Learning to Find Trustworthy Scientific Information

A Report on K-12 Science Education for the 21st Century

In 2017, the CEO of the American Association for the Advancement of Science (AAAS), the world's largest multidisciplinary science society, expressed concern that fewer members of the public understand "the very idea that science is a special way for separating truth from falsehood."[1] Soon, the U.S. experienced multiple outbreaks of preventable diseases such as measles when parents accepted false information about vaccines.[2] In recent years, concern about harmful and inaccurate scientific information has grown greater, and at least six meetings and conferences have been held focused on that topic.[3] In an age of pandemics and climate change, the impacts of people accepting erroneous scientific information have become too serious for science educators to ignore.

In July 2023, Media Literacy Now and Howard Hughes Medical Institute brought together a group of 21 people in Chevy Chase, Maryland for a conference that included science educators, media literacy educators, a researcher studying science communication, a school librarian, a pediatrician, and science media specialists. (See the appendix for a list of the participants.) Planning for the event was informed by the reports from two Stanford conferences focusing on the role of science education in schools.[4] Participants at the Chevy Chase conference were challenged to consider this question:

What should students learn in K-12 science classes to help them better evaluate scientific information and resist scientific misinformation?

Insights from the conference guide this report, which represents the views of Media Literacy Now. Our hope is that the K-12 science education community will find value in this report and make efforts to adapt instructional practices as appropriate in response.

Like others before us, we believe that science teachers can help prepare students for a world where both accurate and inaccurate information is available at the touch of a button, and where, more than ever, people of all ages need to use science to inform decisions they make in everyday life. Science teachers alone cannot solve the problem of people accepting erroneous scientific information, but they can *mitigate* the problem by teaching students how to better evaluate the information they see or hear.

The Crux of the Problem

One insight highlighted at the Chevy Chase conference is that adults must often evaluate science- and technology-related information about topics they did not explicitly study in school. These topics may include COVID-19, Respiratory Syncytial Virus (RSV), and other emerging diseases; climate change; green energy technologies; claims made about food, nutrition, weight loss, and cosmetics; the safety of air, water, and food; or debates about how individuals and institutions are using new technologies, such as ChatGPT, or human genes modified using CRISPR. Even if someone has studied a topic, like vaccines, important aspects of it may be new to them, such as how a COVID vaccine was created and tested in less than a year.

Whether or not science teachers provide instruction about how to evaluate science-related information, sooner or later young people are going to make decisions and communicate with family and friends about science-related topics that are not taught in school. Therefore, it seems essential to provide impartial instruction on how to evaluate science-related information. That insight is closely related to the first one, and it frames the problem of the increasing acceptance of inaccurate claims related to science in a positive way, by focusing instead on finding *trustworthy* scientific information. This framing is a result of the work done by participants at the July conference.

Expressing this idea differently: we believe science educators should acknowledge the importance of the following goal and provide opportunities for students to practice developing the knowledge, skills, and habits of mind necessary to achieve it.

Overarching Goal:
Students should learn in science classes how to find trustworthy scientific information.

Much and perhaps most of the scientific information people find and use in their everyday lives does not come from teachers. Instead, it comes from social media, internet searches, cable networks, friends and family, advertising, news, and other sources. Students need to learn to find *trustworthy* information.

One might assume that students have less need to evaluate and use unfamiliar science-related information than adults because, after all, they are studying science. However, that is doubtful at best. For example, research shows that science classes have not provided most students with adequate information about climate change[5] which suggests they mostly learn about climate concerns from family, friends, and media of all kinds. Only one state requires climate change be studied in all grade levels and subjects.[6] Similarly, much of what students learn about treating diseases, or scientific information related to personal concerns such as diets and mental health, is not likely to come from science classes.

Also, because the internet plays such a large role in the lives of young people, they are more likely to accept inaccurate information than in earlier decades when information was more commonly curated. In the past, not everyone could publish information easily accessible to millions or billions of people. Almost half of teens in the U.S. report that they are online “almost constantly,” and teens also report they are more likely to obtain information from YouTube and TikTok than from traditional media.[7] According to the Wall Street Journal, TikTok is the “new Google” for young people, who turn to the app for everything, including health and medical advice, and where they often encounter information that is incorrect and even harmful.[8] A 2023 survey by the Reboot Foundation found that young people who used the app the most had a hard time correctly answering questions such as “Is astrology a science?” or “Is the Earth flat?” and that TikTok users have low trust in science; they were more likely than the general public to disagree with the statement “Science helps the world more than it harms it.” [9]

Students are growing up in a different world than earlier generations. Today’s students need to practice in science classes how to evaluate science-related claims they see and hear in an environment saturated with information, both accurate and inaccurate.

