IMPLICATIONS FOR PRACTICE

We offer four examples for what attending to these new learning goals might mean in the classroom.

Example 1

In the context of teaching about climate change, students might be asked to evaluate the arguments found on the website CO2science.org. On the surface it is a dot-org which might predispose the individual to think it is unbiased.

Figure 2 Article from Center for the Study of Carbon Dioxide and Global Change (/about/position/globalwarming.php)

This website claims there is a weak short-term correlation between science and temperature. It does not deny that CO2 concentrations are increasing but it argues that this is not the main cause of climate change and uses a range of

arguments to critique the causal connection. The arguments appear scientific and are presented with evidence. For instance, they have a whole page of data called the Data Center. On the surface, such arguments might seem credible. For instance, they argue:

> that the warming predicted to result from a doubling of the air's CO2 content may be *totally countered* by: (1) a mere 1% increase in the reflectivity of the planet, *or* (2) a 10% increase in the amount of the world's low-level clouds, *or* (3) a 15 to 20% reduction in the mean droplet radius of earth's boundary-layer clouds, *or* (4) a 20 to 25% increase in cloud liquid water content. In addition, it has been demonstrated that the warming-induced production of high-level clouds over the equatorial oceans almost totally nullifies that region's powerful water vapor greenhouse effect, which supplies much of the temperature increase in the CO2-induced global warming scenario.
> (/about/position/globalwarming.php)

Superficially, it might appear that these arguments have substance. They are cloaked in the language of science; they appear to refer to published research and the work has been undertaken by an independent organization. Nothing could be further from the truth. To discover this requires that students engage in lateral reading, beginning by asking: is this source credible? By googling CO2science.org this website appears as the first search result, but underneath is the information that this is funded by ExxonMobil. Underneath that is the information that CO2science.org is funded by the Center for the Study of Carbon Dioxide and Global Change, which is identified by Wikipedia and Sourcewatch.org as a front group for the fossil fuel industry.

At this point a student should be encouraged not to attempt to evaluate the science presented on the website—they do not have the knowledge to do that. Rather, they should engage in lateral reading and ask 'what is the scientific consensus on climate change?' The top two sources come from NASA and Wikipedia: the first is a well-established scientific institution of considerable authority, which students may not know but which science education needs to teach them explicitly; the second has widespread credibility as an independent source. Going further, a third source is openscience.org, which offers a peer-reviewed article published in *Environmental Research Letters* with the title "Greater than 99% consensus in the Peer Reviewed Scientific Literature". Granted, at this point it would be unreasonable to expect teachers to know whether *Environmental Research Letters* is a journal of standing in the community. Nevertheless, the paper can be found along with many others [92]. Hence Bertrand Russell's maxim, "If experts are agreed, the opposite cannot be believed," should be applied [15].

Example 2

This example can be used when teaching about vaccinations. Students may be asked to evaluate the arguments presented on the website, childrenshealthdefense.org. Again, the website is a dot-org, which might make students believe the site to be unbiased. This URL creates an opportunity for classroom discussion about internet domains and the false idea that certain domains are indicators of quality and trustworthiness.

Figure 3 Front page on March 28, 2022 (childrenshealthdefense.org/child-health-topics/health-freedom/its-time-to-follow-the-science-covid-vaccines/)

In this case, the website claims that individuals should actively resist COVID-19 mandates, encouraging individuals to follow "the latest science tells us". The site includes a linked list of articles that are meant to serve as examples of lack of vaccine effectiveness in children. Many of the headlines refer to statistical information such as "at least 58% of kids already have natural immunity". The website draws on the authority of scientists with statements such as, "The science was never on their side."[5]

A website such as this one provides multiple opportunities for students to learn about the ideas we have presented throughout this report. As with the case of

5 As shown on March 31, 2022

CO2science, students should be encouraged not to start their evaluation of the website by attempting to decipher the claims it presents. Instead, students should be taught to engage in lateral reading to search for information about the scientific expertise of the people and organizations behind the website. A search for 'Children's Health Defense' brings up the group's webpage as the first result. Here, students should be taught to use click restraint by not clicking on the first result that appears. Instead, they should take time to read the search snippets, which contain information about the contents of each search result. For instance, the Wikipedia entry states that the Children's Health Defense is "an American activist group mainly known for anti-vaccine activities and has been identified as one of the main sources of misinformation on vaccines." (en.wikipedia.org/wiki/Children's_Health_Defense) The result from National Public Radio (NPR) states that the organization is "an anti-vaccine group headed by Robert F. Kennedy Jr." (www.npr.org/search)

