

Lesson Plan for Theory of Knowledge

Grade Levels: 11-12 Theory of Knowledge for IB diploma students (The make up of the IB Diploma class is usually at least 50% gifted and talented; the rest are either above average or in a few cases average over-achievers.)

* With some modification the lesson could be used in Grade Levels 6-12/Experimental Sciences

Name of Lesson: Exploring the Nature of Scientific Knowledge

Strategy Used in Lesson: Simulation

Length of Time Required for Completion of Entire Lesson: 60 minutes plus time at home for extension assignment

Materials Needed: A small box approximately 6" - 10" length, 5" - 7" in width, 4" - 6" in depth. A shoe box is appropriate. The box should contain three or four small random objects of a variety of shapes like a rubber ball, dice, toy car, etc. The box should be closed securely and wrapped in black paper. (The challenge can be increased if you construct compartments within the box.) Provide each team with a ruler, pencils, graph paper, blank large index cards, and paper on a clipboard. Also prepare in advance large index cards with one of a series of aspects in the scientific method printed on each. The words printed on the cards should include: OBSERVATION, HYPOTHESIS, EXPERIMENT, REPEATABILITY, MEASUREMENT, INDUCTION, THEORY, & LAW.

Overview of Lesson: The students solve a problem with group investigation. The student groups will devise a plan in order to make an attempt to determine what is inside a sealed box. They will come to consensus about their findings and then present and defend their findings to the rest of the class.

What is the purpose of this lesson? The purpose of this lesson is to have students simulate the kind of thinking necessary to pursue a scientific explanation and to simulate the component processes of scientific methodology. A key aim of the Theory of Knowledge course is to develop an awareness of how knowledge is constructed, critically examined, evaluated and renewed, by communities and individuals.

Lesson Objectives:

As a result of this lesson, students will know the essential components in the process by which scientific knowledge is acquired and verified. Students will understand the processes involved in scientific methodology and will be able to arrange the steps of the scientific method in a logical, defensible order. Students will be able to explain what is distinctive about scientific knowledge. The following lesson plan relates to any of the sciences but is specifically linked to the Virginia Standard of Learning for Physics. **VA SOL PH.3** The student will investigate and understand how to demonstrate scientific reasoning and logic. Key concepts include

- analysis of how science explains and predicts relationships; and
- evaluation of evidence for scientific theories and how new discoveries may either modify existing theories or result in establishing a new paradigm.

The Black Box Problem

*What's
inside?*



Early philosophers who contemplated the structure of the smallest objects of living or nonliving matter had to do so without the advantage of microscopes, sonograms, MRI's, x-rays, and other technological advances. The exercise you will complete today tries to simulate the kind of thinking skills that must have been used to theorize about the internal structure of things that could not be seen with the eye.

Scenario: Your group represents a team of research scientists: at least one of you works in the field of biology; one of you, in chemistry; and one of you, in physics. The remaining group member is an experienced lab assistant and can align himself or herself with any one of the established fields already represented. You all have been gathered to investigate the composition and contents of a mysterious black box.

Role Descriptions:

In the role of the **biologist**, you may attempt to approach the problem from a biological standpoint and you are responsible for drawing the final sketch with input from all team members. You will be provided with graph paper and pencil for the sketch.

In the role of the **chemist**, after the team has decided how to proceed, you are responsible for writing the team's preplanned procedure on the index card provided, and you may attempt to approach the problem from a chemical standpoint.

In the role of the **physicist**, you may approach the problem from a mechanical viewpoint and you are the spokesman for the group when you present and defend your team's conclusions to the whole group. You also are a special consultant for measurement and scale issues.

In the role of the **lab assistant**, you can contribute to the investigation from a variety of perspectives and you are responsible for taking brief notes as the discussion proceeds and you are in charge of measurement and scale questions for the final sketch.

Team problem: Draw and label a description of the black box and its contents. Labels should identify its composition and component parts. The scale should fit within the 8 x 10 paper but should be approximately proportionate. Present your drawing to the class and defend your claims.

Rule #1: You may not penetrate the box in any way. (You may not poke a hole in it, rip the black paper off, unwrap any portion of it, drop it down a flight or two of stairs, pull tape off, or impale it "accidentally" on a pair of scissors, etc. etc. etc. ad nauseam.)

Rule #2: You may not microwave or x-ray the box. ☺

Rule #3: The box must remain in this classroom.

Rule #4: You will have no more than 20 minutes to complete your task.

Procedure for the Simulation:

Step one:

First, without touching the black box, look at the box closely and discuss with your team of scientists how to approach the problem. You may make a guess about its structure and contents before handling the box, or not, but devise a procedure to begin your investigation..

Step two:

Briefly list the steps in the plan of how you will conduct your investigation on one of the cards provided. The chemist will write out the plan, which can be in simple list form.

Step three:

*Following your plan, begin the investigation. The lab assistant may use measuring devices or make estimates of dimensions. Everyone on the team should make observations, contribute to the discussion, and draw conclusions about the contents and composition of the box and the lab assistant takes notes. *The chemist should revise and edit the team plan written on the card if you decide to add or delete any steps while you are making your investigation.

