Routledge
Taylor & Francis Group

Journal of College Science Teaching

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ujcs20

Transforming Science Education in an Age of Misinformation

Douglas Allchin, Carl T. Bergstrom & Jonathan Osborne

To cite this article: Douglas Allchin, Carl T. Bergstrom & Jonathan Osborne (2024) Transforming Science Education in an Age of Misinformation, Journal of College Science Teaching, 53:1, 40-43, DOI: 10.1080/0047231X.2023.2292409

To link to this article: https://doi.org/10.1080/0047231X.2023.2292409

Published online: 30 Jan 2024.

JOURNAL OF COLLEGE SCIENCE TEACHING
2024, VOL. 53, NO. 1, 40–43
https://doi.org/10.1080/0047231X.2023.2292409

Transforming Science Education in an Age of Misinformation

Douglas Allchin[a], Carl T. Bergstrom[b], and Jonathan Osborne[c]

[a]MCPS, Minnesota Center for Philosophy of Science, University of Minnesota, Minneapolis, MN, USA; [b]University of Washington, Seattle, WA, USA; [c]Stanford University, Stanford, CA, USA

ABSTRACT
Misinformation and disinformation about science have reached alarming levels. Here, we summarize a recent expert report, *Science Education in an Age of Misinformation,* that outlines what science education can do to address this problem and, given the urgency, has to do. We highlight the significance of teaching how the social practices of science contribute to establishing a trustworthy consensus and how students should evaluate the credibility of second-hand claims reported in the media or on the internet. We focus on the concepts of epistemic dependence on experts, competent outsiders, credibility, expertise, consensus, deceptive tactics, and science media literacy.

KEYWORDS
Misinformation, Credibility, Peer review, Expertise, Epistemic dependence, Consensus, Science media literacy, Competent outsider

Misinformation and disinformation about science, medicine, and public health have reached alarming levels (e.g., ALLEA, 2021; Amara, 2022; West & Bergstrom, 2021). In a recent report, *Science Education in an Age of Misinformation*, we and others outline what science education can do to address this problem—and, given the urgency, what we must do (Osborne et al., 2022). In particular, we highlight the significance of teaching how the social practices of science contribute to developing a trustworthy consensus and how students should evaluate the credibility of secondhand claims reported in the media or on the internet (Figure 1).

Our work brought together a multidisciplinary set of experts. These included a Nobel Prize–winning scientist; several science educators; experts in educational psychology, online misinformation tactics, and civic online reasoning; a professional fact-checker; and a philosopher of science, as well as an evolutionary biologist and co-author of the popular text *Calling Bullshit*. We considered the nature of the problem and what can be done to address it in science education.

The problem of misinformation is familiar to university science faculty (Barzilai & Chinn, 2020). For instance, there is widespread denial of climate change—both of the scale of the threat and what has caused it. The safety and efficacy of vaccines too have been attacked, leading to low vaccination rates and aggravating the COVID pandemic. Although misinformation is a general problem, the threat of displacing the cultural authority of trustworthy scientific knowledge is especially grave. This challenge cannot be fully addressed in communication arts or the social sciences, nor can it be fully ameliorated by widespread courses in abstract critical thinking or argumentation (e.g., Chaffee, 2019). And science educators have yet to mount a systematic response and teach science media literacy.

Recent new curricula in science, such as *Vision and Change* from the American Association for the Advancement of Science (and its K–12 counterpart, the *Next Generation Science Standards*), offer a much-needed shift in emphasis from conceptual content to scientific practices and scientific reasoning. However, by design, these curricula still tend to follow a model of preparing future scientists. They do not address the competencies needed by citizens and consumers of science. That is, they aim to develop marginal insiders, not *competent outsiders* (Feinstein, 2011). Students do not need to learn how to redo the science for themselves—nor how to second-guess the experts. Rather, adrift in an ocean of misinformation, they need to know how to find what is a genuine expert consensus and why it can be trusted. A profound shift in orientation is needed in the goals of general science education.

CONTACT Douglas Allchin allchindouglas@gmail.com Minnesota Center for Philosophy of Science, University of Minnesota, Minneapolis, MN, USA.

