Remote Learning Module for 23 March 2020

Lecture Notes for Fernando Espinoza's *The Nature of Science,* Chapter 1

When we were last in the classroom, we finished up our discussion of Ron Giere's book *Understanding Scientific Reasoning*. Everyone was able to submit their responses for Exercise #1; I have graded these exercises, and will be returning them to you individually, via email, just as soon as I've been able to build a few of these modules we'll be using to conduct our regular business remotely. Everyone did just fine, by the way, with all the grades in the A or B ranges. In the meantime, here's wishing that you are all well medically, emotionally, domestically and, of course, philosophically.

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(1) Now, to the business at hand. Let's consider the opening line of our text, for it introduces the overarching theme of the entire book: "Scientific literacy has become a professional imperative in the modern world." This injunction should be familiar; it dominated our first discussions in the opening week of school (which certainly seems like a far distant time, I know). Among the examples we might have in mind as regards this imperative, surely that of "promoting public health" will stand out rather significantly in these days of plague and uncertainty, so our present concerns have more than the usual academic significance. Other examples, of course, include the human impact on the environment, definitions of mental illness, biomedical ethics, data mining and privacy, just to name a few.

(2) What is Critical Thinking? I'll talk with you about this topic in today's audio lecture, as we consider the intellectual sequence involved in the following series:

Data → Information → Knowledge → Understanding

This sequence represents the manner in which science proceeds to answer "Why-Questions." As we'll see in the days ahead, before the advent of scientific thinking, why-questions were answered primarily by myths, and calculations were regulated by rules of thumb.

(3) The Cult of Expertise. On page 6 we read, "reliance by society on the opinions of experts can be dangerous to democracies." This is actually a very old worry; it appears prominently, as we'll soon learn, in the dialogues of the ancient Greek philosopher, Plato, who characterized the experts in rhetoric (public speaking) of his day (known as the Sophists) as "purveyors of unknown goods for the soul." Plato's worry was that reliance on experts leads to the erosion of self-determination, which amounts to a form of slavery. We'll want to think critically about this concern in the weeks ahead.

(4) Scientific Literacy is Necessary. This is especially the case for prospective science and math teachers. For example, much of the public debate these days over evolution vs. creationism is greatly misinformed, and arises from a deep misunderstanding of the historical past (recall our earlier discussion of Darwin's five theories).

(5) Two Perspectives. As we proceed, we'll want to maintain two distinct perspectives for our critical thinking about the transition from data to information to knowledge to understanding: first, the *nature of science* (as regards both the philosophical origins and the empirical methods of scientific reasoning); and second, the *historical development* of science and mathematics (as regards both the idea of progress and the need for context).

(6) Essentials. Why are these two perspectives essential in the modern world? Espinoza adduces two reasons: (a) because large populations appear to have more confidence in *beliefs* about reality than *knowledge* of it (in other words, many people simply prefer to believe things rather than know them); and (b) because in traditional science education we're told *what* we know but not, at least not typically, *how* we have come to know it.

(7) On Lesson Plans. You might want to consult Appendix A of our text, *The Nature of Science,* for teaching historically important experiments in order to provide your future students with an understanding of *how* our current knowledge came to be. You might also be thinking about the exercises we just completed apropos Lavoisier or Pasteur.

(8) Three Fundamental Characteristics of Scientific Knowledge.

(a) Explanations must be *naturalistic;*
(b) Hypotheses must be *simple* (think here about Ockham's Razor); and
(c) Claims must be *testable* in experience (think here about falsifiability).

It's worth underscoring the point here that while other forms of knowledge may exhibit features (a) and (b) above, *testability* is *definitive* of science. If you happen to be thinking right now about the need for effective testing to identify whom among us has contracted Covid-19, you are right on target. In any case, let us note that the cardinal difference between science, on the one hand, and, say, politics or religion, on the other hand, is that in science: *No claim is immune from revision*.

This observation tells us something important about the perspective noted above about the *nature of science*. Now let's ask the historical question: When did testability become definitive of the scientific enterprise? We can actually answer this question with considerable precision: it happened in the year 1660 with the institution of the Royal Society in England. The watchword or motto of this society (of investigators who were known then as *virtuosi*) was *Nullius in Verba* (Latin for "Nothing in Words). The members of the Royal Society were aiming to transform the entire fabric of science in this one phrase. How so? Well, because hitherto scientific education was conducted largely by way of commentary (words) on ancient texts (many of them records of Aristotle's observations of nature, but containing little in the way of actual experiment).

(9) Why Scientific Illiteracy is Bad for Free, Technological Societies. When scientific illiteracy prevails, the overarching danger to any democratic society is this: widespread confusion over the difference between *Engineering Problems* (which are best solved under the rule: "better safe sorry"), on the one hand, and *Political Problems* (which are solved under the rule: "the buck stops here"). Not to put too fine a point on the matter, but in dealing with the outbreak of Covid-19, we face both sorts of problems, and we'll do poorly if we do not adequately distinguish between them. Let us further note that confusing engineering problems with political problems often enough leads not just to incompetence, failure, death and destruction, but to *scientism*—that is, the misuse of scientific statements in areas where they do not apply.

(10) Teaching Science. Our course, you'll recall, is mainly intended to support MTSU's MTeach program, so it's worth our noting here the three areas of essential knowledge that future science teachers should have according to the National Science Teachers Association. Our current textbook is organized around these three areas, so that students can

(a) *Distinguish* science from other forms of knowledge;
(b) *Understand* the development and practice of science as a human endeavor; and
(c) *Think critically* about claims made in the name of science.

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Tomorrow, we'll continue our tour of *The Nature of Science*. I'll be adding a fair amount of material to the concerns raised in Chapter 2, about the Origins of Accomplishing Tasks. Be well everyone, and remember: social distancing saves lives, which is presumably why we are not in JUB 202 presently.