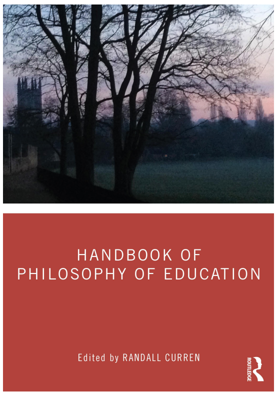

Handbook of Philosophy of Education

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Climate, Science, and Sustainability Education

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CLIMATE, SCIENCE, AND SUSTAINABILITY EDUCATION

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Introduction

In recent years, debates about lay cognition of scientific information and science communication have been at the forefront of debates about climate communication and education, and to a lesser extent, sustainability education (McCaffrey & Rosenau 2012; Priest 2013; Bedford 2016; Plutzer et al. 2016; Ranney & Clark 2016). Theories and evidence concerning especially the motivated cognition of scientific information, and about the frailty of human cognition generally (such as *dual systems* and *argumentative theories of reasoning*), have been taken to suggest that *science literacy* – in the sense of knowing some basic results or methods of the sciences – will be insufficient to ensure that citizens form beliefs and attitudes consistent with consensus climate (and other) science (Suldovsky 2018), and in particular with the thesis that observed global warming in the past 50–100 years is primarily anthropogenic (the AGW or anthropogenic global warming thesis).

Climate contrarians indeed have self-reported high levels of general science literacy (Kahan et al. 2012) and climate literacy (McCright & Dunlap 2011). Many researchers have thus concluded that climate communicators and educators should move away from teaching that reflects a *deficit model* of the causes of science ignorance/denialism and of the methods of remediating it, namely, ignorance of relevant scientific knowledge or methods, or other misunderstanding of science, and teaching designed to remedy such ignorance and misunderstanding (Priest 2013; Bardon 2019; Feinstein & Waddington 2020).

What to put in its place has been a matter of some disagreement. But widely discussed strategies include careful framing of the climate change issue in educator language (Nisbet and Mooney 2007); teaching key ideas about the nature of science (NOS), such as the epistemic status of scientific claims (i.e., they are reliable truths, not certainties) (Feinstein & Waddington 2020); or "inoculating" the learner against fallacious anti-science arguments by exposing them to the scientific consensus or to past examples and showing why they are fallacies (e.g., "The evidence linking smoking to cancer remains uncertain, therefore more research is needed before action is taken") (Linden et al. 2017). Whatever the particular strategy, it is widely agreed that, because science *comprehension* (understanding, knowledge) does not determine a capacity (or will) to recognize and give due credit to trustworthy science, science communicators and educators should alter their purposes to prioritize teaching a capacity to *recognize* and make use of reliable science, i.e., institutionalized consensus science, and so deprioritize teaching for science comprehension (Priest 2013; Kahan 2017; Feinstein & Waddington 2020). In other words, the ability to identify and trust reliable science *independently of*

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any capacity to understand it should be the focal purpose of civic science education, i.e., the learning citizens of a democracy need to competently make decisions about science-laden social issues (*socio-scientific issues*).

This chapter examines the meaning of this debate for the teaching of climate science – and indirectly sustainability – in formal settings, especially K-16 science classrooms. Is it urgent that school and university *science teachers* deprioritize teaching for comprehension and worry more (than they have to date) about how they frame the climate issue, teach the NOS, or inoculate students against fallacious anti-science arguments? Should they in general be less concerned to teach for science comprehension and more concerned to teach for reliable science recognition as they attempt to promote civic science learning?

I critically discuss some oft-cited evidence supporting a "Yes" answer to these questions, the *Humean diagnosis* of the causes of climate contrarianism. Some reforms suggested by this evidence are not obviously very relevant for formal science educators; others make sense independently of it. The latter are dubiously contrasted with *science literacy*, and I will argue that the *Humean diagnosis* is a potentially unhelpful lens for teaching the value dimensions of socially relevant sciences like climate science in science classrooms.

