



Lesson Title: What Is the Difference between Science and Pseudoscience?

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Grade Level: Middle Level

Type of Lesson: Nature of Science

Objectives: To understand the difference between science and pseudoscience. This is critical for students at younger ages as their understanding of these concepts can make important impacts on their beliefs of these subjects. For example, most major newspapers across the world have sections on astrology. Individuals often base their daily and yearly decisions (such as when to ask for a raise and who they can be in a romantic relationship with) on these pseudoscientific ideas. Additionally, *dowsing* is a technique used to find items under the ground, particularly oil and water. It is important for students to understand whether or not these things actually work in order that they are not scammed into paying for these services (e.g. psychics) or basing life decisions on these notions. A common example is people who pay dowsers to find water on their land for a water well. Since dowsing does not work, the landowners actually pay for someone to randomly choose a spot they should dig a well and are, therefore, paying for nothing.

Activities: Listen to and participate in an interactive lecture on the criteria of science. Your lecture allows students to discuss and decide what fields are scientific compared to those subjects that are pseudoscience. It also shows how unlikely it is to win an argument with someone who has a pseudoscientific claim.

The students are then shown a video demonstrating a scientific test of a pseudoscience “dowsing.” Students will reflect on concepts from the video and discuss them.

Finally students will test another subject “astrology” to see if it is a science or pseudoscience. Throughout this lesson students learn and then apply the scientific method to test a broadly used concept of every day life.

Lecture: Background information to include in the presentation:

These are some facts about science:

- It is testable and falsifiable.
- It incorporates multiple pieces of evidence (ex: chemistry, physics).
- Experiments and results should be repeatable.
- Hypotheses and theories are often modified or discarded whenever new or better observations or experiments no longer support them.

- There is no such thing as absolute truth in science, but enough evidence can be collected and analyzed to obtain an objective truth that is considered beyond all reasonable doubt.
- Evidence is really all that matters and is more important than opinion, even by scientists.
- Science only investigates the natural universe and does not operate in the realm of the supernatural.
- Science cannot answer questions about right, wrong, or meaning/purpose, but scientific conduct must be ethical.

On the other hand, these are facts about pseudoscience:

- *Pseudo* means false, therefore pseudoscience means false science or really is not a scientific endeavor.
- Does not comply with the usual scientific evidence and tests.
- May claim to be at a higher level than science, or in an area that science can not understand like the supernatural realm. Therefore, it is irrefutable even when contradicted by science.
- Often inconsistent with existing, well-established scientific knowledge.
- It is stated as being true based on a belief that is often not testable or falsifiable, or if it is, has been falsified.
- Often uses scientific sounding language.
- Claims are often so vague as to be essentially meaningless or are bound to be true sometimes, as is the case with astrology.
- Truth is based on arguments of authority of a famous person rather than evidence.

During the lecture, ask your students which of these subjects is pseudoscience?

Archeology, Astronomy, Astrology, Biology, Chemistry, Dowsing, Geology, Glaciology, Paleontology, Physics, Psychic Abilities.

Include a slide or discuss a pseudoscientific claim. One such claim might be that on the way to school, you saw Bigfoot. See if they can “disprove” your claim. The students won’t believe you, but they also won’t be able to “disprove” you because you can always make up excuses or scenarios. Because it is something you “believe” you actually saw, there is nothing they can do.

Point out how claims like these are pseudoscience because:

- Pseudoscientific claims are often based on personal, anecdotal evidence.
- Essentially they convey second-hand stories: “I saw Bigfoot.” “I was abducted by aliens.”

In addition, there are alternative explanations for pseudoscience:

- Human error, e.g., mistaken observations and/or inferences.
- Fraud/trickery, e.g., fake Bigfoot photos, stage magic masquerading as ESP.
- Chance, e.g., coincidental events, a long run of heads in coin flipping.
- Non-occurrence of the event: It did not happen.
- Scientific evidence may refute it.

Video: After your lecture on science vs. pseudoscience, play a video on *dowsing*: http://www.youtube.com/watch?v=_VAasVXtCOI. The video is almost five minutes long. You may choose to explain dowsing briefly before the video but then talk to the students about their opinions of the video afterwards. Ask them about questions they have.

*** Note: Richard Dawkins is often considered controversial because of his anti-religious books, lectures, and videos. Therefore, mentioning that the video is from him could stir negative emotions from students/parents/administration. However, the video itself is not focused on religion and never mentions Richard Dawkins by name. He is simply narrating and the students and other watchers are not likely to know who he is from the video. It just might be best to not mention him and focus on his testing of dowsing, which is clearly shown to be a pseudoscience.

Use Astrology to test the notion of pseudoscience:

Before class, print copies of the Astrological Descriptions (one double-sided page for each student in the class), and the answer section for the students (each page is good for fourteen students; teachers should cut strips out before class). The answer key for the Personality Descriptions can be found at the end of this exercise (only the teacher should have access to this).

