As another school year begins, we often reflect on what we teach and why we teach it. Students are eager to engage in learning, but they often find the typical content irrelevant. Even skilled instructors with buoyant enthusiasm may fail to inspire them. However, students respond to authentic challenges. They readily invest effort in learning about real, substantive issues related to personal and public decision-making, often characterized as central to scientific literacy. Such cases typically revolve around understanding not just scientific concepts, but how science works. They are gateways into learning about the nature of science, or NOS.

First, survey the news. What is going on that matters to a better society, to our daily lives, and to students? Here is a sample list of topics rich with NOS potential from just one week (from the March 29 issue of Science magazine):

- What is the legacy of child abuse across multiple generations?
- What is causing the decline of bees that pollinate our crops?
- Will biofuel policies cut emissions by simultaneously reducing food crops? Are the trade-offs transparent, and is the system for our food supply sustainable?
- Is climate change as severe as some say?
- Should a policymaker be able to ban the use of the term “climate change” in official state documents?

This is what’s happening – all of it compelling to students who strive for meaningful lives. For biology teachers seeking to motivate, how might they organize the curriculum around such issues, addressing the prescribed content, but not necessarily the order, of the textbook chapters?

Having first identified an issue, the next step is to analyze it more fully. What are the critical concepts or principles to learn for addressing such an issue effectively? Ironically, perhaps, the scientific content is often secondary. What typically matters most is understanding the nature of science – namely, ideas about science, scientific practices, or how science works. For example, to interpret child abuse, we need longitudinal studies that span many lifetimes. We need more than anecdotal reporting. We need the systematic information of scientific studies. Also, we need large-scale studies. Only with sufficient scope can we avoid unrepresentative samples that might be misleading. The key issues involve NOS, not scientific concepts per se.

The case of the decline of bees and other pollinators similarly raises NOS issues. Of course, students need to first appreciate the basic ecology of pollination – but this is relatively simple. More critical is how we determine significant causes in a complex world of multiple possible causes. School laboratory experiences based on simple, one-variable experiments are inadequate as models. In this case, it appears, many factors are simultaneously important, including the use of certain pesticides (a combination of economic, agricultural, and environmental policies); the lack of flowers and nesting sites (habitat loss and land-use policy); and stress from introduced parasites (global culture and economy). Understanding the problem itself involves reshaping views of causality from a single cause to an ensemble of causes. It also means teaching how causes may interact, producing effects larger than the sum of the parts – the cross-disciplinary theme of synergy, or emergence. Again, understanding NOS may be even more important than knowing the basic scientific concepts.

Consider next what is needed to accurately interpret the evidence for climate change in the context of high-profile naysaying by politicians and media pundits. Their piecemeal presentations of evidence, even if misleading, can be persuasive. For example, glaciers in the Himalayas have “surged” forward lately. At first that might appear to be strong evidence against global warming. Yet scientists found that they may actually be losing mass at the same time, indicating warming instead. Appearances may be deceiving. Evidence needs to be complete, not partial – another NOS lesson.

Equally important, one may want to address how nonscientists interpret scientific consensus. Who can legitimately interpret or speak for the evidence of glaciers and climate change? If teachers parade falsification as an ultimate guiding principle, then one “counterexample” presented by critics might well be enough to swamp weeks of classroom discussion of the greenhouse effect, the Keeling Curve, and Mann’s “hockey-stick” graph. Students need, in addition, NOS lessons about the balance of evidence. Moreover, students are not expert enough to weigh the evidence themselves. NOS lessons need to highlight the roles of expertise and consensus.

In Florida, the director of the Department of Environmental Protection has maintained an unwritten policy banning the explicit mention of “sustainability,” “global warming,” or “climate change” in departmental communications. Pressures to omit such language in educational contexts have started appearing as well. Here, the NOS issue involves honesty about science and the intersection of science and political ideology. Are scientists responsible to society for battling such policies as deceptive, or is their role merely to conduct research and publish in professional journals? Who defends good science? To be well informed, the average citizen needs to...
consider the integrity of pronouncements about scientific conclusions – yet another NOS lesson.

Such NOS awareness easily expands to interpreting the reliability of claims in other issues: advertisements about human growth hormone as a “wonder” anti-aging treatment; how we count calories; whether patients can be diagnosed and treated for viral infections with noninvasive devices; the safety of GMOs; Ebola – not just confined to West Africa; even drought in Brazil or the emergence of a mysterious kidney disease in Sri Lanka. Teachers and students alike benefit from moving beyond the textbook, and even the classroom itself, and immersing themselves in how to assess the biological claims that inform our choices as citizens and consumers. All that amplifies the practical significance of learning about the nature of science.

Fortunately for teachers, current reforms in science education all endorse venturing further into NOS. They curtail the emphasis on content. They add weight to understanding scientific practices and science–society issues. That is the shared recommendation of the Next Generation Science Standards (or NGSS, from the National Research Council), Vision and Change in Undergraduate Biology Education (from the American Association for the Advancement of Science) and, bridging them, the newly redesigned AP Biology curriculum. The prospects for institutional support of NOS education are growing. But, as always, focusing on NOS makes sense in terms of motivating students and developing a more worldly and meaningful biology education.

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