The Humean Diagnosis

It will be helpful to organize the reasoning at issue into the following *argument from the Humean diagnosis*:

1 If general or climate science literacy do not correlate with and predict concern for AGW (or other due trust in consensus climate science), then the *deficit model* is false; climate beliefs are not a function of scientific knowledge or comprehension.
2 If the *deficit model* is false, then increasing general or climate science literacy will be (at best) insufficient if science educators/communicators aim to increase belief in AGW or trust in climate science.
3 (*The Humean Diagnosis*) Because of the cultural cognition of scientific information, together with the biased nature of human cognition, including moral cognition, general science or climate literacy do not predict/correlate with concern for AGW.
4 Therefore, the *deficit model* is false.
5 Therefore, increasing general science or climate literacy will be insufficient if educators aim to improve belief in AGW or boost trust.

The Humean diagnosis itself consists of a few components. These include (a) the *cultural cognition thesis*, (b) an *argumentative theory of reasoning*, and (c) a *social intuitionist account* of moral reasoning and judgment. This set of ideas embody a Humean diagnosis in that they analyze denial not in terms of epistemic standards of evidence or warranted belief, but in terms of what causes or explains belief (Bardon 2019: 4). The postulated causes, moreover, are certain desires, such as for social inclusion, as well as associated emotions and gut-level moral reactions. Altogether they embody a certain skepticism concerning moral reasoning in particular.

Cultural cognition is a species of motivated cognition (or reasoning). *Motivated cognition* is any process of belief formation that serves some end other than true or warranted belief (Bardon 2019; Kahan et al. 2012). By hypothesis, motivated cognition is fallacious reasoning that is fallacious because of some factor other than ignorance of relevant information, faulty premises, or faulty cognitive faculties (e.g., memory loss, clinical paranoia). These factors can obviously interact. But motivated cognition is thought to independently explain reasoning that turns on or yields ignorance or false beliefs; the reasoning turns on or yields these because the reasoner is motivated to ignore relevant true information.

Because belief is involuntary, motivated cognition can seem mysterious. In nonmotivated reasoning, evidence that T is true compels belief that T. Motivated reasoners are aware of the evidence that T, yet deny that T; some research subjects who score high on science literacy nevertheless deny the findings of climate scientists. Thus, some mechanism of rationalization or self-deception must be involved. According to the cultural cognition hypothesis, that mechanism is a reasoner's desire to signal and protect their status as a member of a valued cultural group, especially one defining their political identification (Bardon 2019; Kahan et al. 2007, 2012). So, it is sometimes also called *identity-protective cognition,* though it would be more accurate to call it *group identity-protective cognition* (or "GIP cognition"). What is protected through cultural cognition is not just any identification, e.g., "jogger" or "native Pennsylvanian." What is protected is membership in a *political culture* identifying group. Thus, conservatives deny the scientific consensus on anthropogenic climate change because they fear that affirming it would be counter to their status as conservatives; liberals deny the science supporting GM food safety because affirming it would threaten their status as liberals.

Relative to science denial, defenders of cultural cognition are egalitarians of a certain sort. They believe that susceptibility to science denial is human. Conservatives and liberals, scientists and nonscientists, are all equally liable to deny some bit of science depending upon its perceived sociopolitical consequences (Bardon 2019; Kahan 2017). If those consequences fit with the ways conservatives prefer to frame social issues, conservatives are more likely to affirm, whereas liberals are more likely to deny, the relevant science, and *vice versa.* So, conservatives deny whereas liberals affirm climate science because it is perceived to fit with a "big government" framing of this social issue. Conversely liberals deny whereas conservatives affirm the science supporting GM food safety because it fits with a "big ag" framing of food politics. If this is correct, susceptibility to denial of scientific information is symmetrical between liberals and conservatives. Some critics reject this egalitarianism, arguing that conservatives are demonstrably more susceptible to science denial, given factors such as personality and the tendency of new science to disrupt the social *status quo* (Jost 2017).

