies et al., 2009), but its broader social impact is uncertain. Furthermore, future investment in museum-based interventions must contend with the pervasive equity and diversity problems of museum-based education. Across multiple national contexts, museum visitors consistently represent a privileged and empowered cross-section of society (Dawson, 2019; Feinstein & Meshoulam, 2014). Changing this inequitable dynamic will likely require redesigning museum-based public deliberation exercises in partnership with diverse stakeholders. Museums might also use purposive sampling and recruitment strategies like those used in political experiments such as deliberative polling (Fishkin et al., 2018). Promising museum-based programs are inevitably haunted by questions of scale: How can museum-based policy forums ever be more than civically engaged entertainment for a small number of people? The rapid spread of science cafes offers some hope, but the same organizational heterogeneity that makes the museum world a source of exciting innovations poses a clear challenge to implementing those innovations widely and at consistently high quality.

Of course, informal science education is not limited to museums. In some national and cultural contexts, clubs and co-curricular organizations may offer better opportunities to develop and introduce innovative programs at a sufficiently large scale. In the United States, for example, about half of adult women participated in a youth organization called the Girl Scouts at some earlier point in their lives, many for multiple years (Girl Scout Research Institute, 2012). Because organizations like Girl Scouts consider civic engagement to be a part of their educational mission (Taft, 2010), they may represent an unusually good context for introducing civic science activities.

Whether in clubs, museums, or classrooms, educators must confront the social and epistemological complexity of the post-truth era rather than retreat from it, and researchers must find effective ways of supporting them. The impulse to retreat into a largely internalist and individualist posture is understandable. In the post-truth era, acknowledging the epistemic limitations of science seems like one more threat to scientific authority, and the social world appears to be a thicket of bias, polarization, and motivated reasoning. There is a comforting clarity to be had in focusing on the triumphs of science rather than rather than its uncertain and variable relevance to decision-making, on what individual students know rather than their shared capacity to make sense of science in social context, and on their ability to act like scientists crafting disciplinary explanations rather than citizens making decisions under conditions of deep uncertainty. In the end, though, these internalist, individualist strategies are the science education equivalent of abstinence-only sex education: They satisfy a moral and esthetic urge to provide a clear picture of right and wrong, but in doing so, they ignore the complex social and epistemological reality of life and leave students unprepared for the challenges they face. We cannot protect students from the messiness of the post-truth world, nor can we inoculate them against the distorting influence of the social systems that they (and we) inhabit. Until and unless our societies repair the institutional and technological infrastructure that supports the use of science in addressing civic questions, the best thing that science education can do is help students work within this "epistemically unfriendly environment" (Pritchard, 2013), drawing in science as they make better sense of that world together.

## ORCID

Noah Weeth Feinstein http://orcid.org/0000-0001-5071-7761

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