

Scientific methods discussion

- Science → cause and effect
- Science as a global effort → ethics matter!

Outline:

the method – linear?

skepticism

where are we in science?

creativity

ethics

(Materials here from: On being a Scientist (NAS), A framework for K-12 Science Education (NAS). Originals at nap.edu)

The Scientific Method!

Old School:

Observation

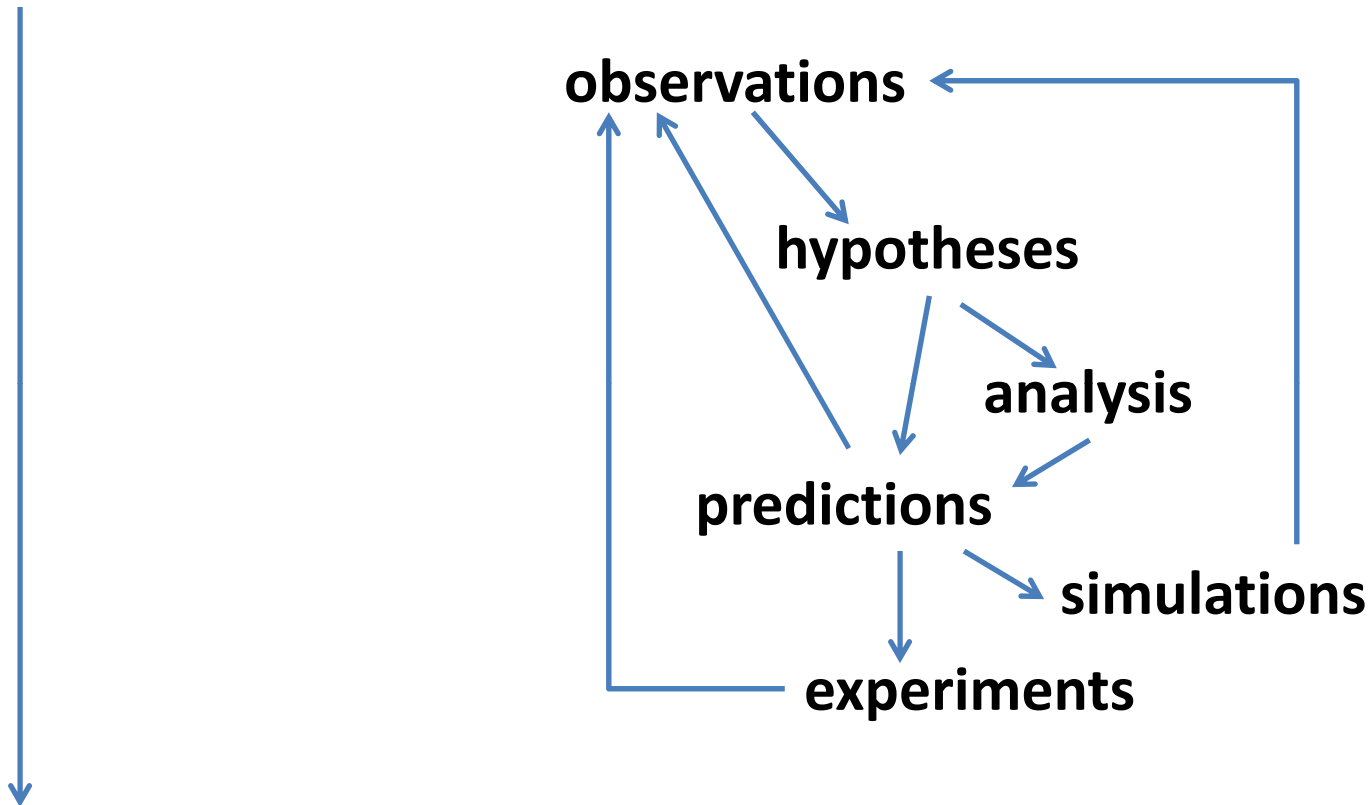
Hypotheses

Experiment

Theory

So very linear! So very feed forward!