In a Humean analysis, the cultural cognition thesis is combined with the *argumentative theory of reasoning* and the *social intuitionist* theory of moral judgment. According to the argumentative theory of reasoning, human practices of argumentation, and the faculties of cognition underlying them, are not evolved for the purpose of uncovering truth. Rather they evolved for the purpose of coordinating social action, which they do primarily by helping us identify reasons that will persuade others to see things as we do (Mercier & Sperber 2019). Consequently, humans are bad at reasoning, and they prefer to draw conclusions based on intuitive shortcuts or gut feelings, heuristics, and biases. Jay Odenbaugh has noted that many of these – including availability bias and anchoring, loss aversion, and temporal discounting heuristics – "are relevant to how we think and act regarding climate change": "Our pro-environmental behaviors depend on the options we consider, their anchoring, their being represented as losses or gains, and how close or remote their impacts in time are" (Odenbaugh 2017: 27).

Social intuitionists apply this thinking to moral belief, claiming that it is generally conditioned by the emotions (Haidt 2013). Moral beliefs are governed by intuitive, emotional reactions to situations, and changes in our feelings are regulative for our moral thinking – and not *vice versa* – even when the grounds of these feelings are irrelevant to the moral issue at hand. Thus, one study found that induced feelings of disgust can bias moral judgment (Wheatley and Haidt 2005) and that moral reasoning frequently appears to occur *post hoc,* in order to justify beliefs antecedently adopted on the basis of gut reactions.[1] To this, social intuitionists add that differences in moral, and even political, beliefs reflect different prioritizations of several intuitive *moral foundations*, i.e., foundational moral values, including care/harm, fairness/cheating, loyalty/betrayal, deference to authority/subversion of authority, purity/degradation, and liberty/oppression. Whereas liberals tend to prioritize care, fairness, and liberty, conservatives tend also to give weight – more so than liberals – to loyalty, deference to authority, and purity (Haidt 2013).

Together with the politicization of climate science, these ideas make for a powerful explanation of American climate denialism. As is known, special interests opposed to climate mitigation (fossil fuel industry, free market ideologues, "small government" libertarians, and deregulation advocates) have used their power and influence to make climate change a partisan political issue while circulating misinformation designed to undermine confidence in climate science (Oreskes & Conway 2011). They capitalized, in other words, on the psychology, using misinformation to reinforce heuristic thinking (rather than deliberate reasoning) and partisan political identification to stoke tribal defenses and shut down reasoning and reflection. Combining these forces, we would expect denialism to track partisan political affiliation and to be unrelated to knowledge of climate science. In the now-famous study "The Cultural Cognition of Scientific Consensus," Kahan *et al*. found nearly that (2012). Conservative subjects who self-reported greater science literacy more strongly rejected consensus climate science. Other research has found that conservative white men account for the great majority of climate deniers, and that those who self-reported understanding global warming "very well" more strongly denied the consensus science of it (McCright & Dunlap 2011).

The State of Climate and Sustainability Education

To fully evaluate the argument from the Humean diagnosis, we need to appreciate the current state of climate education. As climate is perhaps the world's most pressing sustainability problem, the state of sustainability education is one aspect of the state of climate education. At the K-12 level, the news is not very good in either case, though arguably worse relative to general sustainability.

Climate literacy has been defined in terms of many fundamental principles, too numerous to specify here. Focal principles concern the role of the Sun and solar radiation in climate; the role of Earth systems, such as carbon cycling and oceans; the impact of human activities and natural sources of climate variability; and the impact of climate change for Earth systems and human life (USGCRP 2009).

The news is not all bad. According to research by Plutzer et al. (2016), it is now nearly impossible for students in the United States to leave K-12 schooling having received no instruction at all on climate change. In general, concern for climate change among students is also high, even in conservative states, such as Texas (Foss & Ko 2019). And nearly all teachers teach something about climate change.

Still, a convergence of evidence suggests that few students are leaving schools in the United States with basic climate literacy. Standards mandating instruction in anthropogenic climate change are a relatively recent development and they have apparently been implemented ineffectively, on the whole (Holland 2020; NCSE 2020). Reformed standards for science education that include climate science – the Next Generation Science Standards (NGSS) – were first introduced only in 2013. Many states were slow to adopt the standards, and many implemented their own variation. These variations frequently dilute the NGSS standards relating to Weather and Climate, including standards requiring the teaching the AGW thesis (NCSE 2020).

