

THE NATURE OF SCIENCE
Realm and Limits / Social Context

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SYNOPSIS:

Students are exposed to a compelling idea: the Earth really IS flat! They are challenged to provide the evidence for a spherical earth, then present the evidence (experiences) for a flat earth, discuss the relative strengths of the evidence, and reach conclusions. They look at the nature of science and pseudoscience, and examine the "flat earth" idea in that context. The Social Context of science is also explored, with the roles of collaboration and past experience biases being emphasized. The role of science in exposing illusions in nature is also mentioned.

PRINCIPAL CONCEPT

Scientific knowledge is different from other types of knowledge.

ASSOCIATED CONCEPTS

1. Scientific explanations must be changed when data provide insurmountable difficulties for the existing knowledge.
2. Not all explanations are equally valid; some are "better" than others, simply because they work better, explain more observations.

ASSESSABLE OBJECTIVES (Students will...)

1. recognize how scientific explanations differ from non-scientific explanations.
2. recognize that scientific explanations can change, and why this happens.
3. recognize that some explanations are better than others, and why.

MATERIALS

Copies of "Student Handouts" (listed below) for all students to read, perhaps as homework assignments
OPTIONAL: video worksheet version 2 teacher packet (see list at end of lesson)

TIME

2-3 45-55 minute periods (one night for reading handouts)

STUDENT HANDOUTS (See list at end of lesson)

The Flat-Earth Round-Earth Controversy", (Stanley Weinberg, modified from George Magrane et al, SPAEA, 1986).

Schadewald, R.J. (1981), "The Balanced Treatment for Flat-Earth Science and Spherical-Earth Science Act".
Creation/Evolution, Winter, 1981, pp. 38-41.

OPTIONAL: video worksheet (two versions) – see list at end of lesson

TEACHING STRATEGY

RATIONALE: To see the rationale and ideas for most effective use of this lesson, read the short article in *Connect* - a Teachers' Magazine, by lesson author Jean Beard, available online at <http://www.synergylearning.org/cf/displayarticle.cfm?selectedarticle=641>

1. This lesson would make an interesting, off-beat introduction to your course, in which you can begin to develop understandings of what science is and is not. No prior experience is necessary.
2. It can also serve well as a working example after you have already introduced lessons dealing with the nature of science.

3. No special preparation is needed, other than making sufficient copies of the handouts for students to read.
4. If possible, get and use the video described under "Resources".

PROCEDURES

1. Write on the chalkboard: "What evidence do you have that the earth is not flat?"

STUDENTS: Read question on board and think about evidence for a spherical earth; depending on sophistication of class, challenge them each to write down 3-5 indications that earth is spherical.

2. Put student answers on the board. Help students analyze answers.

- a) get them to identify the evidence as **primary** (personal experience) or **secondary** something heard, read, or seen in TV or movie)
- b) get them to consider which evidence addresses the question (actually suggests its sphericity).
- c) check to see that the evidence doesn't also support the flat-earth concept.

STUDENTS: Volunteer evidence that the earth is not flat, such as: pictures from space, eclipses, disappearance of ships, intralongitude distances (get shorter toward poles).

3. Discuss earlier explanations of earth's configuration (possibly do a web search for information)

- columns to hold up sky
- corners versus circle
- water edges

STUDENTS: Get clarification of historic descriptions of the earth, as needed. Consider why people would expect the earth to be flat.

4. Distribute and ask students to read handout "The Flat-Earth Round-Earth Controversy" by Weinberg/Magrane.

STUDENTS: Read about the flat earth.

#(Break possible: Assign reading for homework)

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5. Have students work in groups (3-5) to determine problems in the evidence given for the flat earth.

STUDENTS: Determine the problems with the explanation of the flat earth.

6. Get whole class to consider what makes the flat earth defense seem scientific, but is not science (pseudoscience).

STUDENTS: Suggest what makes an explanation unscientific such as: not repeatable, ignores evidence, not observable, based on authority or dogma.

