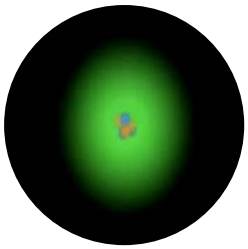

Scientific Reason Not Scientific Treason

Scientific Method vs. Scientific Thinking

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Published by *K20 Center*

Grade Level	9th – 12th Grade	**Time Frame**	2-3 class period(s)
Subject	Science	**Duration**	120 minutes
Course	Biology, Chemistry, Environmental Science, Physical Science, Physics		

Essential Question

What is the difference between the scientific method and scientific thinking?

Summary

Students are introduced to a more holistic view of doing the scientific method by using scientific thinking instead. Students will be challenged to review and revise what they already know about the scientific method. Students will investigate what it means to do science and discover why some science is not good science. Students will also identify reasons that some scientists may participate in bad science.

Snapshot

Engage

The teacher performs a crazy experiment, following the scientific method, using the class as subjects.

Explore

Students review the scientific method, refer back to the opening experiment, and critique the teacher's method.

Explain

Students create a justified list about the credibility of the opening experiment.

Extend

Students watch four videos on junk science, study limitations, and the scientific method, then compare this new information with their prior knowledge.

Evaluate

Students write a letter to the teacher outlining the flaws in the teacher's opening experiment. Students must answer the essential question in the letter.

Standards

ACT College and Career Readiness Standards - Science (6-12)

EMI301: Identify implications in a model
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text

Next Generation Science Standards (Grades 9, 10, 11, 12)

: Ask questions that arise from examining models or a theory to clarify relationships.
: Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
: Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.
: Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Materials

- Penny
- Blank paper

Engage

When Should I Do This Lesson?

This would be a great first day of school lesson, but can be used anytime. It could be used on the day back from a major break, like Christmas break, as a reminder of what doing science looks like. If it is a first day lesson, give the students a seating chart on day one, so that you know the name and whereabouts of each student. The next note will make sense of this.

What Should I Do Before The Lesson?

1. For each period, write the name of one student and place it in a sealed envelope in your desk drawer.

2. Write the scientific method on the board or project it on your board: The steps I write are: Make an observation, Ask questions/Research, Form a hypothesis, Conduct an experiment, Gather and analyze data, Make a conclusion.

3. Make sure you have a penny.

As students enter the room and take their seats, the song Weird Science will be playing. See the note about playing the video.

Embedded video
https://youtube.com/watch?v=Jm-upHSP9KU

Remark About Appropriateness Of Video

You may choose to play the video as the students enter or just the audio from your computer. The video has a couple of parts showing a woman in her underwear so screen it first before you decide to play the video.

Once the bell has rung, turn off the music and tell the class, "There is a student in our midst today who is psychic." The students will look at each other and laugh, thinking you are crazy. Reaffirm what you just said, "Yes, indeed I believe that there is a student in this class who is psychic, and I want to test my hypothesis right now. Stand up. Raise your hand if you think the coin that I am going to toss in a few seconds will land on heads. Keep your hands raised." Pay attention to the student whose name you wrote down before the period started. Your results will be skewed every time to match the side that student thinks the coin will land. Flip the coin so that you catch it and no one sees on which side it landed.

If the chosen student has a raised hand for heads, be sure to call heads even if the coin landed on tails. If the student does not have a raised hand, be sure to call tails even if the coin landed on heads. Ask the losing students to please sit down. Now say, "Raise your hand high if you think the coin will land on tails this time. Keep your hand raised." Again, be sure that your chosen student remains standing. Skew the result of the coin toss in his/her favor. Continue doing this until only that students remains standing.

Adding Credibility

When the actual facing side matches the guess of the chosen student, you might let another student see the coin in your hand to verify the results. This will add credibility to the so-called experiment.

Once the chosen student is the last to remain, declare "My hypothesis is supported we do indeed have a psychic in our midst." Students will immediately start to question you and your method, although some will have total buy-in. To jazz it up, now you can take the envelope from the desk drawer and declare, "Before class began I wrote down one name. The name in this envelope is the person that I believed to be the psychic." Reveal the name. It should match the student that is standing.

Student Reactions

Some students won't have a clue what just happened. Others will be on to you and your game immediately. Don't give anything away at this point.