At the high school level (ages 14–18), the NGSS standards for Weather and Climate crucially include the following (NGSS Lead States, 2013):

> HS-ESS2.D3: Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
>
> HS-ESS2.D4: Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by [sic] the ways in which these gases are absorbed by the ocean and biosphere.

> HS-ESS2.A3: The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

These standards reflect the fundamental ideas of climate literacy, including those that would require knowledge of the chemical/physical mechanism of global warming and of the impact of human activity on climate. However, these particular standards are not among those governing climate education in many NGSS states, such as Michigan. Instead, one finds more vague standards, such as (Michigan State Board of Education, 2015):

> MS-ESS3–5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
>
> HS-ESS2–4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
>
> HS-ESS3–5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Any education imparting understanding meeting such standards will require students to consider many of the fundamental concepts of climate literacy, including the human impact on climate. They stop short, however, of directing educators to teach the truth that human activity is the answer to the questions students will presumably ask in curricula built around standard MS-ESS3–5.

This is shocking. But unfortunately, it is consistent with other shortcomings of post-NGSS climate education. Studies of the state of teacher preparation in climate education and climate teaching in schools find that climate is frequently not addressed at all (Foss & Ko 2019; Plutzer et al. 2016). Teachers lack knowledge as well as resources, time, and support (not least, and as just indicated, the support provided by curricular standards that authorize their teaching of the subject) (Colston & Ivey 2015). When it is addressed, as much as 80% of K-12 educators significantly underestimate the degree of consensus among climatologists about the anthropogenic causes of recent global warming and 30% take a "both sides" approach to teaching this focal issue (Plutzer et al. 2016).

The NGSS are not the only relevant set of standards governing science education. For many educators the Common Core State Standards and C3 Framework apply to their work. Concepts relating to climate change appear in guidelines for geography in the C3 Framework (NCSS 2013). Concepts relating to sustainability are implicit there and in other dimensions as well. They are, however, quite sparse. More importantly, they are absent from standards and guidelines for relevant subjects like social studies and even economics. This later omission is especially remarkable given the influence of economic ideas in early prominent articulations of "sustainability" as a concept for global politics, such as the Brundtland definition of sustainable development: "development that meets the needs of the present without compromising the capacity of future generations to meet their needs" (WCED 1987).

Climate change and sustainability are interdisciplinary problems requiring a capacity for reasoning that integrates scientific information and the civic reasoning skills taught – in theory, anyway – in the humanities and social sciences. The absence of sustainability concepts outside the domain of science is both troubling and a potential source of hope. Given the obvious urgency of these topics over the past couple of decades, how can our institutions still have failed to address them at this late stage? At the same time, the humanities and social sciences offer an array of promising approaches to correcting possible sources of error, confusion, maybe even vice, in socio-scientific reasoning. A few of these approaches will be briefly discussed in the penultimate section of this chapter.

Teaching that badly frames the climate issue or misrepresents the NOS may be important obstacles to a citizenry that can recognize and credit consensus climate science. But basic climate literacy is not being effectively taught in K-12 schools and materials and methods from outside the sciences are both apt and underappreciated for teaching sound socio-scientific reasoning. It is hardly clear that science teachers at present should prioritize the former to simply teaching sound climate science.

The Epistemic Aims of Science Education and Framing

Ensuring belief in the AGW thesis and general trust in consensus climate (and other) science is a legitimate purpose of formal science education. The AGW thesis is true, given the best available evidence, and it is the business of educators to teach what is known to be true. Educators also have a responsibility to prepare future citizens to cope with the world they will (likely) inherit so that they may make informed, reasoned choices about how best to flourish in it (Curren & Metzger 2017). Unmitigated climate change will seriously impact the world they will inherit, mostly for the worse.

