Mystery Tubes

A Black Box Activity for Exploring the Nature of Scientific Knowledge

Maryland Loaner Lab Teacher Packet

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Mystery Tubes Loaner Lab Overview

The Mystery Tubes Loaner Lab is designed to give students an opportunity to explore some of the characteristics of scientific knowledge. Students who participate in the Mystery Tubes activity will be actively engaged in the same scientific and engineering practices that scientists use every day. The Mystery Tubes activity is a way to explicitly address how scientists work and how scientific knowledge is developed. An understanding of these processes is necessary for students to become scientifically literate and is an important instructional goal in both current Maryland science standards, as well as the newly adopted Next Generation Science Standards.

The goals of the Mystery Tube activity include understanding:

- how scientists construct explanations for phenomena they cannot see directly
- that science is empirical and that data and evidence are what allow scientists to be confident in their understandings and explanations
- how scientific knowledge is tentative, yet durable
- how and why scientists develop and use models

This version of the Mystery Tube activity was adapted from a previous version found in *Teaching about Evolution and the Nature of Science* (1998), pp 22-25, published by the National Academy of Sciences.

Maryland Standards

Table 1 lists the standards from the Maryland State Curriculum for Grades 6-8 covered in the Black Box Maryland Loaner Lab activity.

Table 1. Standard 1.0 Skills and Processes for grades 6-8.

A.1.a	Explain that scientists differ greatly in what phenomena they study and how they go about their work.
B.1.a	Verify the idea that there is no fixed set of steps 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.
B.1.b	Explain that what people expect to observe often affects what they actually do observe and that scientists know about this danger to objectivity and take steps to try to avoid it when designing investigations and examining data.
B.1.c	Explain that even though different explanations are given for the same evidence, it is not always possible to tell which one is correct.
B.1.d	Describe the reasoning that lead to the interpretation of data and conclusions drawn.
B.1.e	Question claims based on vague statements or on statements made by people outside their area of expertise.
C.1.c	Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
C.1.d	Criticize the reasoning in arguments in which •Fact and opinion are intermingled. •Conclusions do not follow logically from the evidence given. •Existence of control groups and the relationship to experimental groups is not made obvious. •Samples are too small, biased, or not representative.
C.1.e	Explain how different models can be used to represent the same thing. What kind of a model to use and how complex it should be depend on its purpose. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering
C.1.f	Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
D.3.a	Explain that the kind of model to use and how complex it should be depends on its purpose and that it is possible to have different models used to represent the same thing.
D.3.b	Explain, using examples that models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.
D.3.c	Explain that models may sometimes mislead by suggesting characteristics that are not really shared with what is being modeled.

Table 2 lists the standards from the Maryland State Curriculum for Grades 9-12 covered in the Black Box Maryland Loaner Lab activity.

Table 2. Goal 1.0 Skills and Processes for Grades 9-12

1.1.2	The student will modify or affirm scientific ideas according to accumulated evidence.
1.1.3	The student will critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
1.1.5	The student will explain factors that produce biased data (incomplete data, using data inappropriately, conflicts of interest, etc.)
1.2.3	The student will formulate a working hypothesis.
1.2.4	The student will test a working hypothesis. (NTB)
1.4.2	The student will analyze data to make predictions, decisions, or draw conclusions.
1.4.8	The student will use models and computer simulations to extend his/her understanding of scientific concepts.
1.4.9	The student will use analyzed data to confirm, modify, or reject a hypothesis.
1.5.1	The student will demonstrate the ability to summarize data (measurements/observations).
1.5.2	The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.
1.5.4	The student will use tables, graphs and displays to support arguments and claims in both written and oral communication.
1.5.5	The student will create and/or interpret graphics. (scale drawings, photographs, digital images, field of view, etc.)

Next Generation Science Standards

Table 3 details how the Black Box Maryland Loaner Lab activity is aligned with and supports the Next Generation Science Standards.