Scientific method take 2

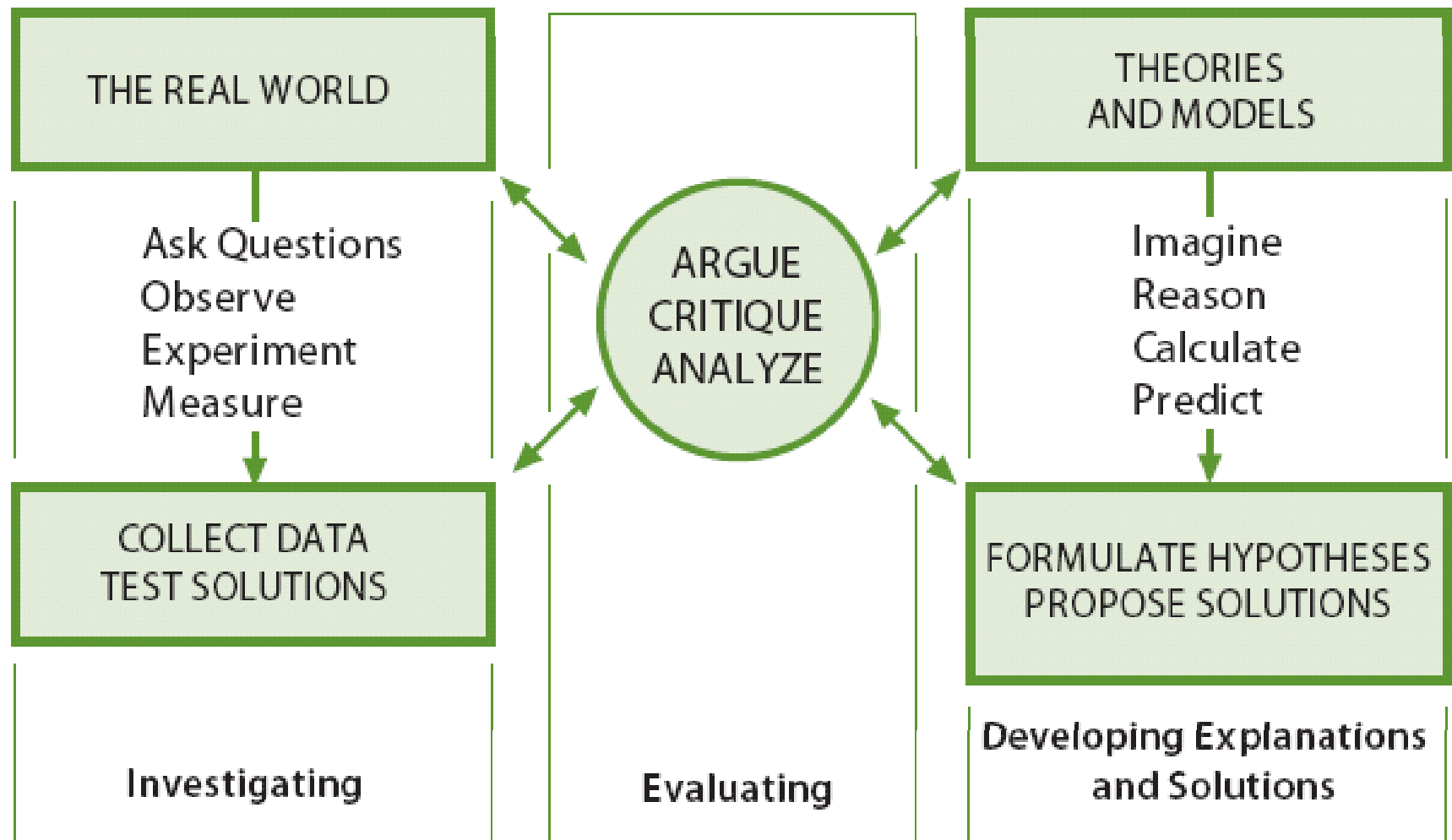


If analysis, simulations, and experiments agree → theory

Experiments are the referee of the process

A FRAMEWORK FOR K-12 SCIENCE EDUCATION

Practices, Crosscutting Concepts, and Core Ideas



Unfortunate examples – high energy (particle) physics:

1) the Standard model

2) String theory

**Be skeptical – form your own opinion
build a mental model based on your
observations**

Do not accept arguments from authority

**Scientific truth is not determined by authority or
by democracy**

Often repeated explanations

Be ready to be wrong – buoyancy example

Changing Knowledge (from On Being a Scientist, Pg. 13)

In the early part of the 20th century, astronomers engaged in a prolonged debate over what were then known as spiral nebulae—diffuse pinwheels of light that powerful telescopes revealed to be common in the night sky. Some astronomers thought that these nebulae were spiral galaxies like the Milky Way at such great distances from the Earth that individual stars could not be distinguished. Others believed that they were clouds of gas within our own galaxy.

