Learning Critical Thinking Through Astronomy: Precise Scientific Terminology

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STUDENT NOTE

PLEASE DO NOT DISTRIBUTE THIS DOCUMENT.

Contents

Questions

Why is precise terminology necessary?

Materials Needed

For this activity, you will need the following materials:

- a pencil (do not use ink)
- the ability to read and follow directions

Points To Remember

STUDENT NOTE

You should always begin by reading the instructions in greater detail than what you are most likely used to.

Unless otherwise explicitly instructed, your responses must not contain personal opinions. All of your responses must be in the form of complete sentences; the fewer sentences the better. Spelling and grammar must be correct. Effective communication is essential for both learning and doing science.

Don't ask instructors for answers to questions posed in activities; you won't get them. You may ask questions regarding the clarity of the instructions or the soundness of your reasoning. If you encounter a word you are not familiar with, don't ask the instructor about it. Look it up first in your glossary and then a dictionary or some other source if necessary. Ensure that all definitions are unanimously agreed upon before proceeding. There are, of course, sound reasons for these policies. See the instructor if you have questions, but do not complain about these policies. They are not negotiable.

1 Introduction

This activity consists of an incomplete glossary of precise scientific terms that you are expected to begin learning immediately. These terms form the foundational vocabulary your instructor will use, and expect you to use, throughout the course. At certain points in the course, you will be asked to add terms to the glossary and will be expected to do so for your own benefit.

We are not trying to rewrite philosophy, psychology, or linguistics here. Instead, we need to acknowledge that scientists' refusal to use consistent terminology, especially at the introductory level, causes avoidable problems for students and laypersons. These problems aid the public in undermining science and prevent students from seeing the coherence that underlies all science.

2 The Glossary

Here is the glossary, arranged alphabetically.

accept

To *accept* is to treat a claim or argument as true based on supporting evidence. *Accept* is often used synonymously with *know* and *believe*, although it is significantly different from the latter.

argument

An *argument* is structure consisting of at least one premise followed by a conclusion. An argument is intended to persuade the listener or reader. Unlike claims, arguments have structure. Arguments may be proposed as an explanation. Premises are sometimes indicated by words like *because*, *given that*, *since*, *assuming that*, *as indicated by*, *inasmuch as*, or *in view of the fact that*. Conclusions are sometimes indicated by words like *therefore*, *thus*, *consequently*, *as a result*, *it follows that*, *we can conclude that*, *so*, or *hence*. These indicators need not be present.

belief

A *belief* is similar to an opinion, but not necessarily formed by the individual. Beliefs are usually created by another person or group of persons, and are usually instilled through *indoctrination*. Note that this does not mean that indoctrination is inherently bad.

believe

To *believe* is to treat a claim or argument as true without any supporting or contradictory evidence.

bias

A *bias* is an intentional or unintentional tendency toward one conclusion at the expense of other possibly equally valid conclusions.

claim

A *claim* is a statement or judgement that something is or is not the case. A claim contains no logic and is not meant to persuade the listener or reader of anything. In science, claims are not evaluated on whether or not they are true. Claims contain no logic, and no conclusions can be drawn from them.

critical thinking

Critical thinking is the set of skills necessary to evaluate the validity of evidence and the resulting conclusions based on that evidence.

debate

This entry has been deliberately omitted. You will create an entry for this word in a question later in this activity.

deductive reasoning

Deductive reasoning is the process of reasoning from one of more general statement regarding what is known to reach a very specific, logically certain conclusion. Assuming the general statements (sometimes called *premises*) are true, the conclusion is guaranteed to be correct as long as all rules of logic are adhered to during the reasoning. Because of this, the outcomes of deductive reasoning need never be explicitly tested. Science is not inherently based on deductive reasoning.