Step four:

Come to a consensus and in collaboration with each other assist the biologist in making a sketch of the box, including the interior structure and adding labeled details to give as clear a description of the box and its contents as possible.

Step five:

The physicist of each team displays the team's drawn description to the rest of the class and defends the choices the team has made.

Step six:

After all groups have presented, all student "scientists" will be given the opportunity to realign themselves with the group they believe has the most reasonable and most accurate description. The group with the largest number of converts will win the Most Convincing Scientist title. We will open the box, and the group that comes closest to the "truth," as determined by the teacher, will be declared overall winner.

Debriefing procedure for the teacher:

1. Display the 8 index cards with the words printed on them.

HYPOTHESIS LAW OBSERVATION
INDUCTION EXPERIMENT REPEATABILITY
MEASUREMENT THEORY

2. Ask the students if there are any of the words that are less familiar than others. If no one questions INDUCTION, ask someone to explain what *induction* is. (*Induction* is a word that may need clarification. *Induction* is a type of reasoning that draws a general conclusion from specific multiple trials, experiments, questionnaires, or surveys, etc.)

3. Ask the students if they can match components of the activity just completed with these words. Allow time for discussion.

Examples:

“Our group used a ruler to *measure* the box.” Or “We *repeated* the shaking of the box several times.” Or “We made a guess based on the sounds we heard, so that is somewhat like a *hypothesis*.” Etc.

4. Ask the students to identify the concept that the words are associated with. They should, at least, say *science*, but if no one offers the phrase *scientific method*, keep the discussion going until they come up with it.

Note: What you can add to the discussion if necessary.

When we refer to the Sciences we can be talking about a very broad range of inquiry. If we define science as seeking “to discover or formulate in general terms the conditions under which events occur in the world around us,” then we could include the observation of the rise and fall of air temperature, the rise and fall of stock prices, and the rise and fall of empires.” Using the term Natural Sciences has a rather more restricted meaning, “the study of the phenomena of the physical universe” or “physical reality” the Human sciences are somewhat different. Human sciences refer to the study of human behavior in a systematic way. But what distinguishes science from non-science is mostly methodology. A truly scientific hypothesis must be testable.

5. Ask students to put the words in a logical order to represent scientific methodology and to describe the process of scientific method using the words.

One reasonable arrangement of the terms follows:

Observation leads to the formation of a **hypothesis**,

Experiments are designed to test the hypothesis

Measurement and **repeatability** are usually part of the experiment’s procedure. Using **induction** from repeated experiment, scientists may develop a **theory**. After repeated trials that may take years to complete, the theory may be accepted as a scientific **law**.

Students can defend different arrangements and someone should bring up that observation is also an important part of experiments as well as forming the original hypothesis and that induction may be used to formulate the hypothesis as well. Collaboration that brings forward new information can alter the results and consequently the formation of theories.

Extension: For homework, complete one of the following two writing assignments:

1. Read the following quotation and in an essay critically evaluate this way of distinguishing the sciences from other areas of knowledge.

“What separates science from all other human activities is its belief in the provisional nature of all conclusions.” Michael Shermer, www.edge.com

2. Read the following letter from Mr. Jay Sommerville. Write a letter in response to his appeal for help in substantiating his claim that he has created a new science. Consider each of his arguments.

Bonnie P. McLaughlin



Dear Director of the Royal Academy of Sciences:

I am taking the liberty of calling upon you to be the judge in a dispute between me and an acquaintance who is no longer a friend. The question at issue is this: Is my creation, umbrellalogy, a science? Allow me to explain . . . For the past eighteen years assisted by a few faithful disciples, I have been collecting materials on a subject hitherto almost wholly neglected by scientists, the umbrella. The results of my investigations to date are embodied in the nine volumes which I am sending to you under a separate cover. Pending the receipt, let me describe to you briefly the nature of their contents and the method I pursued in compiling them. I began on the island of Manhattan. Proceeding block by block, house by house, family by family, and individual by individual, I ascertained (1) the number of umbrellas possessed, (2) their size, (3) their weight, (4) their color. Having covered Manhattan after many years, I eventually extended the survey to cover the other Boroughs of New York, and at length completed the entire city. Thus I was ready to carry forward the work to the rest of the state and indeed the rest of the United States and the whole known world.

It was at this point I approached my “friend.” I am a modest man, but I felt I had the right to be recognized as the creator of a new science. He, on the other hand, claimed that umbrellalogy was not a science at all. First, he said, it was silly to investigate umbrellas. Now this argument is false because science scorns not to deal with any object, however humble and lowly, even to the “hind leg of a flea.” Then why not umbrellas?

Next, he said that umbrellalogy could not be recognized as a science because it was of no use or benefit to mankind. But is not the truth the most precious thing in life? Are not my nine volumes filled with the truth about my subject? Every word in them is true. Every sentence contains a hard, cold fact. When he asked me what was the object of umbrellalogy, I was proud to say, “To seek and discover the truth is object enough for me.” I am a pure scientist: I have no ulterior motives. Hence it follows that I am satisfied with the truth alone.

