FACT • OR • FAUX

Teaching about the Critical Role of Key Scientific Institutions

ANDY ZUCKER AND JOCELYN MILLER

ABSTRACT

The Fact-or-Faux column addresses issues of misinformation and science media literacy. Here, we focus on the important role of key institutions in fostering critical discourse, developing scientific consensus, and providing reliable sources of scientific information.

"To get the most from this golden age of science," wrote a former President of M.I.T. and the American Association for the Advancement of Science, the best approach is to "recognize the critical role of institutions in nurturing the scientific enterprise" (Hockfield 2018). Her recommendation underscores the importance of teaching students about the role of institutions—such as the Food and Drug Administration (FDA), the Centers for Disease Control and Prevention (CDC), the Intergovernmental Panel on Climate Change (IPCC), the National Academy of Sciences (NAS; pictured above), and many others (see logos throughout). Simple and practical strategies to incorporate information about scientific institutions into existing science curricula are provided in the following sections to enhance current instructional practices.

Instructional Practice: *Focus on scientific institutions while discussing the nature of science*

Reaching a scientific consensus. How do we know that common vaccines are safe and effective, that Einstein's theory of relativity is credible and accurate, or that the continents on Earth move? Are these simply the conclusions of a single great scientist? No; these are examples of a "scientific consensus" reached after years of effort by many scientists. Teach students what that means, and how scientific institutions help scientists reach a consensus.

The nature of key scientific institutions

Scientific institutions such as those above were explicitly created to "obtain, evaluate, and communicate" scientific information, an essential science and engineering practice identified in the *Next Generation Science Standards* (*NGSS*). As a result of their missions, staff, and procedures, they are almost always more trustworthy sources of information than those typically found on social media or in political commentary. Yet how many of your students could name several of them and tell you what they do?

These institutions employ expert scientists who obtain and evaluate research conducted at universities and research labs worldwide and synthesize the results from multiple studies into consensus reports. For example, the Institute of Medicine (now called the National Academy of Medicine) commissioned a committee of 18 experts in immunology, plus a staff of six, to review more than 1,000 research articles about common vaccines to ensure their safety and efficacy (Institute of Medicine 2012). The Sixth Assessment Report from the IPCC enlisted hundreds of expert scientists from multiple disciplines to synthesize climate research across multiple fields of science (e.g., oceanography, atmospheric science, computer modeling), resulting in consensus recommendations about climate change impacts, adaptation, vulnerability, and mitigation (IPCC 2023).

In these and other cases, scientific institutions are a critical component of the scientific enterprise. As the word suggests, consensus reports issued by these institutions represent "scientific consensus," a conclusion reached by the great majority of scientific experts in a particular field. Reaching a scientific consensus is critically important. For example, scientific consensus involving multiple experts led to worldwide agreement about the accuracy of Einstein's theory of relativity, the elimination of polio, and the rapid development of new vaccines. There are undoubtedly brilliant individual scientists, but science generally relies on collaboration, argumentation, and peer review, which leads to developing a scientific consensus over time. Reaching a scientific consensus requires careful work and agreement among a majority of scientists who are experts in a particular aspect of science, a process that can take decades.

The role of key scientific institutions

A key responsibility of institutions like the CDC, FDA, and IPCC is authoring reports for non-scientists, including policymakers and the public. These reports are designed to communicate scientific findings accurately in language appropriate to non-expert audiences. The public-facing reports and summaries are often freely available online and can be used as classroom resources.

Some scientific institutions also propose and enforce regulations to ensure our food and water supply is safe, control harmful pollution, monitor the integrity of our roads and bridges, etc. Teaching students how reliable scientific knowledge compares to regulatory development and enforcement helps prepare them to be civically engaged, scientifically literate citizens. For example, after people had used lead plumbing pipes for millennia

without understanding the risks of severe cognitive impairment, scientists reached a consensus about the harmful effects of ingesting lead. Scientists used that knowledge to advise the policymakers who developed regulations about lead—but regulators consider costs, timelines, technical and political feasibility, and other factors. Creating and enforcing regulations is extremely important and is informed by science, but it is not science, per se.