doubt

Doubt is the refusal to accept for fear of being wrong or refusal to accept with the intent to discredit. It is usually the latter. *Doubt* must not be confused with, or equated to, *uncertainty*. The former is frequently used as a tactic to discredit science. The latter is present in all scientific endeavors, and it not inherently a reason to discredit science. The phrase *exact science* must be avoided because there is no such thing.

evidence

Evidence is information that either supports or contradicts a claim or argument. Evidence can sometimes support an invalid or faulty claim or argument. Evidence is very difficult to define because many things can constitute evidence, and some are more reliable than others.

fact

A *fact* is evidence that is repeatable and reliable to the extent that it is taken as general knowledge. *Facts* are not subject to opinion.

fallacy

A *fallacy* is an error in reasoning that may or may not lead to an incorrect conclusion. Very few introductory science students ever get exposure to fallacies and how they are used to subvert and undermine science, especially in the public's perception.

falsifiable

To be *falsifiable* means having one possible outcome of experiment or observation that conclusively shows a claim or argument to be incorrect (or untrue, not true, or however you wish to say it). *Falsification* has nothing to do with whether a claim or argument is correct or incorrect. A claim or argument that can only be shown to be true is called a *tautology*.

framing

Framing is a strategy for controlling how certain people will accept or reject a claim or argument based on, among other things, what words are used, and in what context, to articulate the claim or argument. *Framing* is not inherently bad, but it frequently used by politicians and propagandists with the intent of exploiting an audience's understanding, or lack thereof, of the words chosen for that audience *Framing* has been used by anti-scientists to discredit *science*.

framework

A *framework* is a set of rules defined both explicitly and implicitly by a set of scientifically valid hypotheses. The rules may also be presented as operational definitions. Frameworks define what questions can and cannot have reasonable answers. Frameworks generate predictions. When used to explain natural phenomena, frameworks can be called *theories*. Do not confuse *framework* with *framing*.

hypothesis

A *hypothesis* is a testable and falsifiable claim or argument.

indoctrination

Indoctrination is education without supporting evidence. Propagandists sometimes knowingly use *indoctrination* to refer to any form of education.

inductive reasoning

Inductive reasoning is the process of reasoning from a few specific statements or observations of what is known to more general statements about something that may be more broadly known. This is, loosely speaking, the opposite of *deductive reasoning*. As such, there is no guarantee that the resulting broad conclusions will be correct, and so further testing is always welcomed. Science is inherently based on inductive reasoning.

laws of nature

The *laws of nature* are the internally consistent models, supported by observational and experimental evidence, forming a conceptual framework that allows us to describe everything we currently understand about a subset of naturally occurring phenomena and allows us to make testable and falsifiable predictions about the remaining naturally occurring phenomena we do not yet understand, but are likely to eventually understand. By this definition, the laws of nature are mutable and ever better approximated as models are improved. We don't know the ultimate laws of nature. We only find better and better approximations to them based on our understanding.

literacy

Literacy is the ability to reason with, and express oneself with words, either orally or in writing. *Literacy* must not be confused with being an expert on literature (e.g. an expert on Shakespeare).

misconception

A *misconception* is a conclusion based on incorrect reasoning or faulty evidence. When you learn something incorrectly, thinking it is true but not realizing your reasoning is incorrect, you have a misconception.

model

A *model* is a collection of one of more internally consistent hypotheses that constitutes an explanation for some observed natural phenomenon and that generates testable and falsifiable predictions about that phenomenon. Models may have limited scope and may be replaced by better models over time. *Better* is subjective.

natural phenomenon

A *natural phenomenon* is an event, occurrence, or process that can be explained with testable and falsifiable arguments.