Give each student an Astrological Description of Personalities sheet and an answer section strip. Students should write both their name on the answer section strip and their actual astrological sign: Aquarius (Jan. 21st–Feb. 19th), Pisces (Feb. 20th–Mar. 20th), Aries (Mar. 21st–Apr. 20th), Taurus (Apr. 21st–May 21st), Gemini (May 22th–June 21st), Cancer (June 22nd–July 22nd), Leo (July 23rd–Aug. 21st), Virgo (Aug. 22nd–Sep. 23rd), Libra (Sep. 24th–Oct. 23rd), Scorpio (Oct. 24th–Nov. 22nd), Sagittarius (Nov. 23rd–Dec. 22nd), Capricorn (Dec. 23rd–Jan. 20th).

The students should then read the Descriptions page and write the number, which best fits their personality on the answer strip (if students do not write on this, they can be reused for other classes). The teacher will then collect the strips from each student as they finish and will write on the board how many students accurately matched their personality with their astrological sign and how many did not. If astrology is a science then their personalities should match their sign. If it is a pseudoscience, we would expect 1 out of 12 students to match the sign up by random chance.

Lead a discussion about the students thoughts regarding science and pseudoscience. Can the students give some examples of pseudoscience?

Answer Key to Personality Descriptions:

Aries = 1; Gemini = 2; Virgo = 3; Leo = 4; Cancer = 5; Libra = 6; Pisces = 7;
Aquarius = 8; Taurus = 9; Sagittarius = 10; Capricorn = 11; Scorpio = 12

Astrological Descriptions of Personalities

- 1) _____ is the sign of the self, people born under this sign strongly project their personalities onto others and can be very self-oriented. _____ tend to venture out into the world and leave impressions on others that they are exciting, vibrant and talkative. _____ live adventurous lives and like to be the center of attention, but rightly so since they are natural, confident leaders.

- 2) _____ people are many sided, quick both in the mind and physically. They are brimming with energy and vitality, they are clever with words. They are intelligent and very adaptable to every situation and every person. _____ are curious and always want to know what's going on in the world around them. This can sometimes make _____ nosy, they do not mind their own business!

- 3) _____ exists in the mind, everything is inside. To the world, _____ presents a calm and collected exterior but on the inside, nervous uncontrolled intensity in the mind, trying to figure things out, how to improve everything, analyzing and thinking. _____ can tire itself out without even moving! _____ has a constant drive to improve and perfect, this can lead to extreme pickiness and finickiest.

- 4) _____ possess a kingdom which they protest and cherish. They are high esteemed, honorable and very devoted to themselves in particular! The kingdom could be anything from work to home to a partner, whatever it is, you rule it. _____ is always center stage and full of flair, they enjoy basking in the spotlight. A _____ always makes their presence known.

- 5) _____ is a mysterious sign, filled with contradictions. They want security and comfort yet seek new adventure. They are very helpful to others yet sometimes can be cranky and indifferent. _____ has a driving, forceful personality that can be easily hidden beneath a calm, and cool exterior. _____ can come out of their shell and fight but they can also hide in their shell of skitter away back into the depths of the ocean. They are very unpredictable.

- 6) _____ are able to put themselves in other's shoes and see things through another person's point of view. They are the ones that always want to make things right and have balance and harmony in their life, their surroundings and the lives of the people close to them. They have captivating charm, elegant taste and they are easy to like due to their eager-to-please, easygoing nature.

- 7) _____ live in two worlds, the real world and the spiritual or mystical world where they interpret what they see into what they want. They do this to avoid all the realities of pain and suffering in the world. They have extremes of emotions and feel both good and bad intensively. _____ have formidable intuitive ability. Most _____ are somehow involved with occult or spiritualism.

8) _____ is the sign of visionaries, unconventionality and intellectual independence. _____ are the people who deviate from the crowd and go their own way. They are always after intellectual stimulation, constantly discovering something new, forming new opinions and stubbornly traveling their way regardless of what other people think.

9) _____ is the one who has immense perseverance, even when others have given up, the _____ rages on. Solid and persistent, _____'s have a well known reputation for being stubborn, which is not necessarily a bad thing. The stubborn streak can cause _____ to butt heads and conflict with other strong character types. _____ are not fond of change.

10) _____ seem to be guided by luck, good things happen to _____ and this is usually because of their optimistic outlook and positive disposition which attracts good fortune. Despite hardships, _____ is always optimistic that good things will happen tomorrow and the future carries good luck. _____ have a vibrant, expansive personality that is free like a bird, _____ cannot be contained.

11) _____ are very ambitious people, they always have something they are pursuing and they want their lives to be fulfilled and important. _____ have a very active mind and strong powers of concentration. _____ like being in control of their surroundings and everyone in their life. _____ tend to see life in black or white, definitive's only.

12) _____ is the astrology sign of extremes and intensity. _____ are very deep, intense people, there is always more than meets the eye. They present a cool, detached and unemotional air to the world yet lying underneath is tremendous power, extreme strength, intense passion and a strong will and a persistent drive. On the outside, a _____ has great secretiveness and mystery.

Name _____
Birth Astrology Sign _____; Number you think you are _____

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