Next, he said, my truths were dated and that any one of my findings may cease to be true tomorrow. But this, I point out, is not an argument against umbrellalogy, rather an argument for keeping it up to date, which exactly is what I propose. Let us have surveys monthly, weekly, or even daily, to keep our knowledge abreast of the changing facts.

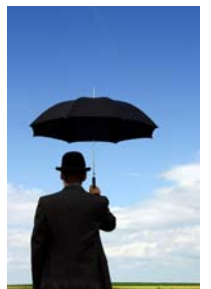
His next contention was that umbrellalogy had entertained no hypotheses and had developed no theories or laws. This is a great error. In the course of my investigation I employed innumerable hypotheses. Before entering each new block and each new section of the city, I entertained a hypothesis as regards the number and characteristics of the umbrellas that would be found there, which hypotheses were either verified or nullified by my subsequent observations, in accordance with proper scientific procedure, as explained in authoritative texts. (In fact, it is of interest to note that I can substantiate and document every one of my replies to these objections by numerous quotations from standard works, leading journals, public speeches of eminent scientists and the like.)

As for theories and laws, my work represents an abundance of them. I will here mention only a few, by way of illustration. There is the law of Color Variation Relative to Ownership by Sex. (Umbrellas owned by women tend to great variety of color, whereas those owned by men are almost all black.) To this law I have given exact statistical formulation (See Volume 6 Appendix 1, Table 3, page 582.) There is also the Law of Tendency Towards Acquisition of Umbrellas in Rainy Weather. To this law I have given experimental verification in Chapter 3 of Volume 3. In the same way, I have performed numerous other experiments in connection with my generalizations.

Thus I feel that my creation is in all respects a genuine science, and I appeal to you for substantiation of my opinion.

Sincerely,

Jay Sommerville



Reflection:

Research supports using advanced curricula for the gifted in core areas of learning at an accelerated rate. The curricular elements of this lesson plan are from the Theory of Knowledge course guidelines within the International Baccalaureate Program requirements for IB Diploma students. Theory of Knowledge meets the level of rigor that can challenge the gifted because it is an interdisciplinary course designed as a college level seminar class that encourages serious reflection on how we know what we know and how we justify and verify information within the different areas of knowledge. A major objective of the course is to critically analyze knowledge claims, their underlying assumptions and their implications. The context of the lesson would be placed early in the introduction of a unit on the Natural Sciences as an area of knowledge. I chose to develop the strategy of the lesson as a simulation. According to Dorothy Sisk in *Methods and Materials for Teaching the Gifted*, the interaction and task focus of simulation makes it appropriate and effective for gifted learners because simulation “provides for collective decision making; develops language skills; develops decision making skills; . . . and provides opportunities for experimenting with ideas.” (548). The benefits may also include fostering independent thought and personal responsibility while engaging in group dynamics that require them to question assumptions and listen to and evaluate diverse opinions. (550) The lesson provides the aforementioned qualities by calling on the students to play the role of someone in the field of science, by requiring interaction and collaborative decision making on the “experiment” procedure and the solving of the mystery, and by asking them to reevaluate their assumptions in light of input from other groups.

After having my junior class of TOK students complete the lesson, I was gratified to see that the lesson plan did provide joy in the role play aspect and the students had fun handling the mysterious box and solving a mystery of the unknown. One group asked if they could go to their chemistry class and retrieve their white coats and goggles. They took the simulation to a new level and won the Convincing Scientists Award very easily. They even retrieved a cardboard box out of the trash to do additional trials to notice the sounds of different size coins within the box. In another group, a student adopted an accent for his physicist’s explanation to make it sound more scholarly. All were really anxious and excited for the opening of the box portion of the game. The rigor emerged in the need to make a reasonable plan and in the critical thinking necessary for solving the problem and defending the solution. They used mathematical calculations to estimate the circumference of the sphere. They questioned each other’s group spokesman with valid and probing questions. The rigor continued in the discussion of scientific methods and in the evaluative stage represented by the writing assignments. I was pleased that the students related the simulation to their articulation of the scientific method and how method shaped their research and conclusions.

I chose simulation for its recommendation as an effective strategy for gifted learners and because the introduction of the unit on scientific knowledge could be dry and less appealing if handled with readings and lecture. I considered Socratic Seminar but the nature of the topics were not provocative enough to stimulate engaging dialogue in the introductory stage. I felt that “the game” aspect of the simulation is an attention-getter and would arouse interest in the subject. I would revise one aspect of the simulation. The students’ drawings of the box were not as detailed as I would have liked in some cases. I think I would give a sample of a drawing of a different container with labeled parts to give them a better idea of what I expect for that portion of the assignment. I would also give the groups additional time for the drawing and reserve all of the twenty minutes for the observations, small group discussion, and note taking.