Learning Critical Thinking Through Astronomy: What do you know?

Joe Heafner
heafnerj@gmail.com

2017-09-13

STUDENT NOTE

PLEASE DO NOT DISTRIBUTE THIS DOCUMENT.

Contents

Questions 1

Materials Needed 1

Points To Remember 1

1 One Type Of Question 1
- 1.1 Commonality . . . 2
- 1.2 What You Know . . . 2

2 Another Type Of Question 4
- 2.1 Commonality . . . 5
- 2.2 What You Know . . . 5

3 Inquiry 7
- 3.1 Two Kinds of Knowledge . . . 7
- 3.2 Operative Knowledge . . . 7
- 3.3 Using Operational Definitions . . . 7
  - 3.3.1 The Concept of Parallel . . . 7
  - 3.3.2 The Concept of Perpendicular . . . 8

4 Feedback 10

Questions

What are the advantages of certain types of questions? How do we know what we think we know?

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

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 One Type Of Question

For this section, consider the following list of questions. Let's refer to these as *group one questions*. Read these questions very carefully before proceeding. **Note that you're not being asked to answer them.**

- What is the numerical value of Earth's radius?
- What is the numerical value of the average distance from Earth to Moon?
- What is Saturn's chemical composition?
- What is the numerical value of Jupiter's escape speed?
- How far away, approximately, is the nearest star to Sun?
- In what year was Galileo born?
- What is the approximate numerical value of the temperature in Sun's core?
- What is a main sequence star?
- What is the numerical value of Sun's mass?
- What is the proton-proton chain and how does it relate to astronomy?

1.1 Commonality

1. The answers to all of these questions have something very important in common. What is it?

STUDENT NOTE

You need not know any of the answers to these questions. Yes, they are all related to astronomy, but is that worthy of intellectual debate or discussion? Yes, they are all written in English, but is that worthy of intellectual debate or discussion? **Think about how you would go about answering these questions if you were asked to do that.**

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 ———|

1.2 What You Know

2. Pick one question in the list for which you **think** you may know the answer. Whether or not the answer is correct isn't important. Just pick a question for which you think you may know the answer. In a single complete sentence, write the question's answer in the space provided. **Again, don't worry about whether or not the answer is correct; that's not important.**

Response

3. What was the primary source for your answer? (HINT: Did you read it in a book? Did you hear it from a television show? Did someone tell you?)

Response

4. How confident are you that your source was correct? Do you question your source's accuracy?

Response

5. Now think about the source you cited. What was that source's source for the answer?

Response

6. Trace all the sources for the answer as far back as you possibly can. Try very hard not to leave any gaps in the lineage. Include your level of confidence in each source. Comment on any pattern in your confidence.

Response

7. What is your ultimate source for the answer?

Response

|——— CHECKPOINT ———|

2 Another Type Of Question

Consider the following list of questions. Let's refer to these as *group two questions*. Read these questions very carefully before proceeding. Again, you're not being asked to answer them.

- Why are some people afraid of science?

- Why do some people not want you to take this class?
- Does keeping an umbrella with you keep you from being attacked by pink elephants?
- Why would scientists not believe in evolution?
- Why do scientists assume the laws of physics are the same in distant galaxies as they are here on Earth?
- How can you determine Earth's shape and size from your own backyard?
- How fast can Bugs Bunny pitch a baseball?
- What is an orbit anyway?
- When is noon?
- Why should you laugh to yourself when you hear about astronauts being weightless?

2.1 Commonality

8. The answers to all of these questions have something very important in common. What is it?

STUDENT NOTE

Is it something worthy of intellectual discussion or debate? **Think about how you would go about answering these questions if you were asked to do that.**

Response

|——— CHECKPOINT ———|

2.2 What You Know

9. What is the first indication that these questions are fundamentally different from group one questions?

Response

10. Would you prefer to spend an entire semester addressing group one questions or group two questions? Defend your answer. Consider worthiness of intellectual discussion.

Response

11. Why, if at all, would you think instructors might prefer group two questions? Consider worthiness of intellectual discussion.

Response

12. Why, if at all, would you think students might prefer group one questions?

Response

13. Cite any evidence you know that supports the claim that Earth is flat.

Response

3 Inquiry

3.1 Two Kinds of Knowledge

As a follow-up to this activity, you may wish to research *declarative knowledge* and *operative knowledge* and how these concepts relate to this activity and to this course.

3.2 Operative Knowledge

Sometimes, it is much easier to define a concept as the result of a series of specific, well designed steps rather than as just a potentially meaningless word. Such a series of steps used to define a concept is called an **operational definition**. As an example, consider the concept of *peanut butter sandwich*. Rather than just saying it's *peanut butter between two pieces of bread*, imagine writing down all the steps necessary to actually make a peanut butter sandwich. That constitutes an *operational definition* of *peanut butter sandwich*. Operational definitions take more space to write out than conventional definitions take, but they are much more precise. You will now use operational definitions to solidify your understanding of some important concepts to be used later in the course.

3.3 Using Operational Definitions

3.3.1 The Concept of Parallel

14. You have no doubt heard the word *parallel* before. This word defines a very specific geometric property. Devise an operational definition of the concept of *parallel* using the sticks you've been given. You may use more sticks if you wish. **Do not refer to any other geometrical or mathematical concepts that involve angle or degrees.** Avoid these words: angle, degree, north, south, east, west, left, right, top, bottom, vertical, horizontal. These words are okay: point, vertex, shape names (e.g. rectangle), midpoint, bisect, opposite, adjacent, perimeter, center, length. You will probably find this very challenging, so don't worry if that's the case. Thinking about a geometrical construction may be helpful.

Response

3.3.2 The Concept of Perpendicular

15. Again, you have probably heard the word *perpendicular* too. Again, this word defines a very specific geometric property. Devise an operational definition of the concept of *perpendicular*. Again, thinking about a geometrical construction may be helpful.

Response

16. Consider this statement: *That stick is parallel.* Is this a legitimate, meaningful statement? Defend your response. Replace *parallel* with *perpendicular* and analyze the new statement.

Response

17. What are the advantages of certain types of questions? How do we know what we think we know?

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 ———|

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

Response

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

STANDARD

I can create an operational definition of a physical, geometric, or mathematical concept in either list form (as a series of enumerated steps) or in paragraph form (in complete sentences).

STANDARD

I can trace a piece of scientific knowledge all the way back to its observational origin.

4 Feedback

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

Response