Table 3. Next Generation Science Standards

<table>
<tr><th>Scientific and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>• Asking Questions and defining problems
• Developing and using models
• Planning and carrying out investigations
• Analyzing and Interpreting data
• Constructing Explanations and Designing Solutions
• Engaging in Argument From Evidence
• Obtaining, Evaluating, and Communicating Information</td><td>• This is a decontextualized Black Box activity, which by definition does not address disciplinary core ideas directly. Rather, it focuses students' attention on how scientific knowledge is developed (see Dimensions 1 and 2).</td><td>• Patterns
• Cause and effect: Mechanisms and explanations
• Systems and system models
• Structure and function</td></tr>
<tr><td colspan="3"><u>Nature of Science:</u>
• Scientific investigations use a variety of methods
• Scientific knowledge is based on empirical evidence
• Scientific knowledge is open to revision in light of new evidence
• Science models, laws, mechanisms, and theories explain natural phenomena
• Science is way of knowing
• Science is a human endeavor</td></tr>
<tr><td colspan="3"><u>Connections to Engineering, Technology, and Applications of Science:</u>
Not applicable.</td></tr>
<tr><td colspan="3"><u>Connections to Common Core State Standards in Math and English Language Arts:</u>
<u>ELA/Literacy:</u>
CCSS.ELA-Literacy.CCRA.SL.1   CCSS.ELA-Literacy.CCRA.SL.4
CCSS.ELA-Literacy.CCRA.SL.2   CCSS.ELA-Literacy.CCRA.SL.5
CCSS.ELA-Literacy.CCRA.SL.3   CCSS.ELA-Literacy.CCRA.SL.6
<u>Math:</u>
Not applicable</td></tr>
<tr><td colspan="3"><u>Performance Expectations:</u>
This activity will serve to support students as they engage in Performance Expectations that utilize the following scientific and engineering practices:
• Asking questions and defining problems
• Developing and using models
• Planning and carrying out investigations
• Analyzing and interpreting data
• Constructing explanations and designing solutions
• Engaging in argument from evidence
• Obtaining, evaluating, and communicating information</td></tr>
</table>

Grade Level and Time Required

- Appropriate for grades 6-12
- 45 – 90 minutes required to complete activity

Equipment and Supplies

Table 4. Materials supplied by the Maryland Loaner Lab Program

Description	Quantity	Must be Returned?
Mystery Tubes	10	Return. Do NOT open Mystery Tubes.
Cardboard Rolls	15	No
String	1 ball	Return any unused portion.
White Boards	10	Return. Please wipe clean.
Dry-erase Markers	10	Return
Scissors	10	Return

Table 5. Materials supplied by the Teacher

Description	Quantity	Comments
Copy of Student Worksheet	1 per student	2-page student handout provided. Pages S-1 and S-2 in this binder.

Teacher Introduction to the Mystery Tubes Activity

When focusing heavily on content and memorizing definitions in science class, students can come to view science as a static collection of facts with nothing new left to learn. 'Black Box' activities can be used in science education to engage students in learning about the nature of scientific knowledge, allowing them to see science as it really is - a dynamic enterprise, filled with diverse, creative people all working toward a greater understanding of how the world around us works.

Black Box activities are so named because they mimic a scientist's search for an explanation for a natural phenomenon that they cannot see directly, either because it is too small, too large, or otherwise inaccessible to their senses. A few examples include figuring out the structure of the atom, determining what the center of the earth is made of, or understanding how chemical reactions take place. In these cases, scientists must rely on indirect evidence that they can gather with their senses or extensions of their senses (such as microscopes).

An important aspect of science, and one that is highlighted by Black Box activities, is that scientists cannot 'check their answer'. There is no back of the book in science, no authority figure 'grading' answers. But if that is the case, how do scientists know when they are on the right track? How can we ever be certain about something if we cannot see it (or otherwise sense it) directly? Does this mean that scientists can never be confident of their understandings and explanations? No! While it is true that scientists cannot directly observe every phenomena, the empirical nature of scientific knowledge requires that there be evidence that support their conclusions. In cases where scientists cannot directly observe (or otherwise sense) a phenomena, they can, and do, rely on indirect evidence.

