

Teach Philosophy of Science *

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Holden Thorp became Editor-in-Chief of the *Science* family of journals on 28 October 2019. He came to *Science* from Washington University, where he was provost from 2013 to 2019 and professor from 2013 to 2023.



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Much is being made about the erosion of public trust in science. Surveys show a modest decline in the United States from a very high level of trust, but that is seen for other institutions as well. What is apparent from the surveys is that a better explanation of the nature of science—that it is revised as new data surface—would have a strong positive effect on public trust. Because scientists are so aware of this feature, it is often taken for granted that the public understands this too. A step toward addressing this problem would be revising undergraduate and graduate curricula to teach not just theories and techniques but the underlying philosophy of science as well.

As Pew studies have [shown](#), trust in scientists and medical scientists in the US is higher than for all other institutions surveyed except the military. There was a modest decline over the past 4 years, but a similar decrease was seen for other professions. In absolute terms, trust in scientists is at 73%, whereas trust in most other institutions is far lower, with business leaders at 35% and elected officials at 24%. Despite this relatively high level of trust, Lupia *et al.* found ways that it could be enhanced. Most prominently, the study showed that 92% of respondents felt it important that scientists show they are “open to changing their minds based on new evidence,” which is of course what they must do.

Many scientists would be surprised to find that this idea needs to be reinforced. Science is, after all, a work in progress that changes as new findings cause revision and refinement of held interpretations. The history of science is a powerful narrative of this culture of self-correction, and it is the essence of science to attempt to make discoveries that change the way scientists think. But whenever science becomes important in the public eye, as with climate change and the pandemic, the continuous

revision can become a target for those who wish to undermine scientific knowledge.

French sociologist Pierre Bourdieu coined the term “[scholastic fallacy](#)” to describe the tendency of academics to assume that everyone thinks about problems in the way that scientists do. As Bourdieu points out, most people do not have the time and effort to spend thinking about these issues in the same way as those for whom this is a full-time job.

Academics often fail to recognize this and are mystified when the public doesn’t understand that interpretations are continually revised in light of new data, as has happened across history. Such revisions are the most reliable way for a scientist to get published in high-profile journals and gain scientific recognition, such as when [footprints are found](#) that change our idea about when humans were present in the US or when a [diabetes drug is found to have many other uses](#).

The scientific community has generally done a poor job of explaining to the public that science is what is known so far. There are many reasons that make this difficult. The way scientific findings are reported in the media, particularly outlets that do not specialize in science journalism, is often highly simplified without the caveats that would give a more realistic picture while making the stories seem less compelling to some readers.

Another obstacle is that, because of the scholastic fallacy, scientists tend to take for granted that their findings could be updated and forget to explain this to the public. And when scientists talk to each other, they tend to be passionate about their ideas and disagreements. When those conversations are processed by the public, they can easily be misinterpreted.

Resetting the public’s understanding of how science works will be a big job, but a

good place to start is with students who get science degrees. Unfortunately, most programs are full of didactic classes about scientific principles, with few if any requirements on the history and philosophy of science.

Because many undergraduate science majors pursue careers outside of science, including medicine, a shift in curricula would ultimately produce a public that is more literate in the way that science works. This means making hard decisions about how to fit a broader, deeper perspective into curricula that are already jammed tight with the necessary basics. However, it’s urgent for scientists to make compromises in the way they teach for the greater good.

Comment

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Dr. H. Holden Thorp makes a compelling case for integrating philosophy of science into undergraduate and graduate science education curricula, emphasizing the principles that shape scientific inquiry in

lieu of too subject matter- and technique-focused training (1).

We applaud Thorp's call as we have been making this idea a reality in graduate science education by reviving the "Ph in PhD" in our R3 (Rigor, Reproducibility, and Responsibility) program at the Johns Hopkins Bloomberg School of Public Health, since 2017 (2, 3). Together with a growing, global network of scientist-educators across institutions and disciplines who adopt our approach and shared materials (4-6) for their own students, we and others recognize the need to shape broadly and critically thinking individuals, rather than narrowly trained specialists (2, 3, 7, 8).

