Teaching for Scientific Literacy, in a Pandemic

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(Short Version)

Introduction

In the next half hour I will present ideas that I hope will help you teach for scientific literacy. Teachers are on the front lines, and for many of you right now that is not a comfortable place. Yet the work of science teachers, science educators, has seldom been more important than it is today, given the current war on science. Scientific literacy is not a luxury. It's a necessity.

We're in the middle of a global pandemic. The White House spreads misinformation about science and other topics like never before. We've had massive fires out west and a record-breaking start to the hurricane season. Almost all schools suddenly required far more remote teaching and learning, with little or no time for teachers to prepare. In New York, state science education standards still feel new.

The stress of this moment reminds me of what we hear when we fly. "Put on your own oxygen mask first, before putting masks on children." The same is true now. In the middle of all this stress, people need to take care of themselves. Give yourself permission to experiment, sometimes to fail in this challenging environment, and yet try again. Give yourself time to watch TV, to enjoy the fall colors across the state (it's been gorgeous), to spend time with family and friends.

My first job out of college was as a science teacher, and it was in New York. I have never forgotten how important it was to be a classroom teacher first, before taking other positions in education. I still remember attending my first NSTA conference. It opened my eyes to what a career in education might be and inspired me. Organizations like STANYS are essential parts of the profession. Hats off to you.

SHARE SCREEN. Note that the slides will be available for you to download, including references to articles and websites I mention. I put a comma in the title of the talk, because I want to focus on both curriculum generally **and** remote instruction. First I'll talk briefly about remote instruction, but most of the presentation will be about five keys to teaching scientific literacy.

Teaching online

SLIDES 2-6. Fifteen or twenty years ago I was an expert on the subject of online high schools. Now, many of you are probably far more informed about remote science instruction than I am. As a "former expert" I will simply offer a few suggestions.

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Scientific literacy

Let's turn to what to teach, curriculum. SLIDE 7. The introduction to the New York State P-12 Science Learning Standards asks that "our education system keep pace with what it means to be scientifically literate." But what **does** that mean? Well, knowing some content is critically important, and so is understanding the scientific practices. But of course you know that.

Scientific literacy is an ill-defined term. We could say scientific literacy is everything in the *Next Generation Science Standards* (NGSS), and the *Framework for K-12 Science Education,* and the NY science learning

standards. Altogether that's about 1,000 pages. I am not an English teacher, but it seems to me that's a very long and unwieldy definition! A better definition would be helpful.

SLIDE 8. This slide shows how the Program for International Student Assessment (PISA) defines scientific literacy. For years PISA has tested a sample of students in dozens of countries, and PISA has been testing science for many years. For PISA, scientific literacy is defined as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. I think that's a great and useful definition that has implications for teachers and for leaders, which are overlapping categories. E.g., STANYS is both a teacher organization and a leadership organization.

My excellent colleague Penny Noyce and I have been writing and blogging about science education standards for two years. *Phi Delta Kappan* published our article about the NGSS last month.

SLIDE 9. Penny and I believe that these five aspects of scientific literacy need special attention in the classroom. I believe focusing on these components of scientific literacy will help interest more students in science and other STEM subjects. I believe each of them is vital if young people are going to become scientifically literate. **This slide is the linchpin of my talk**. Let's go through the five keys one at a time.

Personal and societal contexts

SLIDE 10. Teaching science in the context of societal and personal issues is the title of a Position Statement issued by the National Science Teaching Association (NSTA) in 2016, and the same ideas are loosely sprinkled throughout the NY science learning standards. Every student, even the millions who will never receive a college degree, will need to apply science to personal and societal decisions. Why wear a mask? Should any of my taxes be used to subsidize electricity produced by wind, solar, or other "green" energy sources?

SLIDE 11. A vital example of societal context during the pandemic is the role of government scientific agencies. At a time when, recently, many former directors of the Centers for Disease Control and Prevention and the Food and Drug Administration issued statements complaining of unprecedented politicization of these agencies, young people should learn about the *role* of such institutions, a little about *how* they operate, and consider why scientists should be protected from political interference.

SLIDE 12. Here is what a former President of MIT, who was also President of the American Association for the Advancement of Science, wrote in 2018: [*One good way to get the most from this scientific golden age is by recognizing the critical role of scientific institutions in nurturing the scientific enterprise*.] Are we doing that in schools? Almost certainly not enough.

SLIDE 13. Often, too often, we teach students that science is done by individual scientists. But that obscures an essential aspect of the Nature of Science. Science is a team sport, a collaboration among experts. Think about this: the latest report of the Intergovernmental Panel on Climate Change (IPCC) was written, edited, and reviewed by more than 2,000 scientists, and is based on more than 9,000 scientific studies. There are wonderful individual scientists to teach about, but it is the team that ultimately reaches a scientific consensus, not one person.

We should be concerned that science education standards say little or nothing about the network of scientists that are essential to science. Inter-disciplinary research, like about climate change, by definition **requires** collaboration.

Connect to traditional forms of literacy

SLIDE 14. Another aspect of scientific literacy is connecting science to traditional forms of literacy. This is related to Practice 8, obtaining, evaluating, and communicating information. Also, remember that the

Common Core State Standards call for students to read more non-fiction, including science. Science teachers can help students by assigning science-related articles and books, including high quality fiction. This isn't controversial. Connecting reading and writing to science is part of the NY standards.

