



Honoring Aristotle: A Science Lesson that Fosters Intellectual Humility

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Thermodynamics

Intellectual Humility, Critical Thinking, and the Art of Making Mistakes

Is it your fervent hope that the study of modern science might cause a student to be proud of recent innovations, while maintaining



intellectual humility? In a recent study done at the National University of Singapore, Ziqian Zhou ties intellectual humility to critical thinking, cautioning teachers not to promote the tendency to have a false sense of objectivity that fails to be sensitive to highly contextualized circumstances.

"the intellectual virtues in general or that of intellectual humility in particular is an integral character disposition of the critical thinker" (Zhou, 2022)

Our educational presentation of modern science can sometimes give one the feeling that we moderns know much more than the ancients and we therefore must be superior to them. Therefore, to instill a humble sense of respect in our students, while inspiring an interest in the subject matter, it sometimes helps to offset some mainstream views.

I often tell my students that the next discovery in science is constantly happening in real time. Scientific endeavors are rife with mistakes and guesses that lead us to the next uncovering of truth. And I stress that each truth we find is only true from the specific point of view of our time and our current state of consciousness - and that when you can view the same facts from another place, you can see another aspect of truth. In other words, there is not one right or wrong for all time. Humanity's consciousness is constantly learning, forgetting, and learning again. One fun way I have done this, for over fifty years of science classes, is to stage a courtroom scene and put ancient science on trial.

Ancient Science on Trial

You are in a courtroom. You are in the jury. The trial is to decide how ancient science should be taught in public schools. The prosecuting attorney for the state is representing modern science. The defending attorney is representing ancient science. Take a seat in the courtroom as you watch the judge read some paperwork about the case. Quiet down now, he is about to begin.

Judge: "What seems to be the problem here? Am I to understand that modern science is questioning the use of ancient science? Ah yes, I see. Very well, the court will hear arguments on both sides. Prosecution, you will begin with your opening statement."

Prosecution: "Your honor, members of the jury, we intend to argue that ancient science has outlived its original use and as such, should be downplayed in public schools. Our argument will rest on two charges.

First, that ancient science tends to provide ***outdated*** concepts.

Second, the ancient documents that have survived are ***primitive*** and ***simplistic***."

Judge: "Thank you counselor. The court will now hear an opening statement from the defense."

Defense: "Your honor, members of the jury, we feel that to some extent, these allegations are warranted. The defense has great respect for modern science. It has made incredible progress through scientific investigation of the physical world in recent times. In one way, we concede that it has distanced the ancient scientific knowledge and methodology. We do have a problem, however. Perhaps we have convicted them without proper representation."

Judge: "Of course, of course. Everyone shall be heard. Now, prosecution, call your first witness."

Prosecution: "The prosecution calls STEM Education. STEM, thank you for coming. Is it true that STEM is an acronym that stands for science, technology, engineering, and mathematics?"

STEM: "Yes, that is correct."

Prosecution: "You have heard the charges against ancient science. Let me read it to get the exact wording. They have been charged with '*outdated* concepts, and *primitive* and *simplistic* documents'. But STEM, isn't it true that the modern curricula have downplayed the education of ancient science, focusing more on modern science? Aren't you just following the times?"

STEM: "Yes, precisely. We are quite aware that we accent things like modern measurement, technology, mechanical invention, and mastery over the environment. The ancients had no such prowess in these areas of scientific investigation. We show students how the last two centuries represent almost all of the crowning achievements of humankind."

Prosecution: "Would you please tell the court what you require of your teachers?"

STEM: "We instruct them to teach the skills and facts of science so that they can encourage the next generation of *invention* and *innovation*."

Prosecution: "Why do you do this?"

STEM: "We want students to enter the highly competitive workplace in good stead. This requires a solid, practical knowledge of science."

Prosecution: "I see, I see ... invention, innovation, solid practical knowledge of science ... And does ancient science help in this pursuit of a competitive workplace?"

STEM: "Not really. Ancient science is historically interesting, but you can't build technology with stories from a pre-technological age."

Prosecution: "Thank you." Turning to the defense, "Your witness."