Four Supporting Goals

Supporting Goal: Evaluate sources.

To achieve the overarching goal from the previous page, finding trustworthy scientific information, **students first need to learn the characteristics of trustworthy *sources* of scientific information.** We are highlighting this statement because we identify it as one of four supporting goals.

People who are non-experts generally cannot assess the *quality of evidence* about many significant scientific claims (e.g., claims such as vaccines cause autism). The evidence is often too complex for non-experts to obtain, understand, and evaluate by themselves. No one has the capacity to be an expert about all topics or every trade.

Instead, to judge the accuracy of most significant scientific claims, people must rely on the relevant scientific experts, just as they rely on experts in law, pediatrics, plumbing, bridge construction, air traffic safety, cosmetology, and other fields.[10] From this point of view, the problem for K-12 science educators becomes a matter of educating “competent outsiders,” meaning non-scientists who are able to find and use trustworthy scientific information.[11]

Therefore, a major goal for science education is to teach students to distinguish between *sources* of scientific information likely to be reliable versus sources that are not well qualified to make a scientific claim. Making such judgments uses different skills than are required to evaluate *evidence for the claim itself,* because for most important scientific claims evaluating the evidence itself requires an expert, and often a large group of experts (who reach a scientific consensus). Students should first look for evidence about the trustworthiness of the source, not the claim.

> ***"I can find lots of information on my phone; some of it is good, some of it is not. How do I know?*** *And what do I do to figure out what's reliable and what's not? That's a skill we need to be teaching because it's a critical skill for democracy, too."*
>
> — Helen Quinn, chair of the National Research Council committee that wrote *A Framework for K-12 Science Education*

Fortunately, there are two approaches that have been developed and tested that we highlight here for use in science classrooms. These approaches have been shown to help people become better at distinguishing between accurate sources of scientific information versus false information even when they lack expertise about the claim. One approach involves asking a standard set of questions and the other is to point to inaccurate information and identify it as such.

- For the first approach, a variety of routines have been developed in which students are trained to ask several standard questions about a dubious science-related claim to help decide whether the *source* is likely to be trustworthy. Using these routines is a form of media literacy. Experimental studies have shown that with practice students become more skilled at distinguishing between accurate information and inaccurate information.[12]

What is common to the questions is that one needs to search for information about the source making the claim. This is the way that professional fact-checkers work. Considering the source of a scientific claim is critical because a multitude of sources make false claims purported to be based on science, whether advertisers, entertainers, or "friends" online.

Standard questions that are valuable include: What do other sources say about the claim? Does the source have relevant expertise to vouch for the claim, or cite other sources that do? Is there a scientific consensus among the relevant scientific experts? Is there a potential conflict of interest?

- In a second approach, a large body of research shows that exposing people to small doses of inaccurate information, and saying that it is inaccurate, helps them resist other inaccurate claims.[13]

A simple example that has been used in schools for decades is illustrating how certain advertisements are deceptive and attempt to fool people.[14] Learning about techniques of false advertising helps make people less likely to be deceived in the future. A relevant example in science education is that many tobacco companies were forced to pay hundreds of billions of dollars in damages for advertising they sponsored that intentionally tried to mislead the public about the dangers of smoking.[15] Teaching about this deception may help students resist similar ones.

If science teachers begin to use these two approaches, they will help students become more skilled at finding and using scientific information. In addition, teaching in ways that achieve three other supporting goals can help students learn to find and use trustworthy sources.

Supporting Goal: Learn more about the scientific enterprise.

Students need to learn that science is a complex enterprise with goals, norms, values, institutions, and social practices whose purpose is to develop reliable knowledge about the natural world, based on evidence. Students obviously do not need to know as much about the scientific enterprise as scientists, but they need more knowledge than is commonly provided,[16] including the significance of scientific consensus. Reaching scientific consensus involves dozens, hundreds, or even thousands of scientists working as a community to weed out errors. For example, the claim that vaccines – such as for measles, mumps, and rubella (MMR) – are safe and effective is based on research conducted by many scientists involving thousands of vaccinated people that was later reviewed by dozens of researchers under the auspices of scientific institutions such as the Centers for Disease Control and Prevention (CDC) and the National Academy of Medicine.[17] Students should learn something about the functions of the U.S. Food and Drug Administration, the Environmental Protection Agency, the CDC, and other institutions that play important roles applying science to personal or societal issues.

