The Galileo Gambit

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ABSTRACT

Fact or Faux addresses issues of misinformation and science media literacy. Here, we address those who reject the scientific consensus and justify their beliefs by appealing to Galileo. They claim that the majority persecuted him for his scientific beliefs, but his evidence proved right in the end. However, this view is historically incorrect and also misrepresents the social nature of science and the critical role of consensus.

Keywords: Misinformation; Galileo Gambit; Galileo; consensus; Galileo trial; Copernicanism

Nowadays, many claims that circulate through the internet and social media fail to respect the scientific consensus. What can science teachers do? Surely, they do their part by promoting the *value* of science. But have they adequately explained the importance of a *critical consensus* as a core feature of science? Have they guided students in an understanding of the *social* practices of science, and the ultimate cultural significance of a community that *checks for errors, exposes individual bias*, and thereby *constructs reliable knowledge*?

Worse, perhaps, some purveyors of misinformation present their own claims as the "real" science instead. Anti-vaxxers, flat-Earthers, climate change deniers and the pandemic-blind, ironically, all believe that the science is "on their side." Puzzling, yes. But sadly true. Why do these non-scientists think they can second-guess the experts? How can they publicly justify blithely dismissing the concurrence of professional scientists?

All too frequently, the would-be dissenters appeal to Galileo. They contend that Galileo's arguments about Copernicanism were right, but that the Church (apparently blinded by religion) unjustly declared him wrong and persecuted him for his beliefs (image above; 1857 painting by Cristiano Banti). Galileo (we are told) bravely argued from the empirical evidence—which prevailed in the end. The implied take-home lesson seems to be that the majority opinion can be misguided. We need not trust a scientific consensus? The true hero—the modern contrarian—instead holds steadfast to the observations and the arguments, so they contend. These voices imagine themselves as latter-day Galileos—champions (not deniers) of science!

This widespread defense of alternative versions of "science" (notably, outside professional journals or the discourse of the experts) is now so well-known that it has earned a place in the pantheon of logical fallacies: it is known as *the Galileo Gambit*. (Go ahead, check Wikipedia!) We need to help students understand fully how this rhetorical trope about dissent—so frequent and so beguiling on the surface—is unfounded. It runs afoul of both history and the nature of science. And therein lie important, as well as fascinating, science lessons. By learning more about Galileo, we learn more about what makes science "science."

Galileo was "right," wasn't he?

Ironically, the central argument of Galileo's great work of 1632, the *Dialogue Concerning the Two Chief World Systems*—the publication that got him in hot water with the Church—was scientifically wrong. Copernicanism was right in the end, of course. In the end. But not Galileo's audacious argument that it was physically *proven*. It was clever and ingenious, yes. But wrong, even today.

How so? Back then, the problem in the debate between the old Earth-centered and alternate Sun-centered systems was that there was no physicial evidence to decide between them. It was basically all conventions of mathematics and reference frames. Indeed, a rotating Earth created all kinds of problems for interpreting terrestrial motion. For example, if you drop a ball from the top of a tall tower, and the Earth is spinning underneath it all the while, why does the ball drop at the foot of the tower rather than a ways away (the Tower Argument)?

Modern readers rarely know about Galileo's telltale *original* title: *Dialogue Concerning the Flux and the Reflux of the Tides*. Rather a non-starter, to today's ears. But scandalous at the time. (Yes!) The Inquisition even insisted that Galileo change the title before publication. That's how important it was.

The Church was willing to set aside Earth-centered astronomy *if, and when, there was unequivocal physical proof*. Galileo claimed that he had found just that: in the mere existence of ocean tides. He imagined that the daily rotation of the Earth, combined with the orbital motion of the planet, set up contrary motions that led to water sloshing back and forth in the oceans: namely, the tides (Figure 1). How else could you explain them? The tides, Galileo thought, were the crucial physical proof. The Church would have to yield, wouldn't it? Hence, the titillating original title of his work.

But Galileo was wrong. And, ironically, it was the centerpiece of his book, its culminating argument. The sought-after physical proof would not be found until astronomers could document the Earth's annual movement relative to the stars by observing stellar parallax—*centuries later*.

The Jesuits of the Collegio Romano at the time were no less schooled in astronomical observation and the physics of motion. They thus clearly understood the flaws in Galileo's argument. They had good reason to discount his conclusion *scientifically*.

Galileo's scheme ostensibly predicted one high tide and one low tide each day. However, there are two. Everyone at the time knew that. Galileo tried to argue around it. His reasoning was awkward, and not wholly convincing.

