

## SCIENTIFIC HABITS OF MIND

### Performance Standard 13A.F

Students will apply scientific habits of mind to analyze cases of scientific (or pseudo-scientific) studies accordingly:

- *Knowledge*: Describe the principles which apply to valid scientific studies and the scientists, themselves.
- *Application*: Analyze research studies or claims to evaluate soundness of their methods and conclusions.
- *Communication*: Explain the basis of valid and faulty research studies with specific examples.

### Procedures

1. ***In order to know and apply accepted practices of science (13A)***, students should experience sufficient learning opportunities to develop the following:
  - Identify valid and flawed research practices in the context of curricular concepts.
  - Compare research studies that have produced valid and non-valid inferences and conclusions.

Note to teacher: This activity relates to the foundational concepts of the nature of science, the characteristics called scientific habits of mind and the accepted practices of science and scientific methods, all of which are referenced within Standard 13 A. Addressing misconceptions in students' prior knowledge base should be incorporated into all curricular concepts effectively. This activity could be used to focus on questioning skills, scientific reasoning, skepticism, openness to new ideas and intellectual honesty for continued use as life-long learners.
2. Have students review and discuss the resource sheet, the assessment task and how the rubric will be used to evaluate their work.
3. Preview [www.badastronomy.com](http://www.badastronomy.com) provides a resource about the scientific research on number of different science concepts or events which have been disseminated through various media (television, movies, etc.) or as urban myths or 'conspiracy theories', etc. This web site offers research explanations presented by both sides of the many publicized science media arguments. As always, teachers should review web sites and their links for classroom utility and conformity to school parameters for Internet site use. While the webmaster's personal comments are editorial and clearly denoted, his presentation of the scientific evidence is clear. His links do not currently present materials that will cause censoring problems in a classroom. This site will be used in the context of this activity, but the activity format could be easily modified with other sites or resources.
4. The activity and assessment resource will focus on understanding the reliability and validity of scientific research. The determination of a resolution statement and teams of students will follow the generally accepted format for debating the resolution by affirmative and negative teams. The affirmative team will make its first statement, followed by the statement of the negative team and alternatively followed by 3-4 rebuttals for each team (each at a maximum of 5 minutes). Students will judge the debate's proceedings in terms of the merits of the debate (effective and complete communication of each team's statement with sufficient mastery of information and evidence), as well as the research debated (degree of agreement about credibility, intellectual honesty, soundness of scientific reasoning, etc.).
5. Set the stage for understanding the foundations that are common about scientific research. Provide each student a copy of the "Bias and Validity" resource. Time should be spent on self and group definitions for intellectual honesty, soundness of scientific reasoning, bias and validity, etc. Students could be asked about their understanding about conspiracy theories that apparently have documented scientific evidence. A common conspiracy theory is related to the hoax of the Apollo landings on the moon. Students will be assigned to debate the issue of the credibility of research about the Apollo moon landings. The activity should follow generalized debate rules using an affirmative team of 4-5 students and a negative team of similar number with the remaining class in judging team groupings. Students should initially explore this site: <http://www.badastronomy.com/bad/misc/apollohoax.html>. The resolution could be: *The research that supports the reality of the Apollo moon landings is credible.* Affirmative teams must present scientific evidence of the credibility, intellectual honesty, and sound scientific reasoning of the research; negative teams present scientific evidence that disproves the credibility, intellectual honesty and sound scientific reasoning of the research. The judging teams must evaluate the factual information presented and the degree to which the subject was approached objectively, effectively and persuasively.
6. Students may complete the Reflections page as a final assessment for this activity, to demonstrate their understanding of scientific habits of mind and the processes of scientific research, as a separate focus beyond the activity of the debate.

7. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
- *Knowledge*: The determination of credibility in research studies was complete and correct.
  - *Application*: The analysis and determination of why the researchers reached valid or invalid findings and conclusions thorough, well-organized, and well-detailed.
  - *Communication*: The explanation of how bias and flaws in research methods can affect conclusions of the studies was thorough, well-detailed and well-reasoned.

**Examples of Student Work not available**

**Time Requirements**

- 20 to 25 minutes

**Resources**

- Copies of the "Bias and Validity" resource and task sheets
- Science Rubric
- Other research studies about school snacks and vending machines, smoking and cancer, infomercials purporting scientific studies, etc. could be starting points for student work or teacher preparations. Students could also use current magazines which have full-page medical drug advertisements with accompanying patient or product information, which describes in detail the research studies. Some magazine and newspaper articles on research might "jump to conclusions" beyond the evidence researched. Students should also consider magazines and journals that have critiques of research.

## BIAS AND VALIDITY – Resource Sheet

**When discussing bias and validity in scientific research, it is important to use terms correctly.**

**Bias:** A preference, especially one that inhibits an impartial judgment; a uniformed or unintentional inclination that can operate either for or against something.

*For example, a research study may be trying to prove that students want the school cafeteria to stop selling snacks. The researchers send a general invitation for students to volunteer to answer a questionnaire about removing the snacks. The conclusions of this study could be invalid because of a selection bias. This means that the researchers may have unintentionally encouraged only students who were in favor of removing snacks to show up. Researchers can avoid this bias by making sure that their sample of students is representative of all the students in the school.*

**Valid:** Well-grounded; sound.

*A valid inference: containing premises from which the conclusion may logically be made;*

*A valid argument: correctly inferred or deduced from a premises,*

*A valid conclusion, and*

*A conclusion or inference can have validity, but the practices and methods of the research do not. (For example, biased survey questions or a flawed procedure will most likely lead to invalid inferences and conclusions).*

**Premise:** A statement from which a conclusion is drawn;

*An example of a premise is as follows: if you smoke cigarettes, you will get cancer. The researcher will have to use unbiased methods to prove this statement and reach a valid conclusion. The evidence may show that the statement is a valid conclusion but only under certain circumstances and for certain kinds of cancer.*

The following terms are often used interchangeably:

**Findings:** A conclusion reached after research or an investigation.

**Inference:** A conclusion based on evidence, facts or premises.

*The implications of a study's findings often lead to inferences.*

**Conclusion:** A judgment or decision based on evidence, facts or premises.

Source: *The American Heritage Dictionary, Second College Edition*. Boston: Houghton Mifflin.

## INDIVIDUAL STUDENT REFLECTIONS

**In order to look at the soundness of the work of scientists and accept its validity, certain factors must be considered. Respond to one of the following statements on separate paper, citing references to the scientific research concerning (title)**

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**Statement #1: When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.**

**Statement #2: Scientists differ greatly in what phenomena they study and how they go about their work. Although there is not fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.**

**Statement #3: What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results. Scientist know about this danger to objectivity and take steps to try and avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same question.**

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