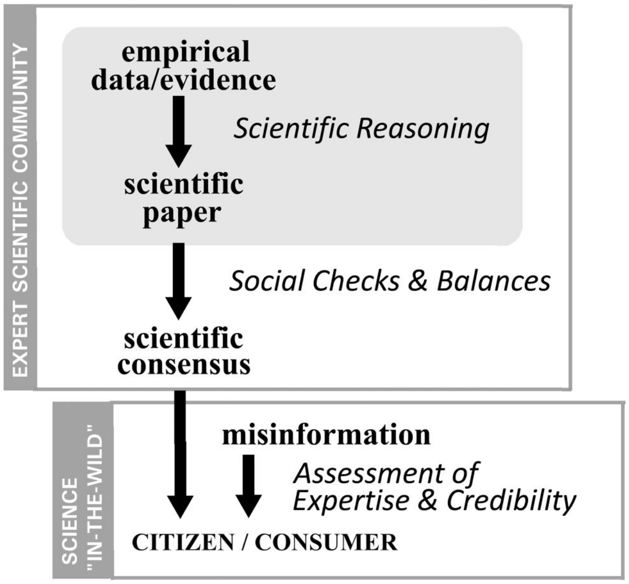

Figure 1. The pathway of scientific information "from test tubes to YouTube."
Note. The shaded area represents the scope of current curricula aimed at developing "marginal insiders." The rest of the figure indicates the competencies required to be a "competent outsider": (i) understanding the social checks and balances in developing a consensus within the expert scientific community; and (ii) assessing the credibility and expertise of sources of scientific claims in the public media. Having these competencies enables an individual to differentiate reports based in scientific consensus from misinformation ("science in the wild").

Most science curricula, including the newest ones, rest on a fundamental premise: that by learning about investigation and scientific reasoning, one becomes competent to judge the evidence for oneself. However, this much-touted goal of intellectual independence is an illusion. Making expert scientific judgments requires extensive disciplinary knowledge, intimate familiarity with methods and their many sources of error, awareness of alternative hypotheses, and more. Even if nonscientists can read the authoritative reports by the IPCC, they are in no position to (re)evaluate the expert consensus. Even the scientists who authored the report depended on one another for their respective expert contributions. Students need to learn how to evaluate the expertise of others, rather than think through the evidence on their own (Norris, 1995, 1997).

Our modern society—with its specialization, distributed expertise, and mutual interdependence—no longer accommodates the Enlightenment ideal of rationality based on an individual knower. We all depend on the knowledge of others. We rely on doctors, lawyers, accountants, airplane pilots, Wi-Fi technicians, and bridge welders, as much as we do on immunologists and paleoclimatologists. Yet, given the near-instant availability of information on the internet and other digital media, many people readily imagine that they, or anyone, can easily evaluate all the requisite knowledge on their own. However, given the limits of our individual expertise, this is nothing short of epistemic hubris. Students need to recognize the bounded limits of what any one person can know (Hertwig & Kozyreva, 2021). They need to understand the complex social structure of knowledge and their inescapable dependence on experts, including scientists.

The purveyors of disinformation capitalize on this illusion of intellectual autonomy. Individuals who believe that they can rely solely on their own wits are vulnerable to the use of misleading, cherry-picked evidence. They are susceptible to plausible but ill-informed arguments. Such tactics have entered a recurring playbook for spreading scientific disinformation (Kenner, 2015; Michaels, 2020; Union of Concerned Scientists, 2018). In addition to understanding the status of epistemic dependence on experts, students also need to be aware of such deceptive strategies.

Some commentators characterize the problem as one of overcoming "science denial" or a blanket distrust in science (e.g., McIntyre, 2019; Sinatra & Hofer, 2021). However, recent polls by the Pew Research Foundation and by 3M indicate that public confidence in the trustworthiness of science and its authority remains high (3M, 2023; Kennedy et al., 2022). The problem, we contend, is not trust in science itself, but rather *knowing whom to trust*. Unfortunately, the non-scientist lacks precisely the knowledge required to assess who is an expert. Only fellow experts have that level of knowledge. Non-experts, by contrast, can easily be misled by strategic disinformation campaigns, charismatic iconoclasts, or earnest voices who all claim to know the truth. Accordingly, lessons about the nature and criteria of scientific expertise are needed in the science classroom and lecture hall.

Understanding the social architecture of trust is central (Allchin, 2012). How does one establish a scientist's *credibility* (rather than certify their argument)? Here, the relevant evidence is not in the empirical data or arguments themselves. Rather, the critical information is the media context in which a scientific claim is presented. We recommend emphasizing two basic features for students (Figure 1, "Science in-the-wild").

First, does the spokesperson have a track record of integrity? Is there a conflict of interest? Are there marked political, economic, or ideological biases that betray a lack of objectivity? Even if fragments of authentic scientific evidence are offered, they are irrelevant if the source of information itself is questionable. However, most conventional lessons in argumentation, critical thinking, or media literacy do not address these fundamental concerns about the quality of the source. Rather, they all tend to assume that non-experts can participate in discourse at an expert level. Yet credibility is foundational.