7. Have students list characteristics of science. Put their ideas on the board. (Note: teachers need to avoid technical terms.)

STUDENTS: Offer characteristics of something scientific, e.g.: consistent, observable, predictability, repeatable, tentative.

(Break possible: Assign reconsideration of Science Characteristics)

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8. Assign student groups to develop a list of the features of something that is scientific (6-10 terms). Have each group provide a copy of its list for the teacher.

STUDENTS: Work in groups to develop better list of science characteristics (6-10). Discuss options with fellow students and reach tentative consensus.

9. Explain the procedures for using their lists to develop science vs pseudoscience grids:

- a) make their terminology list complete.
- b) add short descriptions of evidence they would expect in that category for:
..... 1) science 11) pseudoscience 111) protoscience?
- c) assign students to continue to work on their grids.

STUDENTS: Listen to assignment. Ask questions, if unclear. Think about elements of science grid. Make addition before the next class.

10. Distribute "Balanced Treatment" article. Ask them to try their new grids on it and the "Flat Earth" handout before the next class period.

STUDENTS: Before the next class, read the "Balanced Treatment" article. Try their science grid on it and on the "Flat Earth" article, too.

11. Before (or after?) discussion of the "Balanced Treatment" article, you should point out that Schadewald wrote it as a parody of the Arkansas "equal treatment" law (1980), and that the Flat Earth exercise illustrates in general the danger of not updating explanations when new information becomes clear.

ASSESSMENT

1. Students will eagerly participate in the discussions (both whole class and group).
2. Given a sample article, students will point out the parts that show good science, poor science, non-science, and/or pseudoscience (presented as science, but omits one or more rules of science).

EXTENSIONS & VARIATIONS

1. If the video "In Search of the Edge: The World is Flat" is available (see Resources), be sure to show it at some point during this lesson. Try it as an introduction, during the middle of the lesson, or at the end. It is most provocative, and fun to watch (both the video, AND the reactions of the students). Try to introduce and show the film in all seriousness. Discussion will naturally follow. Two worksheets are provided to give some structure and focus for viewing the video (see list at end of lesson). Version 1 is more open, version 2 is more structured. Teacher guide for version 2 includes comments to "Evidence" items, suggestions for using the worksheet, and summary notes of the video. Film available in VHS and DVD (see Resources). Worksheet is also available from Bullfrog Films (source of film), but probably not as useful as the ones provide here.
2. It might be interesting (and helpful for strongly visual students) to have one or more build a model of their perception of a flat earth that would satisfy all our perceptions, and compare with a globe. Have student demonstrate what we see (e.g., apparent movement of Sun, moon, stars) with the flat earth model, then with the spherical model (globe). This could be an extra credit project for a student or two.
3. An interesting extension of this lesson might be the attached activity: "In the Name of Education: A Case Study" (author unknown, but it's apparently from the 1989 ENSI). It involves a hypothetical letter sent to the superintendent of schools in Lancaster, California, from the "president" of the International Flat Earth Research Society, requesting that Flat Earth Theory be included in the district curriculum. Discussion questions are included, and could lead to some interesting dialogue in class. The parallel to similar requests and pressures from "scientific creationists" is rather obvious, and this could provide a relatively neutral example of the dilemma, and how it might best be handled. The three-page activity is in pdf format at the end of this lesson.
4. The natural world has many illusory phenomena (e.g. the apparent daily movement of the sun across the sky). This lesson is a good springboard to exploring illusions, and the role of science in exposing them. Be sure to try our Illusions lesson: "**Perception is Not Always Reality.**" There, not only is there a do-able problem-solving experience awaiting, but also links to many sources for illusions, and a list of some of the many natural illusions in our world. Illusions can be used from time to time as "sponge" activities at the end of the period, fun ways to remind students of the many natural illusions, and the power of science for explaining those illusions.
5. A further fun extension into the realm of illusions is to learn some simple sleight of hand "magic", or use some magic shop gimmicks, to insert as appropriate throughout your course (e.g. make a coin disappear when introducing laws of probability in genetics, or work with cards or dice in the same way). See our lesson "**The Magic Hooey Stick**" for a list of books on magic that teachers can use, recommended by ENSI '93 teacher/magician Walter Wogee. Scroll down to "Other Resources" in that lesson. The **Magic Hooey Stick**, by the way, is an excellent way to help students distinguish science from non-science.