Let's suppose, then, that the Humean diagnosis is accurate. Does it follow that *science teachers* should prioritize recognition to comprehension? It is not evident that it does. The criticism of the deficit model and science literacy approach is that they are *insufficient* to remediate misunderstanding of and resistance to consensus climate science, especially concerning AGW (Suldovsky 2018). The full meaning of this criticism for formal education might be easily misunderstood. It is standardly a claim about the efficacy of supplying information to the general public; increasing people's knowledge of science or supplying more, or more accurate, information does not (often enough) improve their beliefs. From here it may be tempting to draw the following conclusion: The educational value of science literacy, if any, must be independent of its impact on better civic decision-making with respect to socio-scientific issues. The tempting conclusion is, in other words, that science literacy is not educationally valuable as a component of better socio-scientific citizenship.

This would clearly be an absurd conclusion to draw. It can be true both that merely sharing new information with the public is not (commonly) persuasive and that the same audience would be even less capable of recognizing consensus science absent basic science literacy acquired through formal science education. Indeed, contra the evidence supporting the thesis of cultural cognition of climate science, other research finds that climate science literacy is exceptionally low across all political groups and that climate science literacy is highest among those most concerned for anthropogenic global warming and lowest for those least concerned (AGW) (Bedford 2016; Ballew et al. 2019).

Overall low climate literacy across all political groups has been taken as evidence that concern (or lack thereof) for AGW is rooted in "elite cues or the views of family and friends," not a lack of understanding of climate science (Bedford 2016: 195). In studies of concern for AGW among the American general public, researchers have found that only about 8% of subjects receive climate literacy scores of A or B (on an A–F, school-style grading scale) whereas about 80% score a D or an F (Leiserowitz & Smith 2010; Libarkin et al. 2013). However, those with higher climate literacy scores constitute the majority of the most concerned about climate change, whereas those with the lowest scores constitute the majority of the least concerned (Leiserowitz & Smith 2010; Ranney & Clark 2016: 54). In a study of concern about AGW among undergraduates, Bedford also found that:

> … basic climate literacy appears to reduce polarization between Republicans and Democrats by increasing the chances that Republicans will become more concerned about

> AGW (Democrats are already concerned, more or less regardless of their level of climate literacy). Thus, *the specific type of knowledge examined seems to matter when considering how different groups respond to information*. While increased levels of education (Hamilton 2012) or of scientific/quantitative literacy (Kahan et al. 2012) can simply better equip individuals to seek out information that accords with their existing views, increased levels of climate literacy appear to have the opposite effect.
>
> *(Bedford 2016: 195, emphasis added)*

The form of climate literacy perhaps most relevant to the problem of concern for AGW is knowledge relating to solar radiation and the chemical/physical mechanism through which global warming occurs. In a study of the effect of this knowledge on climate belief, Ranney and Clark (2016) found that virtually no subjects could produce a short, accurate explanation of this mechanism, such as this: "Earth transforms sunlight's visible light energy into infrared light energy, which leaves Earth slowly because it is absorbed by greenhouse gases. When people produce greenhouse gases, energy leaves Earth even more slowly—raising Earth's temperature" (2016: 52). However, being provided with and taught to produce such a simple explanation resulted in increased acceptance of anthropogenic climate change across the political spectrum (2016: 59).

The precise meaning of this research is debatable. However, as Ranney and Clark observe, such basic climate knowledge could be expected to ensure an appropriate burden of proof surrounding the AGW controversy:

> … if asserting that increased greenhouse gas emissions is not problematic, one who denies global warming ought to explain either flaws in the scientific consensus's mechanism, an alternative mechanism, or how the scientific mechanism is parametrically inconsequential (e.g., that climate sensitivity is low). The mechanism essentially demands a denier to answer this: "If nonnatural greenhouse gases chemically increase Earth's temperature, how can anthropogenic additions be negligible?"
>
> *(Ranney & Clark 2016: 52)*