Second, does the spokesperson or institution advancing the claim have the relevant expertise? For other forms of expertise, our society has established various forms of credentialing—professional licenses, accreditation, certifications, and so on. No such public markers exist for science. Scientists, of course, learn about their professional peers. They thus know whose work they may readily trust and whose work might be open to question. Essentially, scientists function socially with an implicit system of credibility. But this familiarity, too, generally circulates only among fellow experts. Thus, students must learn how one can establish that a purported expert scientist has a track record among their professional peers, who are uniquely positioned to assess shared competence. Good science journalists, for example, usually take note of such credentials and peer reputation. Again, the critical lessons about gauging expertise are virtually absent from current science curricula (the shaded domain in Figure 1).

Purveyors of disinformation, of course, try to convey an image of expertise (Rampton & Stauber, 2001). For example, they may list affiliations with institutions or organizations that sound grand but are not accredited or generally respected. They may cite published papers, but not from reputable peer-reviewed journals. They may rely on their expertise in one area to make pronouncements in another. But being an expert in nuclear physics, say, does not make one an expert in virology. Students have much to learn about subterfuge and deceitful tactics.

Expertise is essential. However, a single expert is insufficient. Experts may differ in their verdicts, at least initially. Science differs from many other forms of expertise. Here, consensus is the ultimate marker of reliability (Figure 1, "Expert Scientific Community"). Scientific knowledge is developed by a distinctly collective enterprise. For example, peer review occurs before publication. It continues afterward. Methods are scrutinized. Assumptions are reviewed. Possible errors are probed. Where there is disagreement, further research is done with the goal of resolving ambiguities or residual uncertainties. Science has a powerful social system of checks and balances that helps filter out error and bias. The resulting consensus is stronger epistemically than that which any individual can achieve alone. Thus, the consumer of science as a competent outsider must ask, "What is the *consensus* of the relevant scientific experts?" (Oreskes, 2019). Again, this understanding of the social practices of science is absent from nearly all science classrooms and even recent model curricula.

Consensus is not composed of snap judgments. Although textbooks and most lecture styles focus on settled facts, scientists spend the vast majority of their time grappling with unsettled matters. Multiple hypotheses may fit the data, and scientists may legitimately disagree about how to interpret the evidence. In some cases, rival camps may advance mutually incompatible models and explanations. When members of the public observe this happening, as they did early during the COVID-19 pandemic, they sometimes imagine that science is in disarray—or worse, that it is corrupted by political or financial interests. Science teachers need to help students recognize that uncertainty is an ordinary part of science-in-the-making. They need to appreciate the lively dynamics of science-in-progress. Resolving uncertainties takes work. It does not happen overnight.

Science teachers should also explain how and why scientific consensus is not a process of collective self-interest or groupthink, as some naysayers purport. Scientists earn credit for exposing past errors while making revelatory new discoveries. The rewards for conformity are limited. Indeed, reciprocal criticism is the norm (Ziman, 1968). Discourse is not just a political free-for-all. Evidence and expertise are essential currencies in argumentation. Investigators must frequently go back to the lab or field to collect additional data that can address alternate points of view and, ultimately, persuade their colleagues. Consensus in science is not easily achieved. It is hard won. This is why scientific consensus can be considered so trustworthy and proves so resilient over time.

Our chief concern, however, is how scientific information reaches individuals, not just how it is produced or validated (Figure 1). What is the essential know-how for navigating the treacherous ocean of information now available on the internet and via social media? In our report, we include some sample lessons, highlighting a set of basic heuristics that can benefit all students. The lessons echo the methods of professional fact-checkers (Neuvonen et al., 2018). We argue that when individuals encounter unfamiliar websites or receive tweets (or worse, retweets) from remote sources, they should begin by "taking bearings." Like an experienced navigator, they should ask, "Where exactly am I?" They should open new tabs in their web browser and research the credibility of the author or sponsor—a technique known as lateral reading (Wineburg et al., 2021)—leveraging the power of the internet against the very persons who would seek to abuse it. As a foundation, students will need to be familiar with a few trustworthy, independent benchmarks, such as professional scientific institutions, established fact-checkers, and veteran science journalists.

Everyone can benefit from science—but only if they can access reliable scientific information. For typical consumers and citizens, understanding a set of scientific concepts or practices acquired through formal education will be of minimal help. Rather, the science that matters most to their personal choices and to public decision-making will most likely be new, complex, and possibly incomplete. Moreover, the information will be mediated through secondhand reports. Thus, the student must ask whether the source can be trusted. Lessons in science media literacy are essential. Our full report, which we have only summarized in brief in this article, provides the rationales and guidelines for meeting this urgent challenge to science in the public domain and to supporting the informed discourse that sustains our democratic societies.