6. NEW For a thought-provoking cartoon for your overhead, take a look at this one by Steve Sack of the Star Tribune (courtesy of Steve Sack). Use discretion; could offend some. This might be most appropriate to use when talking about examples of pseudoscience, or in your introduction to evolution if you address "Intelligent Design" and/or "Creation Science" as so-called "alternative explanations" for evolution, and WHY they are inappropriate in a proper science class.
7. Consider doing the **CONPTT** lesson following this "Flat Earth" lesson, where articles from newspaper or magazine can be analyzed to see if they have the necessary features of science – or NOT.

RESOURCES

1. RATIONALE: Beard, Jean. 2007. "Using Historical Explanations - Teaching How Science Works". Connect - A Magazine of Teachers' Innovations in K-8 Science & Math, Vol. 20, No. 3, Jan/Feb, 2007. Abstract: Many ancient explanations are based on non-technical, but careful, observations. These phenomena are still observable and indeed are part of the first knowledge gathered by young people. A number of these observations, e.g., the Flat Earth idea, can be used as the basis for learning how science works. <http://www.synergylearning.org/cf/displayarticle.cfm?selectedarticle=641>

2. If you can, get the video: "In Search of the Edge: The World is Flat". This is a humorous and thought-provoking 26 minute film (1990). Absurdist and matter of fact, this program presents a carefully constructed, "well-researched" argument to prove that the earth is flat! Interviews with "experts", stock footage, still photographs, and animation combine to dismiss the "global earth" theory as little more than an elaborate hoax.

This video was shown on the "Assignment Discovery" series on cable TV's Discovery Channel in the mid 90's. It is available for \$195 purchase (VHS or DVD), or \$50 rental.

Bullfrog Films Inc. P.O. Box 149 Oley, PA 19547 Phone: 1-800-543-FROG (1-800-543-3764)

For a complete listing of their films, call for a catalog, or check their website: <http://www.bullfrogfilms.com/>

3. For more information about the Flat Earth Society, consult the following website:

<http://www.talkorigins.org/faqs/flaearth.html> (includes a verbatim copy of the flyer from the FES)

<http://www.lhup.edu/~dsimanek/fe-scidi.htm> (This is a Science Digest article, July 1980 by R. Schadewald, plus a 1996 postscript).

4. Have students search the web for pictures of the Earth, especially those taken by NASA astronauts from space. Look for the "Blue Beauty" PowerPoint show with views from the ISS by astronaut Sunita Williams – breathtaking (ask students "Do the slides show sphericity, or flatness?")

ATTRIBUTIONS

1. Original Source: Jean Beard

2. ENSI / SENSI version developed by: Larry Flammer, 1999

3. Modified by: Jean Beard and Larry Flammer: 12/18/06 and 5/18/09

4. Reviewed / Edited by: Martin Nickels, Craig Nelson, Jean Beard: 12/15/97

5. Edited / Revised for website by L. Flammer 8/98

PDF FILES:

1st READING (4 pages): "The Flat-Earth / Round Earth Controversy"

2nd READING (3 pages): "The Balanced Treatment for Flat-Earth Science and Spherical-Earth Science Act"

#VIDEO WS Version 1 "In Search of the Edge: The World is Flat": Student WS v1

#VIDEO WS Version 2 "In Search of the Edge: The World is Flat": Student WS v2

#VIDEO WS Version 2 "In Search of the Edge: The World is Flat": Teacher Notes (4 pages: key, ideas)

#Flat Earth Extension: "In the Name of Education: A Case Study" (3 pages)

Steve Sack cartoon for Overhead: So much for ...ID, ...now to .."Intelligent Geography"