That this burden of proof will be difficult for most climate science laypersons to meet may explain findings (by some studies) that the most vehement climate contrarians include those reporting the highest rates of numeracy or science literacy. Sustaining denialism while in possession of basic climate literacy requires considerable resources and capacity for rationalization, resources, and capacity that only those highly educated or motivated will possess. From this it obviously does not follow that high science literacy is *the reason* they deny, nor that we should expect that knowing more about climate change will have no effect whatever on the ordinary layperson's ability to recognize the climatological consensus on AGW. Moreover, GIP cognition is only one explanation of the will to rationalize among such people – the motivation to deny, that is. Others include naked self-interest, not knowing how to know, genuine (if wrongheaded) moral disagreement, fear or hopelessness, or any number of folk-scientific confusions about the NOS (Barzilai & Chinn 2020; Shtulman 2015). GIP cognition also does not explain how the needed rationalization works. More illuminating in such cases are failures to appreciate some aspect of the NOS (such as its social nature and the role of norms of trust), inability to evaluate the reliability of testimonial information, relative unconcern for truth, or genuine disagreement about how to know (Barzilai & Chinn 2020).

An education ensuring that citizens can appreciate the full weight of the burden of justifying climate beliefs is crucial to overcoming climate contrarianism. Basic science literacy has crucial value here. In this regard, the preoccupation with framing in climate communication arguably is of relatively little significance for formal climate education. School and university educators should probably be aware of some of the most hazardous ways of framing the climate change issue in their presentation of it. Beginning a climate change unit with Al Gore's *An Inconvenient Truth* is very likely to alienate denialist students. Activist framings in general are likely to induce a "boomerang effect" (Hart & Nisbet 2012). However, research on framing reveals many and very subtle effects that it would be unreasonable to expect teachers to know or avoid. Republicans are known to recoil more at use of the term "global warming" than to "climate change." However, discussion of global warming cannot be eliminated from teaching that would address the AGW thesis.

Framing operates on the learner's cognition implicitly, moreover, and it is designed to solicit endorsement independently of argument or evidence. Careful framing is not for that reason improperly manipulative; framing is inevitable and a theory of legitimate *versus* illegitimate framing is required. However, because it operates behind reasoning, framing "would be unlikely to accomplish very much in the way of encouraging deeper thought about the NOS – or thoughtful views on particular controversies" (Priest 2013: 141).

Communication researchers do not in general assume that sharing relevant facts and information is unimportant or unnecessary for enhancing receptivity to publicly contested science.[2] However, so far as pragmatics are concerned, once a deficit model is abandoned, one could ask why any information used to build trust in socially relevant science has to be *accurate* at all. One obvious theory is not obviously compelling: Communication that is inconsistent with consensus science might be a counterproductive way to enhance trust in that science. In fact, much might be done or said that could, potentially, both effectively increase confidence in the socially relevant claims of climate science *and* be false, misleading, or otherwise inconsistent with climate science or science generally. A statistic that 90% of male Republican ornithologists believe that humans are causing climate change might be an effective frame for communicating consensus information to conservative white males. But if it is false (I just made it up) or very misleading (perhaps there are only 10 in the world), strategic grounds for refusing to use it are not plainly available. The need for a careful science of science communication arises partly because the public are not well-positioned to evaluate such claims for themselves. Unscrupulous science communicators might craft effective but entirely misleading messaging that increase trust in institutional climate science.

Such *merely* instrumental, strategic thinking is incompatible with the values and epistemic aims of liberal science education. The success of institutional science depends heavily on the sincerity and trustworthiness of scientists as they collectively build knowledge. Ultimately such values are important because scientists aim to uncover truths about our world, i.e., because, at their best, they are lovers of truth (Pennock 2019). Whatever other principles or values should guide our thinking about how to reform science education for the "post-truth era," this value should be paramount.

Problems for the Humean Diagnosis

Citizens, including scientists, have limited capacity to comprehend and evaluate the claims and evidence of new scientific information. Evaluating evidence (for any given claim in some field of science) requires expertise, and this expertise requires judgment acquired partly through experience working in the relevant field. Thus, even scientists in one field of study – climatology, say – will lack sufficient expertise to authoritatively evaluate new information in another field – epidemiology, say. Nonscientist citizens are obviously in a worse position.

