Unit 4 Chapter 4 Natural Sciences

Unit Overview:

This chapter examines the natural sciences and the way knowledge is gained in the field. Science and the scientific method are often assumed by many to be two of the best ways of gaining sound and indisputable knowledge. While this is true in many instances, there are many problems with knowledge claims in science. This chapter looks at both the process behind making sound knowledge claims as well as the problems inherent to making these knowledge claims in science. Induction is examined thoroughly as is the process of observation and different interpretive biases which are caused by subjectivity. There is also an examination of the role faith (not religious conviction) plays when claiming to know in science.

Lesson 4:1 Scientific Method, Hypothesis, Observation, and Knowledge

Objective(s):

- *To introduce some of the problems of knowledge in science.*
- *To examine the process of obtaining knowledge in science.*

Homework:

- Preparatory reading of next section as deemed necessary.
- Assignment of discussion questions if preferred.

Vocabulary:

- Scientific Method
- Observation
- Expectation
- Hypothesis
- Metaphysics

Lecture Support:

This lesson is intended to be a lecture. Following the lesson there are questions for discussion.

The body of this lesson is found in the corresponding section of the teacher version of the student activity book. *Lesson 4:1 Scientific Method, Hypothesis, Observation, and Knowledge* The students have the same material in their version of the activity book with the exception of the suggested answers to the questions. It would be a good idea for the students to have the material accessible during the lecture for this lesson.

The purpose of this lesson is to introduce some of the problems of knowledge in science as well as examine how knowledge in science is obtained. Observation, the first step of the scientific method will be considered because even though this step seems rather straightforward, observation can be, and sometimes is, biased by expectation and theory. After a look at the scientific method and examination of how it is used to create scientific knowledge, there is a look at the specific ways which theory and hypotheses could bias what is observed and what can be discovered; therefore theory and hypothesis may also ultimately affect and/or limit the amount and type of knowledge gained.

Suggested Teaching Strategies:

Make use of the color pictures on the PowerPoint presentation, the class notes, or from the CD copy of the activity book. Students enjoy the multi-media aspect of the material.
Even if a projector is not available in your classroom, try making color overhead pictures.

Lesson 4:2 Induction

Objective(s):

- To understand what induction is and to understand its importance to knowledge claims in science.
- To understand knowledge issues in science caused by induction.
- To understand Popper's and Hume's philosophies about induction and scientific knowledge.

Homework:

- Preparatory reading of next section as deemed necessary.
- Assignment of student activity if preferred.
- Finding horoscopes for the activity

Vocabulary:

- Induction
- Falsification

Lecture Support:

This lesson is set up to be both an activity lesson and a lecture about induction. There are three steps to the lesson. The steps are described below. The topic of this lesson is induction. Induction, without a doubt, is one of the most significant knowledge issues when making scientific claims. The paradox of induction is a well known philosophical debate within the field of science and philosophy of science. Ideas (and text excerpts) about induction from two important philosophers, David Hume and Karl Popper, will be examined in the lecture part of this lesson.

It is imperative that the students understand what induction is and how it works for making scientific claims. It is also imperative that they understand what knowledge problems inductive reasoning can create. If they decide to write about science in their final essays, which many do, induction will likely play a role in their analytic arguments.

Following the lecture portion there is a student activity using horoscopes. The instructions for the activity are included on the activity, but for preparation, at least one horoscope is needed for each student in class. If the students can not bring their own, then horoscopes can easily be found on the internet by doing a search on "free online horoscopes."

The teacher and student lecture section of this lesson begins at the heading "Induction and its Importance to Science" in *Lesson 4:2 Induction*. As usual, the teacher and student version are the same with the exception of the suggested answers to activity questions.

Materials needed:

- A box with top (a copier paper box works perfectly, but any old box will do). The box should be big enough for the students to get their hand down into it. They will be pulling pieces of paper out of it.
- Paper to cover the top of the box so no one can look inside.
- About 25 sheets of regular printer paper.
- Paper money from a game or paper money that you have made yourself.
- Scissors, tape or glue, and a little imagination.
- Possibly a whiteboard ruler or straightedge if you do not have a steady hand.
- For the Student Activity at the end of the lesson bring about 10 days worth of horoscopes from the newspapers or internet. The students will attempt to falsify the horoscope claims in class.

Instructions:

- Cut a hole in the top of the box big enough for students to get their hand down inside of it.
- Cover the hole so no one can see inside.

- Cut about 150 equally sized pieces of white paper; a suggestion is to take about 25 pieces of regular printer paper and to divide each sheet into six equally sized sections.
- Put the paper in the box and shake it up.
- Acquire paper money: If you do not have paper game money readily available, it is just as simple and fun to make your own. (I call mine "Tony Bucks" Tony Bucks come in denominations of 100 and are poorly hand-drawn copies of American money. Tony Bucks say "In Tony We Trust" on them and have an equally poorly hand-written stick like drawing of me on them with various hair-styles, grimaces, and facial jewellery. The students get a laugh out of them and anything to make TOK popular right?).
- Print up enough of your "bucks" to give each student 30. They will only get 15, but there will be betting involved so you will need to have twice as many bills to make sure there is enough. The bucks will be used in both stages of the game portion of the lesson.
- Being armed and ready to go, do not forget the whiteboard pen. At the beginning of class, distribute the bucks to each student. A good thing to tell them is that the one who has the most "bucks" at the end of the lesson is the winner.