Funding

The Gordon and Betty Moore Foundation.

ORCID

Douglas Allchin http://orcid.org/0000-0003-4038-5155
Carl T. Bergstrom http://orcid.org/0000-0002-2070-385X
Jonathan Osborne http://orcid.org/0000-0001-8096-208X

References

3M. (2023). *State of Science Index 2022:* Global *report*. https://multimedia.3m.com/mws/media/2294044O/3m-state-of-science-index-2023-global-report-sosi.pptx

Allchin, D. (2012). Skepticism and the architecture of trust. *American Biology Teacher*, *74*(4), 358–362. https://doi.org/10.1525/abt.2012.74.5.17

ALLEA. (2021). *Fact or fake? Tackling science disinformation* (ALLEA Discussion Paper #5). ALLEA. https://doi.org/10.26356/fact-or-fake

Amara, S. G. (2022). Empower with evidence. *Science*, *375*, 699. https://doi.org/10.1126/science.abo5963

Barzilai, S., & Chinn, C. A. (2020). A review of educational responses to the "post-truth" condition: Four lenses on "post-truth" problems. *Educational Psychologist*, *55*(3), 107–119. https://doi.org/10.1080/00461520.2020.1786388

Chaffee, J. (2019). *Thinking critically* (12th ed.). Cengage.

Feinstein, N. (2011). Salvaging science literacy. *Science Education*, *95*(1), 168–185. https://doi.org/10.1002/sce.20414

Hertwig, R., & Kozyreva, A. (2021). Bounded rationality: A vision of rational choice in the real world. In M. Knauff & W. Spohn (Eds.), *The handbook of rationality* (pp. 505–515). MIT Press.

Kennedy, B., Tyson, A., & Funk, C. (2022). *Americans' trust in scientists, other groups declines*. Pew Research Foundation. https://www.pewresearch.org/science/2022/02/15

Kenner, R. (Director). (2015). *Merchants of doubt* [Film]. Sony Classic Pictures.

McIntyre, L. (2019). *The scientific attitude*. MIT Press.

Michaels, D. (2020). *The triumph of doubt: Dark money and the science of deception*. Oxford University Press.

Neuvonen, M., Kivinen, K., & Salo, M. (2018). *Fact-checking for educators and future voters*. FactBarEDU. https://www.faktabaari.fi/assets/FactBar_EDU_Fact-checking_for_educators_and_future_voters_13112018.pdf

Norris, S. P. (1995). Learning to live with scientific expertise: Toward a theory of intellectual communalism for guiding science teaching. *Science Education*, *79*, 201–217. https://doi.org/10.1002/sce.3730790206

Norris, S. P. (1997). Intellectual independence for nonscientists and other content-transcendent goals of science education. *Science Education*, *81*, 239–258. https://doi.org/10.1002/(SICI)1098-237X(199704)81:2<239::AID-SCE7>3.0.CO;2-G

Oreskes, N. (2019). *Why trust science?* Princeton University Press.

Osborne, J., Pimentel, D., Alberts, B., Allchin, D., Barzilai, S., Bergstrom, C., Coffey, J., Donovan, B., Kivinen, K., Kozyreva, A., & Wineburg, S. (2022). *Science education in the age of misinformation*. Stanford University. https://sciedandmisinfo.sites.stanford.edu/sites/g/files/sbiybj25316/files/media/file/science_education_in_an_age_of_misinformation.pdf

Rampton, S., & Stauber, J. (2001). *Trust us, we're experts!* Penguin Putnam.

Sinatra, G. M., & Hofer, B. K. (2021). *Science denial: Why it happens and what to do about it*. Oxford University Press.

Union of Concerned Scientists. (2018). *The disinformation playbook: How business interests deceive, misinform, and buy influence at the expense of public health and safety*. https://www.ucsusa.org/resources/disinformation-playbook

West, J. D., & Bergstrom, C. T. (2021). Misinformation in and about science. *Proceedings of the National Academy of Sciences*, *118*(15), e1912444117. https://doi.org/10.1073/pnas.1912444117

Wineburg, S., Breakstone, J., McGrew, S., Smith, M., & Ortega, T. (2021). *Lateral reading on the open internet*. SSRN. https://doi.org/10.2139/ssrn.3936112

Ziman, J. (1968). *Public knowledge: The social dimension of knowledge*. Cambridge University Press.