Figure 4 Article on April 4, 2022 (childrenshealthdefense.org/defender/covid-vaccines-dont-prevent-transmission-severe-illness-deaths-data/)

Another search, this time about Robert F. Kennedy Jr., reveals that he does not have any expertise relating to vaccines. He has a law degree and is a known anti-vaccine advocate. Kennedy's lack of relevant expertise indicates that he is not a credible source regarding the science of vaccines, which casts doubt on the claims of his organization. This lack of credibility, along with broad scientific consensus regarding the safety of the COVID vaccines, can be used as justification to disregard the claims being made about vaccines by the Children's Health Defense.

Example 3

In the context of a unit on nutrition, students might be asked to evaluate two websites that provide information on health. The first, Figure 5, is a page for Partnership for A Healthier America (PHA) (www.ahealthieramerica.org/); the second, Figure 6, is the page for the International Life Sciences Institute (ISLI) (ilsi.org)

An initial discussion, based on looking at each website, might show that students see both sites as credible. Both have an '.org' domain name and both websites appear professional and authoritative. Students can then be asked to use the decision tree shown in Figure 1 to determine which website they would choose to trust for health-related information.

Beginning with the first question in the decision tree, "Is the source of this information credible?" students' first challenge is to determine whether these sources are free of bias and whether there are any conflicts of interest. To do this, they will need to open a new tab and begin with lateral reading.

If they search for 'Partnership for a Healthier America,' they will find that one of the first links to appear in the search results is from Wikipedia. After using click restraint to scan the snippets of information beneath each result and looking at the three dots beside each, they may decide to start with the Wikipedia page to get a broad sense of what other information is available about the organization. There students will read that PHA is a nonprofit organization focused on health and nutrition. Its president and CEO is Nancy Roman, who has years of experience working for world food programs, food banks, and nutrition non-profit organizations.

On the other hand, when students apply the same strategy to the ISLI web page, they are also likely to begin with the Wikipedia entry. This tells a very different story. While ISLI is also a nonprofit organization, the Wikipedia entry shows it was funded by a Coca-Cola executive and has numerous ties to food and chemical companies, such as McDonald's and Pepsi. Such ties represent a clear conflict of interest and would strongly suggest that ISLI is not a credible source of information.

A student who was not convinced could, nevertheless, proceed to the next question in the decision tree, asking "Does the source have the expertise to vouch for the claim?" Again, students will find further evidence for rejection. The Wikipedia page, for instance, gives examples of the organization's members publishing books that have been questioned as having "minimal scientific merit" and stating that authors, such as Michael Gough, are not experts on the topics they write about. Furthermore, the entry shows that other sources, with more credible scientific expertise, have concerns about the organization. *The British Medical Journal*, (a high-status scientific journal) claims that the organization has accepted funding from the tobacco industry.

Students can work in pairs with the decision tree, asking and answering questions. An ensuing class discussion can compare their findings and the judgments. Using examples such as this, the standard routines of fact-checkers can become internalized to develop the automatic routines required for checking the credibility of claims that abound on the Internet.