Generalist perspectives on scientific problems can foster capacities for transdisciplinary collaborations and enable young researchers to develop ideas on how to tackle the global challenges that humankind is facing today (2, 3, 7-12). Our students learn to apply the '3R' norms of good science, rigor, reproducibility, and responsibility, to their research practice, thereby becoming versed in epistemology, applied logic, ethical decision making, and quantitative reasoning (2, 13).

Moreover, in agreement with Thorp's point that efforts to rebuild the dwindling public trust in the scientific enterprise need to include effective communication with the public, we made training in value-based, community-centered communication skills another focus point in our 'R3' program (14).

In agreement with the National Academies' long-term advocacy for the integration of the humanities into science education (15), we encourage our fellow scientist-educators across the disciplines to join us and our many colleagues' efforts to develop and share educational materials that are based on the philosophical underpinnings of science.

The following (non-comprehensive) list represents initiatives and resource collections that aim to provide open access materials for classroom or informal teaching and mentoring, based on science's philosophical foundations, for graduate level science education and beyond. The listing order emphasizes breadth of scope and transdisciplinary applicability. We apologize for any unintended omissions.

- The Online Ethics Center (OEC), launched by the National Academies of Science, Engineering, and Medicine, now hosted by the University of Virginia and sponsored by the National Science Foundation (16, 17) is a resource repository of undergraduate and graduate level teaching materials, strategies, and application exemplars for the broad spectrum of research integrity education topics in science and engineering.
- The Innovation in Graduate Education (IGE) Hub, sponsored by the Council of Graduate Schools and funded through the National Science Foundation, fosters a network of grantees, graduate institutions, and scientific societies to support innovative ideas in graduate STEM education. The IGE-Hub's open access resource collections (18) are not limited to grantees but are open to anyone interested in joining a broader group conversation about innovation in STEM graduate education.
- The R3 Center for Innovation in Science Education (R3ISE) (19) at the Johns Hopkins Bloomberg School of Public Health grants free access to its curricular resources on cross-disciplinary training and

mentoring in practice-applied philosophy of science and responsible communication. Materials and implementation best practice guidelines for graduate and post-graduate levels are available openly through R3ISE websites and JHU data repositories.

- The Community 4 Rigor (20, 21), funded through the NINDS Office of Research Quality (22) is a multi-institutional collaboration between scientist-educators from the neuroscience and related disciplines with the goal of creating educational materials for learners on the undergraduate through post-graduate levels, to support teaching and learning the principles and practice of scientific rigor, illustrated through neuroscience applications.
- The non-profit Center for Open Science (23) provides practice-based training tools for research practitioners to advocate for reforming the norms and reward system in science, ultimately to elevate rigor, transparency, sharing, and reproducibility.
- Global Reproducibility Networks (24) are national consortia of researchers aiming to promote rigorous research practices by establishing appropriate training activities on the continuing education level and evaluating research improvement efforts.
- The ‘Many Faces of Reproducibility’ Project of the University of Minnesota Center for Philosophy of Science (25) develops innovative approaches at the intersection of philosophy and science for training researchers and engaging the public regarding the

trustworthiness of scientific claims.

- The Reproducibility4Everyone (R4E) network (26) is a non-profit, grassroots organization run primarily by early career research practitioners and mentors who teach open access workshops on all aspects of reproducibility enhancement, particularly for the laboratory-based disciplines.
- ReproducibiliTea (27) is a global, Open Science journal club initiative organized and led by student volunteers across numerous universities that helps junior researchers-in-training discuss diverse issues, papers and ideas about improving science, reproducibility and the Open Science movement.

We appeal to the scientific community to adopt those shared materials broadly and collaborate with educational researchers to engage in interventions research involving learner populations from as early as K12 and high school students, up to post-graduate practitioners. Wide-spread, evidence-based education on the conduct of science based on a solid epistemic foundation and ethics has the potential to make a difference in the quality of research practice, and ultimately, help win back the public’s trust in science.

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