Another example of a science-informed policy is the issue of how and when schools were closed for face-to-face instruction during the COVID-19 pandemic. Governors of U.S. states decided which schools were required to close in their state and for how long. Federal, state, and local scientists, as well as health experts, offered guidance based on as much scientific knowledge as they had in a rapidly changing situation involving a disease no one had studied. There was not yet a scientific consensus about many aspects of COVID. Nonetheless, it was up to elected officials to make decisions about schools and other pandemic-related issues, decisions which varied from one state to another. Occasionally scientists can have the last word on science-related policies or regulations, but such decisions are more often made by elected or appointed officials who are not scientists, taking into account input from experts and key scientific institutions.

NATIONAL ACADEMY OF SCIENCES

Instructional Practices: *Incorporate more information about key scientific institutions*

Identify functions of institutions. Use existing content as a launching point. For example, when teaching about COVID-19 or other diseases, it would be natural to ask students to look online and identify the roles of the CDC and the FDA. If teaching about nuclear power, students may be prompted to identify the functions of the Nuclear Regulatory Commission (NRC). Similarly, climate change discussions could include the IPCC's role and nature (Figure 1 lists many key institutions).

Delve deeper. Facilitate opportunities for students to obtain, evaluate, and communicate information about various scientific institutions (*NGSS* Practice 8). Ask students to select a scientific institution, obtain information about its mission, origin, the number of employed staff, operating budget, and funding sources, and then communicate that information to their peers through a presentation, poster, or video. Students could also be encouraged to evaluate and compare fraudulent organizations created by industry front groups to oppose credible scientific institutions.

Connect institutions to key NGSS performance expectations. Although the NGSS does not directly mention key scientific institutions, their role is especially noteworthy as part of performance expectations related to engineering design. For example, where will students obtain trustworthy information to "analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal wants and needs" (HS-ETS-1)? An important source of information will almost certainly be key scientific institutions like the IPCC. In this context, teachers have another opportunity to explain the role of scientific institutions.

The role of citizen non-experts

Citizens have an essential role in the scientific enterprise as voters who consider candidates' views on climate change, vaccines, and other topics, or sometimes more directly, such as when voting on state ballot questions of whether to impose carbon taxes or fees on fossil fuels. In addition, people use science to help make decisions in everyday life related to their health and safety and that of their family members, how to respond to climate change in their own lives, what advertising claims to believe, and so on.

As users of scientific information, students should learn that no one, not even a great scientist, can be an expert on all scientific topics. Science teachers help empower students by ensuring they become thoughtful non-experts who can find trustworthy scientific information

FIGURE 1

Some key scientific institutions.

International Research Organizations
- World Health Organization (WHO)
- Intergovernmental Panel on Climate Change (IPCC)

Non-profit Research Organizations
- American Association for the Advancement of Science (AAAS)
- National Academies of Science, Engineering, and Medicine (NASEM)

US Federal Research Agencies

Independent Agencies
- Centers for Disease Control and Prevention (CDC)
- National Science Foundation (NSF)
- National Aeronautics and Space Administration (NASA)
- Environmental Protection Agency (EPA)
- Smithsonian Institution
- Nuclear Regulatory Commission (NRC)

Department of Agriculture (USDA)
- Agricultural Research Service (ARS)
- National Agricultural Statistics Service (NASS)

Department of Commerce (DOC)
- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)

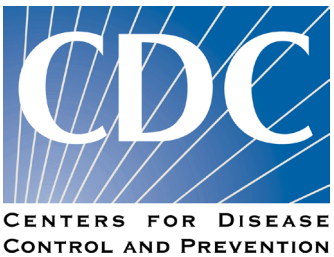
Department of Energy (DOE)
- National Laboratories: Argonne, Brookhaven, Los Alamos, Lawrence Berkeley, Oak RIdge, Sandia and others

Department of Health and Human Services (HHS)
- National Institutes of Health (NIH)
- National Institute of Environmental Health Sciences (NIEHS)
- National Institute of Allergy and Infectious Diseases (NIAID)
- Food and Drug Administration (FDA)

Department of the Interior
- U.S. Geological Survey (USGS)

about topics they did not study in school, thus facilitating lifelong science learning (Zucker and McNeill 2023). To achieve this goal, which usually involves searching the internet, students and teachers will inevitably rely heavily on key scientific institutions as sources of trustworthy scientific information.