For these reasons, it is essential that citizens acquire capacities to recognize credible new science, independently of any capacity to comprehend that science. Alas, as in many other parts of the formal school curriculum, science educators have tended to prioritize college and career readiness over civic science literacy (Tytler 2007). Among other undesirable consequences, this tendency seems to have made science unattractive to most K-12 learners, who have limited tolerance for very technical science.

To reach the conclusion that school science educators should make a significant priority of teaching students how to recognize credible science, it is not necessary to hypothesize that cultural/GIP cognition governs citizens' processing of scientific information. It is certainly not necessary to hypothesize, as social intuitionists do, that moral reasoning is little more than adherence to a set of intuitive, emotionally charged and partisan, foundational moral commitments. It may be educationally edifying to understand and teach human tendencies toward myside bias (evaluating and generating evidence in a manner favorable to prior beliefs), "satisficing" (settling for enough evidence when it is favorable to one's existing beliefs while demanding ever more when it is not), and the like. But the prospects for successful debiasing are unclear; part of the bite of cognitive bias research is that even knowledgeable researchers make these mistakes in research studies (Kahneman 2011). And it is neither clearly true nor helpful to suppose that reasoning does not exist or evolved for the purpose of social coordination – as opposed to the purpose of helping us to know and understand the world or solve the problems we face. Nor is it clear what this theory has to do with the many and various sorts of cognitive bias educators may wish to know and teach, such as anchoring bias (evaluating the next piece of information in terms of a perspective set by the first we encounter), fundamental attribution error (selectively overestimating the role of personality or character relative to situational factors in the successes/failures of others), or myside bias.

In formal settings, a focus on cultural/GIP cognition as the underlying cause of incapacity to recognize credible science would be unhelpful in other ways. At least in the short term, educators certainly cannot do much to remediate students' cultural (or political) identifications, and it is not, within certain legitimate constraints, clearly their business to do so. Teaching for democratic citizenship is a legitimate educator aim. But this aim is sufficiently capacious to accommodate partisan identities that may be at odds with the results of any given science. Climate contrarianism is strongly linked to free market ideology (more so, apparently, than to climate literacy). Unfettered markets are known to be inefficient, especially relative to common pool resource management and pollution. Educators may legitimately teach these facts and may even use methods designed to recruit students' sympathetic identification with them. But they may not teach students that they cannot be libertarians or Republicans. As noted in the prior section, however, education in sustainable economics at the K-12 level essentially does not exist.

A focus on cultural cognition and biased reasoning also obscures other important causes of science denialism. Some have argued it is unclear to what extent the cultural cognition thesis is explanatory at all. What we wish to understand is why citizens rely so heavily on social cues for deciding which information to trust; citing the influence of those social cues is circular (van der Linden 2016). Some explanations cite further social causes, such as misinformation campaigns (Oreskes & Conway 2011). But here again we are left to wonder why such social causes have such force.

Plausible further explanations redirect us back toward the epistemic. In doing so, they both re-establish a linkage between citizen comprehension of science and capacity to recognize credible science, i.e., between *science literacy* and recognition. They also point to areas of the curriculum *outside* of the hard and environmental sciences where reforms could contribute significantly to building learner capacity to recognize credible science.

With regard to climate science, and as discussed earlier, ignorance of the basic mechanism of anthropogenic global warming is one further explanation. In addition, public misunderstanding of (or disbelief in) the degree of scientific consensus is arguably rooted in ignorance of the methods, and especially social–collaborative nature, of scientific knowledge building. This is a failure to comprehend the NOS, and as such is appropriately regarded as a form of science literacy. In general, further *epistemic* explanations of science denialism include not knowing how to know; a host of confusions about the NOS, its scope, limitations, and institutional practices, and about the science and values relationship; genuine disagreement about how to know; naked self-interest; and fear, hopelessness, and paralysis (Barzilai & Chinn 2020).