Stage 1: Induction and Circles

How many sections would there be with 8 dots?

The students will be slightly familiar with induction by now from both the history section and the introduction, but there is perhaps no other area of knowledge where induction plays as significant of a role as it does in science. The following exercise is excellent at illustrating the concept of induction. It will also give you a chance to win back some of your bucks.
Brushing off your circle drawing skills, draw a circle on the board and place two dots, equally spaced, on the edge of the circle (like in the above illustration but only with two dots). Then draw a line connecting the two dots. How many sections are created when the line is drawn? That is easy. There are two sections.

2 dots = 2 sections

Now draw a new circle on the board, but his time put 3 dots evenly spaced along the edge. Connect all of the dots with lines. How many sections? Now there will be 4 sections.

3 dots = 4 sections

Draw a new circle, but this time place four dots evenly spaced along the edge. Connect all of the dots using lines (each dot should have a line connecting it with each of the three other dots). How many sections this time?

4 dots = 8 sections

Aha! A pattern is emerging. Even the sleepiest of students should see it. How many sections will there be when we have five dots evenly spaced? Be sure to involve the students at this point. You might even want to take a few bets of up to 5 "bucks." They will say 16, and they will bet their five and they will win. But alas, they are being baited.

5 dots = 16 sections

How about 6 dots evenly spaced now? How many sections? (Be sure to space the dots as evenly as possible for this bit and when drawing the lines draw them as straight as possible using the straightedge if is available).
Ask the students for their answer which will be 32 if they have not seen this before. This makes sense because of inductive reasoning. Have them bet, reminding them that the one with the most money at the end will win. Some may be sceptical because they can scent a trick, but do what you can to get the sceptical students to bet anyway.
Then draw the lines in the circle and number the sections (yes, there is a little triangular section right in the middle). How many sections? 31!!!!! Not 32. Go collect your bucks.
6 dots = 31 sections

Stage 2: Boxes and Induction

For this stage of the lesson get the box with the pieces of paper in it and give it a good animated shake in front of the class. Then tell them that they are going to bet however much they want that they will get a white piece of paper. What they do not know is that there are only white pieces of paper in the box. Do not tell the students that there are only white ones. Let them think whatever they think.
The point being illustrated is that it will take many successful drawings of white pieces before the student will "know" that they will get a white piece when they draw one from the box. At the same time, many students will have bet their bucks that there would be 32 sections after only seeing the pattern 4 times previously.
At some point, the probability of an outcome becomes so high that we say we "know" it is going to happen. For instance, the sun coming up tomorrow or that the next time we let a rock go over the edge of a cliff it will fall.
When do the students "know" that they will get a white piece of paper? After 20 successful pulls? After 30? What does it take for them to say they know they will get a white one?

Ask them this question after all of the students have drawn their pieces. Ask them also how many successful attempts it takes for a scientist to claim that he or she has knowledge when doing an experiment. One? Five? Fifty? Where is the limit and who decides? How many times does an experiment need to be replicated before knowledge is created?

Suggested Teaching Strategies:

Be sure to have fun with this lesson and stress, again and again, the fact that just because something has happened many times in the past, there is no physical law which states the same must happen again.

Lesson 4:3 Science and Pseudoscience

Objective(s):

- To increase understanding of how knowledge is gained in science by examining how science and pseudoscience contrast with one another.
- To activate the student through an in-class presentation.

Homework:

- Preparatory reading of next section as deemed necessary.
- The pseudoscience group presentation.

Vocabulary:

- Pseudoscience

Lecture Support:

The body of this lesson is found in the corresponding section of the teacher version of the student activity book. *Lesson 4:3 Science and Pseudoscience*. The students have the same material in their version of the activity book with the exception of the suggested answers to the presentation questions. It would be a good idea for the students to have the material accessible during the lecture for this lesson.

The purpose of this lesson is to increase understanding of how knowledge is gained in science by examining how science and pseudoscience contrast with one another. The lesson consists of both a lecture about pseudoscience and a student activity where students are asked to give a five minute group presentation about the type of knowledge claims made in a pseudoscience which they choose from the list in the student activity. The short presentation is a good way for the students to get some practice for the graded presentation that they will do later.

Suggested Teaching Strategies:

Since this is intended to be a practice for the student's own presentations, it might be a good idea to limit the group size to three at the most. Besides in such a short presentation as this, more than three will hardly have a chance to speak.

Lesson 4:4 Faith in Science

Objective(s):

- To understand the role faith (not religious conviction) plays in making knowledge claims in science
- To examine problems of knowledge in science caused by faith

Homework:

- Preparatory reading of next section as deemed necessary.
- Assignment of discussion questions if preferred.

Vocabulary:

- Faith
- Luminiferous aether

Lecture Support:

This lesson is intended to be a lecture followed by questions for discussion. The topic is an examination of how faith works, and does not work as a basis for knowledge claims in science.

The body of this lesson is found in the corresponding section of the teacher version of the student activity book. *Lesson 4:4 Faith in Science*. The students have the same material in their version of the activity book with the exception of the suggested answers to the questions. It would be a good idea for the students to have the material accessible during the lecture for this lesson.

At first glance, faith seems to play little or no role in making knowledge claims in science. Upon looking deeper into the subject, it becomes clear that faith is important in science as it is in other areas of knowledge. It is important for students to understand both sides of the "faith issue" in making scientific knowledge claims.

After an introduction to the topic, the role of faith of science is explored in two contrasting essays.