Another key idea about the scientific enterprise is the importance of specialties. Scientists who are well qualified in one field of science are not necessarily qualified in a different field, just as a doctor specializing in orthopedics is probably not an expert in infectious diseases. A few scientists, even prominent ones, make inaccurate claims when they venture outside their own field. Students should also understand that as new evidence is obtained, scientists are willing to change their conclusions and recommendations; that this is a normal part of the scientific enterprise.

Supporting Goal: Apply media literacy competencies.

In addition, **students need to learn and apply media literacy competencies when they seek, find, and use scientific information.** For example, students should recognize the ways that many internet sources operate. Do certain platforms use algorithms to reward attention-getting or sensational information rather than accurate information? What information is provided to users and why (e.g., by search engines when students look for science-related information)? How can students use Wikipedia or ChatGPT or other media to learn about science in a responsible way? Multiple studies show that media literacy education can be effective, for example by reducing the impacts of advertising promoting unhealthy messages about food and nutrition,[18] or by reducing engagement with disinformation.[19] RAND Corporation developed a list of media literacy standards “to counter truth decay” that may be of interest to science educators.[20]

Supporting Goal: Become more aware of one’s thinking and behavior.

The last supporting goal is that **students need to learn to be aware of their own thinking and behavior regarding scientific information.** Too often students accept the first recommendation from a search engine. Too often some students will share or “like” information that they have not thought carefully about. Of course, being self-aware and self-disciplined are habits of mind that young people are still developing; the point is that these habits will affect how students find and use scientific information.

Students should also learn there are many ways in which people (both experts and non-experts) can be mistaken, sometimes due to the influence of confirmation bias, motivated reasoning, and peer pressure.[21] For this purpose, even optical illusions will help students understand that *"Don't believe everything you think"* is, in fact, sound advice.

Connections to Science Education Standards

Science education standards vary by state. But most states' standards have been influenced by the so-called "blueprint" for standards called *A Framework for K-12 Science Education,* created by the U.S. National Research Council and published in 2012.[22] Two of the goals listed on Page 1 of that document are that students:

- "Are able to continue to learn science outside school;"
- "Are careful consumers of scientific and technological information related to their everyday lives."

To achieve these goals, students must learn how to identify trustworthy scientific information and reject erroneous information.

As intended, publication of the *Framework* led to publication of the *Next Generation Science Standards* (NGSS) in 2013.[23] As stated in the NGSS, and in virtually all state standards, students are expected to learn how to "engage in argument from evidence" and how to "obtain, evaluate and communicate information." These are unquestionably important science and engineering practices because science is based on obtaining and evaluating evidence about the natural world and then reaching reliable conclusions based on reasoning about that evidence. Moreover, these are competencies that can be useful in many situations besides science.

However, the communication channels and methods scientists use to gather and reason about evidence are different than those of non-scientists. Scientists' claims, evidence, and reasoning are tested and communicated via grant proposals, peer reviewed publications, professional conferences, and through syntheses and reports commissioned by key scientific institutions, such as the CDC and the Intergovernmental Panel on Climate Change (IPCC). Some reports prepared by experts are intended for the public; however, non-experts and experts mainly use different sources of evidence, different procedures for evaluating evidence (e.g., non-experts are seldom expected to comb through large data sets for possible errors and then analyze the valid data using appropriate statistical methods and tests), and they use different channels for communicating. Experts evaluate evidence for the claim, while non-experts focus on evidence about the trustworthiness of the source.

Additionally, science education standards almost always connect science and engineering practices – like "engaging in argument from evidence" – to a particular topic specified in the standards, such as why the sun appears much brighter than other stars, or the role of photosynthesis in the cycling of matter and energy. Rarely do science education standards or curricula require that students obtain information about topics students might seek out independently, such as what is known about the safety of vaping; or what do experts suggest as effective ways to lose weight; nor do the standards documents suggest that students intentionally be asked to review or evaluate science-related information that is not true, to help develop their evaluation skills.