Defense: "STEM, I have here a record of remarks your teachers actually made to students. I would like to know if you have heard these.

- 'The ancient scientists were a simple people and their science was primitive.'
- 'The ancients laid foundations for modern science, but their findings are outdated compared to the strides we have made.'
- 'They often had superstitious beliefs that were not based on physical evidence.'

STEM: "Yes these are actual statements. But, as I have already said, we respectfully mention the ancients as foundation builders - not unlike children. But, as with children, when the adults need to move forward, they need modern techniques, not juvenile stories."

Defense: "I have no more questions, your honor."

Judge: "STEM, you may step down. Prosecutor, you may call your next witness."

Prosecution: "I call, Dr. Faraday. Dr. Faraday, you are an expert in the history of science are you not?"

Dr. Faraday: "That is so."

Prosecution: "If you are a fan of the ancients, I apologize. But truly, sir, can you deny that the ancients were necessarily more primitive than we are - especially as regards science?"

Dr. Faraday: "Primitive? I question your indictments. The charges that ancient scientists gave us *outdated*, *primitive*, *simplistic* ideas is itself a gross oversimplification."

Prosecution: "Dr. Faraday, look at the modern scientific laws and principles that have successfully enabled us to build scientific theories and incredible technology."

Dr. Faraday: "Quite right. But the very fact that they did not constantly use technology enabled them to see much of what we have lost."

Prosecution: "I have no more questions. Your witness."

Defense: "Welcome Dr. Faraday, it is my honor to speak with you today. So far we seem to be looking at what we moderns have today ... that the ancients did not. I would like to look instead at **what they DID have ... that WE have lost**. You are an expert in the history of science. Can you fill in some blanks here?"

Dr. Faraday: "I would be most happy to do so. Modern science has new ideas and new inventions, but there is much we have lost. Let's look at a case in point. Aristotle's **Four Elements** and **Four Qualities** are mentioned lightly - if at all - because we have lost the ability to appreciate an ancient view from an ancient consciousness.

Aristotle is considered by many to be the *Father of Science* and one of the most prolific philosophers. He is the tip of a huge iceberg in that, although we have recovered a great many writings, we believe that there may be up to three times as many lost. He is a good example of ancient science and what is more, almost every subject that he wrote about transformed that particular field of knowledge.

I have seen great teachers model intellectual humility and resist the tendency to minimize early scientific ideas of Aristotle simply because we have modern ones that

appear to supplant them. The same applies to many of the greats, such as: Cheng Heng and Bi Sheng of China, Banu Musa Brothers of Islam, metal tool makers of Sumeria, hydraulic systems of the African Kushites, Ptolemy of Egypt, al Gazer of the Turkish Artukid Dynasty, Archimedes, Eratosthenes, Euclid, and Pythagoras of Greece, the Kechuan Indians of Peru, the iron workers of Kashmir, or the Olmecs of Mexico.

So, how can we keep from speaking of them as outdated and simplistic? I'll tell you how. Try listening to them as if they were speaking with a different consciousness. **Do not project your own consciousness** - your own way of thinking - onto them. Instead of reading their publications as if someone next door said it yesterday, try to imagine a person who thinks in a very different way.

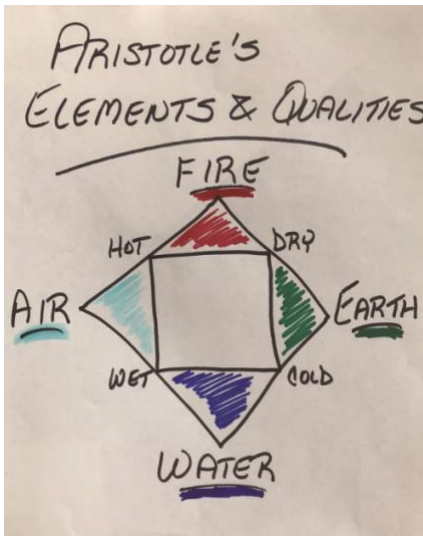
Isn't it the responsibility of the scientific method to find the truth? When moderns look through a narrow lens of **relevance**, we seek to answer questions like, 'What can this do for me?' - or - 'What innovation could use this?' What if the ancient consciousness did not look at things that way - in fact - what if they would say that we moderns sometimes have an unscientific bias here."