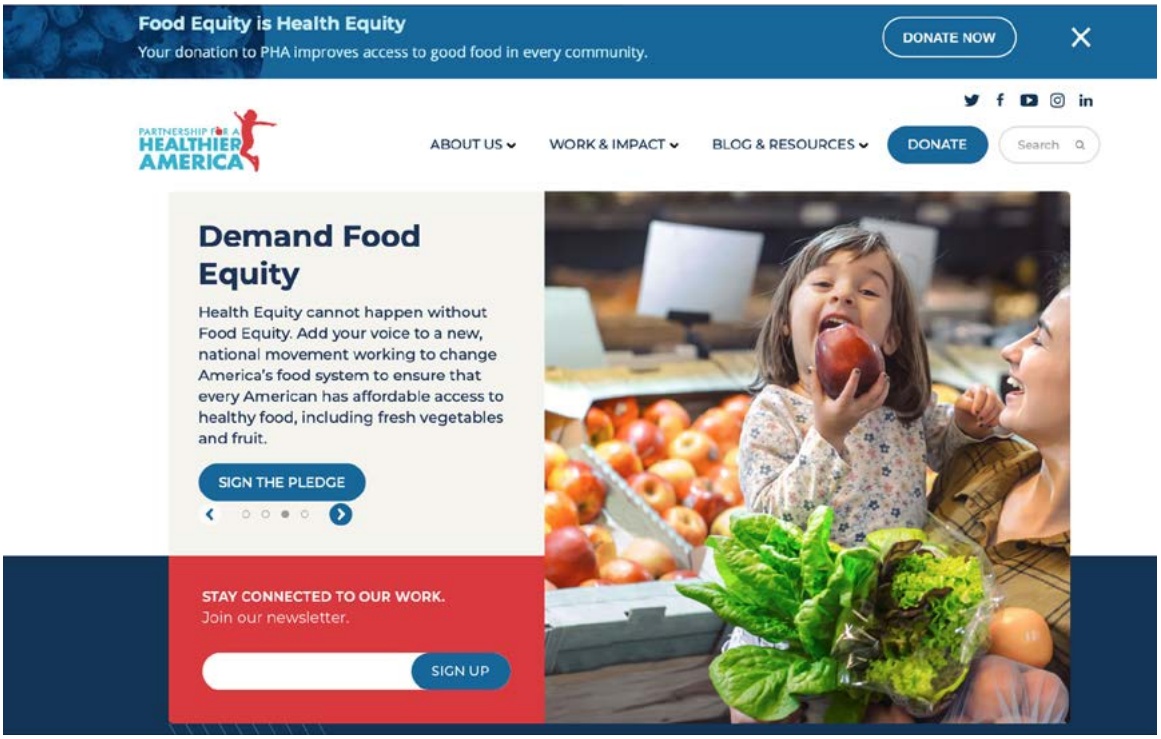

Figure 5 Point 3 on the front page slider of ahealthieramerica.org

Figure 6 Food Safety page under the Science and Research tab (ilsi.org/science-research/food-safety/)

Example 4

The fourth example is adapted from a set of activities developed by Allchin [123]. To teach students about the role of expertise in establishing credibility in science, teachers can provide students with descriptions of different individuals and task them with determining who to trust, using the criterion of *relevant scientific expertise*. For example, in a unit on climate change, students can be provided with the following three descriptions and, in small groups, be tasked with determining which of the following individuals best represents the perspective of the scientific community:

1. Fred Singer, physicist, head of the Non-Intergovernmental Panel on Climate Change, fellow at the Marshall Institute; founder of the National Weather Satellite Service; and former deputy assistant administrator for the Environmental Protection Agency;
2. John Coleman, co-founder of the Weather Channel, former TV weathercaster, with six decades of experience in broadcasting; or
3. Naomi Oreskes, historian of science with a background in geology and a former mining consultant, who undertook an analysis of the consensus about climate change published in *Science*.

Teachers can then engage students in discussion about which individual they chose as a scientific expert and their justifications to launch into a conversation about the characteristics of relevant scientific expertise.

In this case, Naomi Oreskes—ironically the historian—would be the individual most likely to represent and communicate the perspective of the scientific community on climate change. She has a scientific background relevant to the science of climate change (geology), and she has published an article on consensus in a well-established and credible scientific journal. While the other two individuals have also worked in leadership roles, neither has relevant expertise nor standing as a climate change expert within the scientific community. Although Fred Singer is a physicist, he is a member of the Non-Intergovernmental Panel on Climate Change, which has been criticized by the scientific community for producing reports with methodological flaws and using authors from irrelevant fields. John Coleman may have experience in journalism, but he is not trained as a scientist and has not conducted research on climate change. Thus, he should not be considered to represent the views of the scientific community.

During activities such as this one, teachers can engage students in conversations about important features of scientific expertise such as:

1. the role of relevant expertise, and that not just any science PhD or research position makes one an expert in all the sciences;
2. the role of consensus which should be weighed much more heavily than a single scientists' interpretation; and
3. the role of conflict of interest and biases which may lead even expert scientists to dishonest reporting.

Teachers can adapt the descriptions of the individuals that students evaluate

based on the features of expertise they want to highlight, such as valuing expert knowledge over the prestige of titles, by including some non-experts who hold impressive leadership roles.

These examples are offered as illustrations of what might be done. Given the cornucopia of misinformation on the internet, we have little doubt that more and better could readily be developed.