For example, most adults agree that common vaccines (such as the M.M.R. vaccine for mumps, measles, and rubella) are safe and effective, saving millions of children from immense suffering and death. Without advanced training in epidemiology, how do people reach that conclusion? They trust the experts who conducted the research and synthesized the results of many independent studies. Placing trust in scientific institutions is no different from trusting a surgeon to perform a complex procedure, hiring a company to provide internet service in one's home or business, or trusting that the mushrooms in the market are not poisonous. In all cases, we trust experts because they know far more about certain things than we do. The uncertainty surrounding emerging scientific topics, like COVID-19, is a normal part of science; as noted above, it can take decades to reach a scientific consensus.



***Instructional Practice**: Help Empower Students to Become Thoughtful Non-Experts*

Investigating scientific claims. While a few students will go on to study science after graduation, all students will be faced with science-related decisions throughout their lives. Lessons incorporating opportunities to practice authentic decision-making will empower students as thoughtful non-experts. Present students with a claim—sometimes accurate and sometimes not—and ask them to spend a few minutes online to answer two questions (see Figure 2 for sample claims; answers are for teachers).

Ask students: Is this claim based on credible scientific evidence? What website helped you decide, and why do you trust it? Repeating this brief activity throughout the year will help students develop confidence that they can distinguish between trustworthy scientific information and misinformation, and in the process they will learn about sources of accurate scientific information, notably key scientific institutions. (For more information about using this activity, see Zucker, 2023.)

The *NGSS* repeatedly advocates teaching students to identify and use *reliable* sources of scientific information. To accomplish this goal—to learn how to separate fact from faux—students must learn about critically important scientific institutions, including what they do and why they are almost always trustworthy.

FIGURE 2

Some science-related claims students can investigate.

Biology:

- Childhood vaccines are safe and effective (True – CDC)
- Large doses of Vitamin C will cure the common cold (False – NIH)
- Consuming some fat in your diet is good for your health (True -NIH)
- Bacteria or viruses cause all infectious diseases (False – NIH)
- Coral reefs cannot recover from bleaching events (False – NOAA).

Chemistry:

- Antiperspirants that include aluminum cause breast cancer (False – NIH)
- Most people in the United States have PFAS ("forever chemicals") in their blood. (True – CDC)
- Of the 35 million tons of plastics generated in the United States each year, about half are recycled (False – EPA)

Physics:

- Nuclear fusion, a potential source of vast amounts of clean energy, can occur at room temperature (False – NRC)
- A nuclear reactor can explode like a nuclear bomb (False – Argonne National Laboratory)

Earth Science:

- We generally know what conditions are needed to produce lightning, but there is still debate about exactly how a cloud builds up electrical charges and how lightning forms (True -NOAA).
- Sometimes, people see a bright green flash at sunset (True – AAAS)
- Plans are being developed to mine materials from the moon (True – NASA)
- Climate change has been a key factor in increasing the risk and extent of wildfires in the western United States (True—NOAA)

Environmental Science:

- Electricity from renewable energy sources damages the environment more than electricity from non-renewable energy sources (False – EPA)
- Climate change is causing populations of plants and animals to go extinct worldwide (True- IPCC)

World Health Organization

USGS science for a changing world

REFERENCES

Hockfield, S. 2018. "Our Science, Our Society." *Science* 359 (6375): 499–499. https://doi.org/10.1126/science.aat0957.

Institute of Medicine. 2012. *Adverse Effects of Vaccines: Evidence and Causality*. Washington, DC: The National Academies Press.

IPCC. 2023. *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* Geneva, Switzerland: IPCC.

Zucker, A., and E. McNeill. 2023. *Learning to Find Trustworthy Scientific Information: A Report on K-12 Science Education for the 21st Century*. Media Literacy Now. https://medialiteracynow.org/impact/science.

Zucker, A. 2023. Evaluating credibility of claims using bellringers. *Media Literacy Now*. https://medialiteracynow.org/wp-content/uploads/2023/11/Investigating-Claims-Using-Bellringers.docx.

Andy Zucker (*andyzucker@gmail.com*) is a former science teacher who has written about K-12 education policy, scientific misinformation, media literacy, and science education standards, including the recent report Learning to Find Trustworthy Scientific Information. **Jocelyn Miller** (*jocelynamiller@gmail.com*) is the Education Program Manager at the E.O. Wilson Biodiversity Foundation and former classroom teacher who has authored articles about scientific misinformation, climate change, and biodiversity. Her doctoral research explored how policy networks influence climate change misinformation in Texas.