One astronomer who thought that spiral nebulae were within the Milky Way, Adriaan van Maanen of the Mount Wilson Observatory, sought to resolve the issue by comparing photographs of the nebulae taken several years apart. After making a series of painstaking measurements, van Maanen announced that he had found roughly consistent unwinding motions in the nebulae. The detection of such motions indicated that the spirals had to be within the Milky Way, since motions would be impossible to detect in distant objects.

Van Maanen's reputation caused many astronomers to accept a galactic location for the nebulae. A few years later, however, van Maanen's colleague Edwin Hubble, using a new 100-inch telescope at Mount Wilson, conclusively demonstrated that the nebulae were in fact distant galaxies; van Maanen's observations had to be wrong. Studies of van Maanen's procedures have not revealed any intentional misrepresentation or sources of systematic error. Rather, he was working at the limits of observational accuracy, and his expectations influenced his measurements. **Even cautious researchers sometimes admit, "If I hadn't believed it, I never would have seen it."**

Where are we:

We know so little about the broad scope of causes in the universe -- examples

All knowledge is provisional -- examples

**Creativity is a necessary and key skill to
advancing science**

Brainstorming methods

Brainstorming exercise

Scientific practice

Ethics: Responsible conduct in research

- 1) It is an honor to be a scientist; there is trust that colleagues place in us**
- 2) Obligation to ourselves**
- 3) Obligation to serve the public**

The big three problems:

The law!

- I) Fabrication**
- II) Falsification**
- III) Plagiarism**

Fabrication is “making up data or results.”

Falsification is “manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.”

Plagiarism is “the appropriation of another person’s ideas, processes, results, or words without giving appropriate credit.” (From *On Being a Scientist*)

Fabrication in a Grant Proposal (from On Being a Scientist, Pg. 17)

Vijay, who has just finished his first year of graduate school, is applying to the National Science Foundation for a predoctoral fellowship. His work in a lab where he did a rotation project was later carried on successfully by others, and it appears that a manuscript will be prepared for publication by the end of the summer. However, the fellowship application deadline is June 1, and Vijay decides it would be advantageous to list a publication as “submitted” rather than “in progress.” Without consulting the faculty member or other colleagues involved, Vijay makes up a title and author list for a “submitted” paper and cites it in his application.

After the application has been mailed, a lab member sees it and goes to the faculty member to ask about the “submitted” manuscript. Vijay admits to fabricating the submission of the paper but explains his actions by saying that he thought the practice was not uncommon in science. The faculty members in Vijay’s department demand that he withdraw his grant proposal and dismiss him from the graduate program.

- 1) Do you think that researchers often exaggerate the publication status of their work in written materials?**
- 2) Do you think the department acted too harshly in dismissing Vijay from the graduate program?**
- 3) If Vijay later applied to a graduate program at another institution, does that institution have the right to know what happened?**
- 4) What were Vijay’s adviser’s responsibilities in reviewing the application before it was submitted?**

Is It Plagiarism? (from On Being a Scientist, Pg. 18)

Professor Lee is writing a proposal for a research grant, and the deadline for the proposal submission is two days from now. To complete the background section of the proposal, Lee copies a few isolated sentences of a journal paper written by another author. The copied sentences consist of brief, factual, one-sentence summaries of earlier articles closely related to the proposal, descriptions of basic concepts from textbooks, and definitions of standard mathematical notations. None of these ideas is due to the other author. Lee adds a one-sentence summary of the journal paper and cites it.

- 1) Does the copying of a few isolated sentences in this case constitute plagiarism?
- 2) By citing the journal paper, has Lee given proper credit to the other author?

Who Gets Credit? (On Being a Scientist pg 36)

Robert has been working in a large engineering company for three years following his postdoctoral fellowship. Using computer simulations, he has developed a method to constrain the turbulent mixing that occurs near the walls of a tokamak fusion reactor. He has written a paper for *Physical Review* and has submitted it to the head of his research group for review. The head of the group says that the paper is fine but that, as the supervisor of the research, he needs to be included as an author of the paper. Yet Robert knows that his supervisor did not make any direct intellectual contribution to the paper.

- 1) How should Robert respond to his supervisor's demand to be an honorary author?
- 2) What ways might be possible to appeal the decision within the company?
- 3) What other resources exist that Robert can use in dealing with this issue?

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