Individuals may look to social cues for determining what information to trust simply because they do not know how to know. In the realm of science, this sort of ignorance will frequently reflect ignorance of the methods and practices of institutional science, especially of the collaborative nature of scientific knowledge building and the corresponding role of institutions of epistemic interdependence and trust, peer review, reproducibility, transparency of procedures and data, and accountability (Elgin 2011; Priest 2013; Elliott 2017).

But the linkage between factual information, such as science provides, and value judgment is likely another obstacle to knowing how to know. Motivated reasoning involves resistance to factual information perceived to have undesirable consequences given a person's normative worldview. Arguably, susceptibility to this sort of reasoning would be heightened in those who believe that factual information determines reasonable social policy, i.e., if there were no logical distance between facts and values. However factual information does not determine reasonable social policy, or what one ought to do. In having no understanding of this, nor having ever been taught ethics – let alone ethics relating specifically to sustainability – citizens use disagreement about scientific information as a proxy for disagreement about morals or politics (Hicks 2017). Such a state of affairs is precisely what one would expect when disputants do not know how to engage in moral reasoning – reasoning about values and policy directly.

This situation is very unlikely to be fully mitigated absent more and better instruction in science and sustainability history and ethics, as well as STS (science, technology, and society), in the humanities and social sciences. Teachers of these disciplines are tasked, after all, with teaching socially relevant history, ethics, civics, and the like, and the problems of science in a democratic society are urgent social problems. Many of these teachers are also trained in methods appropriate to normative thinking, more so at least than their science teacher counterparts. This favorably positions them to handle, with due depth and subtlety, relevant subjects, such as the fact/value distinction and the limited role of scientific information in normative inquiry; history of civilizations and their collapse; the philosophy of science, and of science in society, through its history; and fundamental principles of ethical and political reasoning, as well as their application to sustainability ethics.[3] We should hardly be surprised that citizens cannot engage in appropriate socio-scientific reasoning – including knowing how to recognize credible science – when topics like these are not being addressed much at all during the years of compulsory schooling.

Promising approaches to all of these kinds of instruction exist and might serve as models for the development of improved standards and curriculum for science and sustainability ethics.[4] Worthy of special mention are approaches that merge insights in sustainability ethics and game theory to teach commons problems and the coordinated action structure of problems like climate change (Sadowski et al. 2013). In *sustainability ethics gaming*, students role-play the decision-making of actors in collective action dilemmas to experience the rewards of cooperating and the hazards of competing. Approaches like these have the potential to address not only sources of error or confusion in sustainability ethical reasoning, but maybe even vice.

Conclusion

As it stands, schools have only just begun to teach basic climate literacy, and it would be premature to abandon as a failure an approach to climate education that has barely been implemented. The evidence supporting the Humean diagnosis of the causes of climate contrarianism is equivocal. Even if it is correct, it does not follow that science teachers in science classrooms should rush to rebuild curriculum in an effort to deprioritize teaching for science comprehension. Moreover, sustainability problems like climate change can be addressed only through the exercise of integrated values-and-science moral reasoning skills. These skills call upon knowledge and practice typically conveyed, when taught at all, in the humanities and social sciences. However, schools and many universities do not prioritize teaching these skills through appropriate instruction in sustainability ethics and socio-scientific reasoning *within* the humanities and social sciences. Overall, it is arguably less important that science teachers spend countless hours fretting over the framing of their climate teaching, or learning how to teach the philosophy of science, and more important that educational institutions update the whole curriculum, and especially the humanities and social sciences, to infuse sustainability and values-and-science moral reasoning into them.

(Related Chapters: 1, 4, 5, 10, 11, 26, 27, 28.)

Notes

1 But see May (2018): chap. 2, for skeptical analysis of this research. In brief, the effect of induced disgust on moral belief is slight. In 7 of 8 cases, it only strengthened commitment to an existing moral position; it resulted in a *change* of moral positions in only 1.
2 Although see Sarewitz (2011), for a bald assertion that it is not.
3 Although see Bialystok et al. (2019), for valuable research on some significant difficulties that arise when high school teachers are pressed into service as philosophy instructors.
4 On sustainability history, ethics, and politics, see Curren & Metzger (2017). On the history and philosophy of science, see Matthews 2014.

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