Occam's razor

Occam's razor is a principle stating that given two or more models that explain a natural phenomenon *equally well*, Nature prefers the simplest model. *Equally well* means all current evidence must be accounted for. Occam's razor can also help you in describing a natural phenomenon. When searching for the right, or best, word to use try to use the simplest word you know that will get your point across accurately.

numeracy

Numeracy is the ability to reason with, and express oneself with, numbers and numerical information, either orally or in writing. *Numeracy* must not be confused with being an expert in mathematics. *Numeracy* and mathematics are different things.

open-mindedness

Open-mindedness is the willingness to accept any *scientifically valid* model and to stay within *established frameworks*. When taken beyond scientific validity, open-mindedness becomes gullibility.

operational definition

An *operational definition* is a set of explicit steps that must be carried out in order to define a concept. The steps must end with a complete understanding of the concept being defined. An operational definition may be written as an enumerated list of steps or as a traditional paragraph. Sometimes, an operational definition may be expressed as a single sentence, but only after a more extensive operational definition has been given.

opinion

An *opinion* is a *personally* held judgement that is not necessarily supported by evidence, but is formed by the *individual*. Opinions are neither valid nor invalid, merely a statement of *personal* judgement formed by the *individual*. Opinions may be relevant or irrelevant. Nature doesn't care about our opinions.

philosophy

A *philosophy* is an opinion or attitude held by a person or organization that acts as a guiding principle for behavior.

proof

Proof is evidence that compels the mind to accept a claim or argument as true. Once something is proven, it need never be considered again.

religion

A *religion* is the belief in, or worship of, a superhuman controlling power, especially a personal God or gods.

science

Science is the *process* of describing or explaining a natural phenomenon by applying successively better models. *Better* is somewhat subjective, but usually means being more consistent with existing evidence. All natural phenomena have scientific explanations. Science is not a political movement, a world view, or a *religion*. Some people try calling science a *religion*, an example of *framing*, as a propaganda technique.

supernatural phenomenon

A *supernatural phenomenon* is an event, occurrence, or process that can *only* be explained with untestable and unfalsifiable arguments.

testable

To be *testable* means having some experiment(s) that can be performed or observation(s) that can be made in an attempt to verify an argument, with *at least two possible outcomes*.

theory

A *theory* is a model that has survived repeated testing to the extent that it is generally accepted as correct *even though it is always subject to further testing*. A *framework* may also constitute a *theory* provided it has survived repeated testing.

uncertainty

Uncertainty is the inherent inexactness present in all scientific endeavors.

3 Inquiry

1. Go through the list and pick out words that you've heard before. Discuss any differences in meanings that you thought applied to these words but now see does not, at least within the scope of this course. Discuss how this may change the way you think about science and reasoning like a scientist.

   This question is mostly discussion, so there's really nothing to write, but feel free to include important thoughts here.

2. Rearrange the glossary terms (not their definitions) into an order that would be the most logical for presenting them in class and for learning them. Note that vocabulary usually progresses from simple to complex. Consider the following things: Which term should come first? It should be the simplest, most basic term, and one that does not rely on any other term. Progress from there.

Response

3. What do you think constitutes and does not constitute good evidence? Think about everything you have ever heard about evidence. **This is more difficult than you might realize, especially if you think deeply about it.**

Response

4. Notice that the entry for *debate* has been omitted. Create an entry for *debate* remembering that it can be both a noun and a verb. Regardless of which part of speech you choose, **the entire class must agree on the wording of the entry you create.** Consider how you have probably heard the word used in the media. Here is a hint: people who agree on everything cannot have a legitimate debate.

Response

5. Why is precise terminology necessary?

Response

STUDENT NOTE

When you encounter a checkpoint, everyone in the class should come to the room's center (or some other designated place) for a meeting of the minds and to discuss questions up to that point. After some discussion, there must be unanimous agreement prior to leaving the checkpoint area.

|——— CHECKPOINT ———|

6. Map this activity into as many of the elements of thought as you can.

Response

7. Every activity will have at least one standard associated with it.

STANDARD

I can use scientific terms correctly even if those terms are used differently in non-scientific applications.

4 Feedback

What could be done to make this activity more interesting? Please be honest.

Response