Next Steps

The purpose of this report is to answer this question: **What should students learn in K-12 science classes to help them better evaluate scientific information, and resist accepting scientific misinformation?** The report is based on bodies of work created by dozens of experts. Our views are also consistent with *A Framework for K-12 Science Education.*

Participants at the conference did an excellent job beginning to create a table of performance expectations by grade level for the goals identified in this report. However, at this point the most important and immediate challenge is to create a searchable inventory of instructional materials to support teachers, which would help teachers immediately, and also inform the development of a consensually agreed table of performance expectations. To inventory, describe and collate them will be a major project, and that is one that we hope can begin soon.

Many teachers and teacher associations are ready for this next step. For example, the National Association of Biology Teachers (NABT) adopted and publicized a position statement advocating that media literacy be included in science education[24] and *The Science Teacher,* published by the National Science Teaching Association (NSTA), several years ago published an issue based on the theme of Scientific Media Literacy.[25]

Teachers who do not wish to wait until an inventory is available can find appropriate articles and lessons in professional journals such as are published by NABT, NSTA, and other teacher associations, as well as from school librarians and school library organizations. Useful materials are also available from PBS and other sources.

Science teachers and future teachers in preservice programs would benefit by the development of scalable resources for professional development. Some excellent materials are available but more, and more comprehensive, materials aligned to the overarching goal and four supporting goals in this report are needed. Funders are urged to consider this need a high priority.

The most important next step is that teachers, teacher associations, schools, districts, and states begin to make the overarching goal identified above a higher priority, which does not require a great deal of class time. Responsibility for making this happen as soon as possible rests in part with policymakers, including state and local boards of education. Other stakeholders include curriculum developers, parents, school principals, school librarians, and organizations such as scientific associations concerned about the spread of harmful and inaccurate scientific information.

Acknowledgments

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Special thanks are due to HHMI for the financial and other support that made the second conference, and this report, possible.

Appendix: List of Conference Participants

The following were participants at the July 27-28 2023 conference convened by Media Literacy Now and Howard Hughes Medical Institute to consider what K-12 students should learn to better evaluate science-related information and resist inaccurate information.

Douglas Allchin	*Fellow, University of Minnesota, and Former Science Teacher*
Kyra Brissette	*Chief Operating Officer, Media Literacy Now, and Conference Organizer*
Courtney Capozzoli	*High School Science Teacher, Boone, North Carolina*
Michael Chapman	*Dean of Teaching and Learning and High School Science Teacher, Buckingham, Browne and Nichols School, Cambridge, MA*
Margaret (Marjee) Chmiel	*Evaluator for HHMI Biointeractive and Tangled Bank Studios, Howard Hughes Medical Institute, and Conference Organizer*
Teshell Ponteen Greene	*Multimedia Content Developer, HHMI*
Michael Heinz	*Acting Director, Office of Standards, New Jersey Dept. of Education*
April Khadijah Inniss	*Founder of eekMD.com, Pediatrician, Expert in Media for Children*
Deanna Lambson	*Founder of White Ribbon Week, Expert in Media Literacy for Youth, and Former Teacher*
Asheley Landrum	*Associate Professor, Walter Cronkite School of Journalism and Mass Communication at Arizona State University*
Reyhaneh Maktoufi	*Science Communication Fellow, HHMI*
Erin McNeill	*Founder and CEO, Media Literacy Now, and Conference Organizer*
Jocelyn Miller	*Ph.D. Candidate, Texas Tech. University, and Former Science Teacher*
Cesar Nufio	*Multimedia Content Developer, HHMI*
Aleeza Oshry	*Technical Program and Accessibility Manager, HHMI*
Tom Peters	*Executive Director, South Carolina Coalition for Mathematics and Science*
Jennifer Woo Regrut	*Science Department Chair, Needham Public High School, Needham MA*
Nadeene Riddick	*Multimedia Content Developer, HHMI*
Steve Tetreault	*Teacher, School Library Media Specialist, New Jersey*
Vanessa Wolbrink	*Associate Director of NextGenScience at WestEd*
Andy Zucker	*Independent Scholar, Conference Organizer, Former Science Teacher*

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O'Rourke, V., Miller, S. J., & Dunne, L. (2019). Increasing the Advertising Literacy of Primary School Children in Ireland: Findings from a Pilot RCT. *International Journal for Digital Society, 10*(2), 1478–1488.

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[24] See https://nabt.org/files/galleries/NABT_Media_Literacy_Statement_Final_Rev.pdf

[25] *The Science Teacher,* 87:5, January 2020.