In addition, by then, mariners and traders were quite familiar with the relationship between the phases of the Moon and the timing and magnitude of the tides. But Galileo (wrongly) dismissed the role of the Moon as nonsense, as mystical action-at-a-distance. His arguments did not convince fellow astronomer Johannes Kepler. Nor Isaac Newton, half a century later. They both recognized that the Moon (and the precession of its orbit) were key—*not* the Earth's motion (Figure 2).

The argument about the tides was not the only time Galileo got things horribly wrong. He argued that comets were sublunary (namely, atmospheric phenomena). Astronomer Tycho Brahe and others (including some astronomers in the Church) were able to calculate a recent comet's trajectory, indicating its pathway through the planetary orbits. But Galileo—possibly just for the sake of provoking his rivals—argued otherwise. The Jesuits of the Vatican's observatory got that one absolutely right on this occasion.

FIGURE 1

Galileo's diagram from the *Dialogue* used to explain the tides. The Earth's annual orbital motion is depicted as A-F-G-I. The daily rotation is B-C-D-L. Galileo claimed that the contrary direction of motions at B and D, coupled with the annual motion (at A), yielded the oscillating east-west movement of ocean waters.

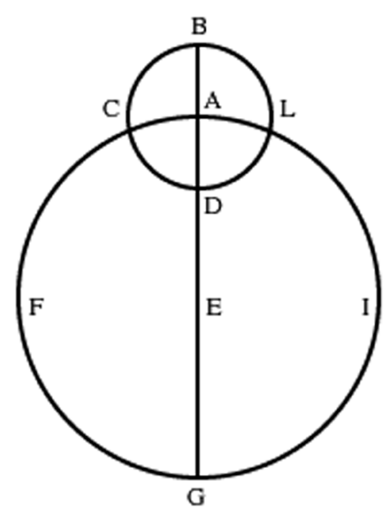

FIGURE 2

Tides are the result of the Moon's gravitational attraction on the oceans, not of the Earth's motion, as Galileo tried to argue in the Dialogue.

All this is to say that there were good reasons for challenging Galileo's science. In particular, he overstated the evidence, implying that he had physical proof, when he did not. It was still all speculative and circumstantial. Yes, Copernicanism itself ultimately prevailed. But *not* Galileo's argument that the tides *proved* it.

Galileo-the-provocateur was *not* "right" in the end. Today's Galileo gambit is plainly historically misinformed. The consensus against him was indeed justified, and correct, as well.

That is science, however. Error happens. We make conjectures. We gather evidence. Sometimes, the ideas are confirmed, sometimes not. And our peers help keep our errors in check. That may be a reminder to maintain a healthy intellectual humility in science.

Galileo and politics

But what about *The Trial*?!! Doesn't Galileo's trial show the conflict between science and religion, between evidence and prejudice, and the important morals for respecting minority views in science? Here, again, the melodramatic popular image is often misleading, eclipsing well informed history (Allchin 2012).

As background here, it is helpful to envision science in the early 1600s—an era when it was not yet a professional occupation (the mere name of "scientist" was nearly two centuries away still). Intellectuals like Galileo, interested in the natural world, had to persuade others to fund their study. They needed *patronage*. You did that by providing after-dinner entertainment at court. Or you helped with weapons, or defense, or industry (mining, chemistry, navigation). Or you discovered impressive new "curiosities" in nature, and dedicated them (judiciously) to your patron. (For a fun classroom activity, see Gabel 2012).

Galileo was the consummate salesman (Biagioli 1993). For example, he did not "waste" his remarkable discovery of the moons of Jupiter. He basically earned a lifelong commission by making the new celestial bodies emblems of the wealth and power of the Medici dynasty. He inscribed the family's privileged status into nature by naming them the "Medician planets." Shrewd, eh? And clever, just like his later argument for the tides.

So, the gritty business of patronage is partly how Galileo eventually became embroiled in Church politics. One of his benefactors and admirers, Maffeo Barberini (Figure 3b), became Pope. (It's complicated: just envision the wealthy elite intermingling with Church power.) Galileo's political fortune seemed to have shifted. He thus sought "permission" to write his controversial book on the tides, and the Pope (at that point still his ally) granted it in 1624. But he stipulated that he must treat the marginal tides argument as conjectural only. Yes, Galileo's

FIGURE 3

(a) Cardinal Roberto Bellarmino, who cautioned Galileo in 1615 not to interfere in matters of Church doctrine. That *political* tension resurfaced when Galileo was censured 18 years later [mid 17th-century, anonymous; Roman Archive of the Society of Jesus]. (b) Galileo's patron Maffeo Barberini, later Pope Urban VIII, who initially supported the writing of the *Dialogue*, then later felt betrayed by Galileo's incautious posture [painting by Michelangelo Merisi da Caravaggio, c. 1594].

risky project originally had "protection" at the highest levels of the Church.