Explore

Ask the students, "Is what just happened a good example of "doing" science?" Most of the class will reach the consensus that no, it was not, but for various reasons. Allow the students to share their ideas, but do not give anything away. Just listen. Argue that yes it was real science. Show them the scientific method on the board.

Student Perspectives

I've done this for years and the arguments are always the same, but varied within the group. Some students will believe that nothing was wrong with your entire experiment. They will think that since you followed the scientific method that it is scientifically sound. Others will struggle with the hypothesis and the fact that it wasn't truly testable. Some students will accuse you of cheating since you had already picked the last person to remain standing. Some mention that the experiment should be completed again or figure out ways to expand upon the procedure. Occasionally, there is a student or two who thinks that what just happened is the most amazing thing they've ever witnessed! Students usually beg to do it again. Sometimes I do, with the results exactly the same.

Creating Your Argument

This is how I present this: "I argue with you that I just did real science. I followed the method perfectly. I have observed you in these halls and as you entered the room. I have asked questions about each of you to other teachers and your abilities of predicting events. I made a hypothesis! I performed an experiment by flipping the coin! I gathered my data and have now concluded by supporting my hypothesis! What could possibly be wrong with this?" I am dramatic and really try to present my case.

Show a video from Khan Academy reviewing the scientific method. Ask students to jot down a few notes as they watch the video, as they will need them for the following activity.

Embedded video

https://youtube.com/watch?v=N6lAzlugWw0

Allow students to pair or pair them yourself. The students will use the strategy I Think/We Think to answer either question: "Why is my scientific endeavor from the beginning of class an example of a good science practice?" or "Why is it an example of a poor science practice?" Encourage students to think back to other science classes and draw from their own experiences conducting experiments. Also, encourage them to use their notes from the video to formulate their opinion(s).

Explain

Each pair of students will need to form a quad with another pair. Instruct the students to compare their We Think statements and create a justified list using the Justified List strategy on a blank piece of paper. As the students are working, approach each quad and allow them to share one statement from their justified list. Be sure that the students are justifying their statements, not just listing the things wrong or right with your opening experiment. They must tell why they believe what they write! Allow a representative from each group to read one statement complete with justification from the group's list.

Teacher Role

Do not affirm or criticize the points being made. Allow for discussion, but without adding any of your own thoughts. The students have to come to the consensus themselves of what is wrong with your way of "doing" science.

Timing

Aim to stop here for the day.

Extend

Day Two

Ask the students to sit with their quad from the Explain section of the lesson. Show a clip from *The Big Bang Theory* to reengage the students for the final parts of the lesson.

Embedded video

https://youtube.com/watch?v=_7sSuhQ1_24

Review the previous day with the students. Instruct them to review their justified list with their group. Remind them that the focus of the lesson is good vs. poor science practices.

Instruct students to take make two columns by drawing a centered vertical line in their notebook or on a sheet of paper. The first column should be titled good science and the second column titled bad science.

Show the following videos. The order isn't important. As they watch the videos, have them list the hallmarks of good science and the telltale signs of bad science. Make sure they keep in mind the opening activity and your argument that you were doing proper science. Allow time between each video for the groups to collaborate and discuss their notes.

The videos are: Junk Science, Why Be Skeptical, The Scientific Method is Crap, and Conflict of Interest.

Instruct the quads to review their justified list from the previous day and refine the list. Have them add anything they wish from the video or take anything away that now doesn't apply.

The quads will now create a I Used To Think But Now I Know chart. Ask students to cite specific examples from the videos that changed their minds. Let each group share one thing they thought and one thing they now know. Have quads turn in their sheet.

Evaluate

Students will return to their original seats, breaking from their quads. Write the essential question, "What is the difference between the scientific method and scientific thinking?" on the board or project it to the class. Instruct students to write a personal letter to you. In the letter they must describe why your scientific approach to finding a psychic in the room is flawed, describe why error can occur in science, and answer the lesson's essential question.

The Letter

Invite students to write a scathing letter to you. I tell mine that it is the only time for them to get to "tell me off." You can evaluate them by what they honestly write to you. Remember, the goal is that the essential question is answered. You want them to think of science as a way of thinking, not just doing! There's so much more to it!

Resources

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