Notice that the word 'synthesize,' which I put in bold letters, is related to the preceding point that science is a team sport. One scientist and one paper is usually the beginning of a scientific investigation, not the end. As a teacher you might ask students to synthesize information from several sources about an important topic, like the safety of vaping, and then present their findings orally or in writing.

Scientific media literacy

SLIDE 15. The volume of dangerous misinformation has exploded in recent years, and spreads quickly via social media. Misinformation transcends science, but scientific misinformation alone is a huge problem.

One source of reliable scientific information is … wait for it … government scientific agencies. We need students to learn why that is true. Does measles vaccine cause autism? Check the CDC website.

One approach to combating misinformation is called "media literacy," based on the idea that young people should learn how to make sense of what they see, hear, or read, including the incredible barrage of social media. In 2018 Pew Research reported that 45% of teens say they are online "almost constantly."

Media literacy is needed in every subject. Students should be taught how to judge which sources of science information are trustworthy, and why. Science teachers need to teach students how to judge whether information they encounter, most often online, is based on science or not. If an advertisement says you can "drain toxins from your body with a foot detox, using our special solution," or by putting a raw onion in your sock, we should teach students how to find out if that is based on science or not.

History of science

SLIDE 16. When the Next Generation Science Standards were being developed, the NSTA wrote that it was important "to make it clear that all students need to understand the nature of science and the history of science." However, in the end history was barely mentioned in the NGSS or the NY standards. That matters, because knowing a little about history of science helps students understand the nature of science and how science fits into society. Teaching a little history is easy to do because it takes so little time.

A great example is that opposition to science based on ideology, i.e. simply asserting the truth, as we are seeing now, is not new. In the early 1600s, when Galileo found evidence that heavenly bodies move around one another, the Church, which was incredibly powerful, ignored the evidence, called Galileo a heretic, and placed him under house arrest. He was courageous. In the long term his ideas were accepted. In the short term, the Church was powerful and it set back humanity's search for truth.

More recently, a twentieth-century biologist named Trofim Lysenko rejected the theory of natural selection and other widely accepted ideas about genetics. Lysenko was utterly wrong but he was strongly supported by Joseph Stalin and other Soviet leaders. He set back Soviet agriculture by decades, and was responsible for thousands of deaths. Some scientists were executed simply for rejecting what Lysenko claimed. Unnecessary deaths based on false science; does that ring a bell? In the face of global climate change and a worldwide pandemic, the stakes of an ideological war on science are higher than ever.

Women and minorities in science

SLIDE 17. The last of the five keys is increasing the participation of women and minorities in science and engineering. I searched the New York science standards for the words "women," "minorities," and "equity." None of those words even appear. This topic is not a priority in NY, or in the NGSS, either.

Teachers can help, and many already do. Maybe you teach about the book or movie *Hidden Figures* (Shetterly, 2016), telling the story of black female mathematicians who made essential contributions at NASA despite being subject to bias based on race and gender. At right are some of this year's Nobel Prize winners.

What do these ideas have in common?

SLIDE 18. Each of the five keys to scientific literacy is either found in the standards or is consistent with the standards. In addition, I believe they have three other significant things in common.

First, they each hold potential to increase students' interest in science. We need to consider why more students aren't **interested** in STEM. Yet a 2018 national survey found that fewer than half of science teachers feel "very well prepared" to encourage students' interest in science and/or engineering.

Reading about a science topic or a scientist he or she chooses can interest many students. False advertising may be of great interest, given the thousands of ads that bombard young people every year. Each of these five keys can help hook students on STEM.

The slides include a great many faces because each of these topics can literally help put a face on science. Young people are interested in themselves and other people. The science standards could do a much better job of humanizing science and engineering.

A second common attribute is that all five topics combat the perception of school subjects as silos, separated from one another. Science is related to reading, writing, language arts, civics, government, history, health education, media literacy, and the role of women and minorities. Science should not stand alone.

On the third point I'm going to speak heresy, and I hope you won't place *me* under house arrest. The heresy is that these aspects of scientific literacy are under-emphasized in science education standards, to one degree or another. Where do the standards mention scientific institutions? Or the role of women and minorities, or the history of science?

Why aren't these more prominent in the standards? Penny and I think we know. The Next Generation Science Standards and the New York State science learning standards are good. However, they are not great because, and I am quoting from the Next Generation Science Standards, "the NGSS content is focused on preparing students for college and careers." That is simply not the same as placing the highest priority on developing students' scientific literacy. Penny and I wish teaching scientific literacy was the primary goal of the standards. I also wish that testing scientific literacy was a prominent goal of high-stakes tests, rather than focusing on preparing students for college and careers.

Given how the pandemic is forcing all kinds of adjustments, this might be an especially good year to teach some new content, and take a broader view of the science that students need to learn. There are hundreds of articles and lesson plans related to the ideas I've discussed. You could try a few new lessons this year, on these topics, and see how well they interest your students in science.

Conclusion

SLIDE 19. I do NOT believe that focusing on these five aspects of scientific literacy will add significantly more time or lessons to the curriculum. You may already pay close attention to some of these topics. Other aspects of scientific literacy, like teaching a few key events in the history of science, can be blended into existing lessons. In a few cases, new lessons would be worth adding, but you can easily find those online or in professional publications.

SLIDE 20. THE END. I hope that the ideas I talked about this evening are helpful. Your work is more important than ever. Thank you for what you are doing. And thank you for your time this evening.