Well, by the time the book was published, Galileo made a political blunder. He placed the Pope's favorite doctrine about philosophical uncertainty in the voice of his simpleton character. Oops. How insulting. Social faux pas. The Pope was outraged. And Galileo's intellectual rivals, the Jesuits, no doubt helped amplify the embarrassing gossip. Galileo had violated the Pope's trust, leaving him politically vulnerable.

Are you getting the picture? There is very little about science here. It was all personal relationships, imagined betrayals, intellectual rivalry, messy power games, and access to institutional leverage. By the end of it all, Galileo was trapped—not by his science, but by his wayward challenge to the authority of the Church *in matters of scripture and faith*. Namely, Galileo had tried to bend Church doctrine to his view. This was not Galileo's first rodeo. In 1615, he had advanced similar *religious* arguments—and the highly respected Cardinal Bellarmine (Figure 3a) had warned him, in no uncertain terms, to back off the exclusive prerogative of the Church.

Humbled, the aging and ailing Galileo prudently acquiesced. His fate—house arrest in his final years—was unfortunate. But it was owing chiefly to politics. And Galileo was not wholly "innocent" in that regard.

Galileo as myth-conception

Where does all this leave the modern observer, reflecting on the nature of science, the authority of science in informing public policy, and the threats posed by scientific misinformation?

First, in the light of history, the Galileo Gambit fails miserably. Galileo was not the lone defender of good science in his era. Consensus mattered, even back then. Galileo had played his own speculative gamble and lost. His claims overstepped the evidence. His tides argument for Copernicanism—his "dissent"—was flawed. Further, the Church took him to account, *not* primarily for his science, but for his renegade religious politics.

Second, the popular image of the Galileo affair (opening image) is a *myth*-conception. It is not just a *mis*conception. It is imbued with falsities that aim to boost Galileo as an iconic scientific hero, the stuff of legends and myths. To convey the nature of science faithfully, teachers need to temper such stereotyped and misleading caricatures—by respecting the historical evidence. We need to portray *real models*, not misleading romanticized "role models." You cannot reinvent history just to bolster your ideology. And that applies to the purveyors of misinformation, too.

Third, we clearly need to teach more today about the *social* practices of science. Scientific knowledge is built on the consensus of the relevant experts. Empirical evidence is important, of course—but it is not enough. We expect the distributed expertise of different investigators to find flaws in the evidence—whether errors arise by accidental oversight, technical incompetence, zealous enthusiasm, or other mishap. We also rely on the interplay of diverse perspectives to filter out individual biases. We have confidence that the conclusions of many researchers are more trustworthy and more resilient than the claims of any one individual. Sometimes, many cooks *do* make a better soup. Science is an inescapably *collective* enterprise.

Too often, perhaps, we fail to convey this simple fact about the nature of science to our students. We emphasize the nature of the evidence and the argument, forgetting how fluid they can be sometimes when contexts of interpretation differ. The scientific community, we should note, is organized to value *robustness*, the convergence of multiple, independent perspectives.

The importance of the role of consensus may seem a trivial detail, at first. But, as we have noted, it has become pivotal in many public discussions about what counts as genuine science. Dissenters appeal to the myth-conception of Galileo in their effort to gain credibility. We need students to understand their empty pretensions—and that the standard of scientific knowledge remains the consensus of the relevant expert community. Lone voices do not constitute science. Not even the great Galileo was an exception.

From history to today's classroom

While all this discussion may seem preoccupied with history, it is really fundamentally about *science*. Including the *social practices* of science. One way to connect to the apparently remote past is merely to share Galileo's compelling story, and invite students to entertain thoughts and questions about what it means for them/us today. Especially for how we regard science in the public realm. The connections are not that obscure.

A more ambitious classroom activity might involve recruiting the whole class in retrying Galileo—set in a strict 1633 perspective, so that one can appreciate the arguments in their original context. It is an exciting way to address *NGSS* science and engineering practice 7, "Engaging in argument from evidence," including especially "respectfully provide and receive critiques from peers" (NGSS, p. 63). All the material to help guide up to 32 separate roles in trial testimony is available online: http://galileotrial.net (with supplemental commentary and instructor notes; Allchin 2012).

In either case—either as a narrative or historical role-play simulation—Galileo's ill-fated effort to portray Copernicanism as physically proven is a prime occasion for lessons about the nature of science: the roles of evidence and argument; their limits; the cultural context of doing science itself; the relation of science and religion; the relation of science *and power*; and, most importantly perhaps, the role of expert consensus in establishing trustworthy scientific knowledge. And that is key to interpreting purveyors of misinformation who appeal to the Galileo Gambit.

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