Defense: "I see. Do we have this bias in how we view Aristotle's **Four Elements** and **Four Qualities**?"

Dr. Faraday: "Indubitably. Aristotle's **Four Elements** spoke of four main divisions of the world, known as the four Elements: earth, water, air, and fire. We sometimes try to translate such ancient language into our own, comparing this to our periodic table. This makes the ancients seem simplistic. In this regard, we may be well shy of Aristotle's full meaning. The consciousness of Aristotle's time used language in a very different way than

we do. The words often were inclusive of very large ideas, connected to passionate feelings that perhaps we moderns cannot even feel today. One thing we have lost here is the ability to **love our world passionately**.

It is the same with Aristotle's **Four Qualities**: hot versus cold and wet versus dry. He paired these with the four elements as below.



Fire is Hot and Dry.

Air is Hot and Wet.

Water is Cold and Wet.

Earth is Cold and Dry.

Yes, these are very simple, broad, sweeping concepts. Every child understands them. So, we sometimes (perhaps arrogantly) ask, 'What is the big deal about learning Aristotle's ideas - I understood them when I was in third grade?' Then, we might dismiss them because they seem so naive.

And the *relevance* of them? Relevance in the modern consciousness can unfortunately get translated to asking, 'What can nature do for me?' or 'What technology can I get out of this?'

Defense: "I understand. By contrast, what do you see in Aristotle, Dr. Faraday?"

Dr. Faraday: "I see a consciousness that is in touch with the incredible ability to appreciate nature with the attention and wonder of a child. I believe that at least one thing he is saying is this: ***that a scientist should not lose touch with the inclusiveness and wonder of nature!*** As Goethe, who was a great fan of Aristotle's science, says ...

'He should form to himself a method in accordance with observation, but he should take heed not to reduce observation to mere notion, to substitute words for this notion, and to use and deal with these words as if they were things.' (Goethe, 1840/1970, p. 283)

But here is the irony. In the modern, headlong pursuit of technology and efficiency, I wonder if we have walked past the obvious. Perhaps instead, if we could peer through the lens of the ancient consciousness, we would reveal a view that is based upon, imitative of, and embedded in nature. Through this lens, I firmly believe that we could uncover at least two benefits.

- For one, we would see that processes and mechanical contraptions that have *fewer parts* have fewer things to go wrong.
- The other is perhaps an ironic epitaph to humankind's recent love affair with the mechanical. We would start inventing new ways of living and new devices that work alongside of and even *behave like nature*. Perhaps such a future could be blessed by clean, friendly, harmonious

technologies that sway like trees, flow like water,
and grow like flames.

You know, the ancients could raise a stage hydraulically in an open-air amphitheater by diverting a stream to let the water in, then allow the entire stage to be lowered by letting the water return to the stream. The music and speaking in the amphitheater could be amplified by filtering out background noise with the limestone seats. Churches used beautiful chalices to resonate to various tonal frequencies and thereby carry sound.

It fills me with wonder to consider such natural simplicity that might be joined to the incredible strides modern science has made."

Defense: "Thank you, Dr. Faraday."

Judge: "The witness may step down."

... [skip to the closing argument] ...

Defense: The defense turns dramatically to address the jury with a passionate appeal, "Where is our HUMILITY? Let us honor in our schools that the ancients had valuable abilities - THAT WE HAVE ALMOST LOST! Our current version of civilization is not the epitome of humankind, passing everything that came before us! Imagine a fusion of our modern expertise with the nature-based approach of the ancients. Just think of the world we could make."

[This lesson has been given many times to adults in a U.S. State prison, to middle and high schoolers September 1975 - March 2023.]

References

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Zhou, Z. (2022). Critical Thinking: Two Theses from the Ground Up. *Journal of the Scholarship of Teaching and Learning*, 22(1), 154-171.