Take Ernest Rutherford's Gold Foil experiment, developed to explore the structure of an atom. While Rutherford was not able to directly observe the inside of an atom, his clever experiment allowed him to infer the existence of a nucleus by observing the pathways of small alpha particles as they were directed at a thin film of gold. Using indirect evidence (flashes of light on photographic film indicating the pathways of these alpha particles), he inferred that some of these particles did not pass directly through the gold foil, but rather were deflected. This observation led him to propose the new idea that there was a 'charge concentration' at the center of the atom, what we now call the nucleus. After coming to this conclusion, Rutherford could not simply check to see if he had the right answer. Instead, he shared his findings with the scientific community, where additional evidence could be gathered and his idea could continue to be tested.

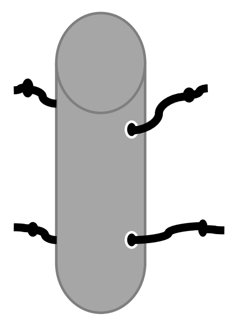
Scientists use evidence as a measure of 'correctness'. As new evidence arises, it is examined in the context of current explanations. The more evidence in support of an idea, the more certain scientists are in their conclusions. If evidence contradicts or otherwise does not support an idea, that idea is open to revision. The idea that scientific ideas are tentative (open to revision in light of contradictory evidence), yet durable (due to the weight of supporting evidence) is a great strength of science and an important concept for students to explore and understand.

Sometimes in science there is more than one explanation that is supported by the evidence. In this case, scientists may disagree about which explanation is best. Many things can affect which explanation they may accept, including their previous scientific training. Many people find this surprising, as scientists are often described as objective. But science is a human endeavor, and as such cannot help but be affected by an individual's own experience. While not all scientists will interpret data in exactly the same way, this does not mean that any idea is acceptable in science. Scientists must be able to make a sound argument, backed up by evidence, as to why and how they have interpreted data to form their conclusions.

Developing and using models has been identified in *A Framework for K-12 Science Education* (the foundational document upon which the Next Generation Standards were developed) as one of the main Scientific and Engineering Practices. The *Framework* describes conceptual models as "explicit representations that are in some ways analogous to the phenomena they represent" and state that they "…allow scientists and engineers to better visualize and understand a phenomenon under investigation or develop a possible solution to a design problem" (p. 56). Examples of models include physical representations, mathematical representations, and computer simulations.

Scientists use models in science for several reasons. They may use them to explain, or convey information, such as in the case of a physical model depicting the earth's core, the solar system, or a strand of DNA. This is likely the use of models that your students are most familiar with, and have the most practice using.

But scientists also use models for another purpose: to make and test predictions. For example, scientists may create a computer model to make predictions about what the weather will be like next week, or what the climate was like in the past. Ernest Rutherford created a basic atomic model that he used to test his predications about atomic structure in his famous Gold Foil experiment. Geneticists use the model of inheritance developed by Gregor Mendel to make and test predictions about allele frequencies. Using models in this way (to make and test predictions) is likely something that your students are less familiar with, and have less practice doing. In the Mystery Tube activity, students will create both a paper-and pencil model, as well as build a physical model that will allow them to test their initial explanation of the inner workings of a Mystery Tube.



In this activity, the Black Box is a Mystery Tube. Students are challenged to come up with a mechanistic explanation as to how the tubes are constructed, but they cannot see directly into the Mystery Tube. One way to develop an explanation of how the Mystery Tube works is to create and build a model of the Mystery Tube, which students can then use to test their proposed explanation of how the Mystery Tube is constructed. If the model behaves in the same way the Mystery Tube behaves (i.e. you get identical results when you perform identical actions on the model and the actual Mystery Tube) then their explanation is supported by the evidence. If their data do not support their proposed explanation, they can conclude that their proposed explanation of how the tube is constructed is likely not accurate. Please note that we purposefully do not provide information as to how the Mystery Tubes are constructed, as one of the goals of this activity is for students to explore and understand how scientists can be confident in their answers when they cannot check to see if they have the 'right' answer. Students (and teachers) should not open the Mystery Tubes at any point during or after this challenge.

Resources

For more information on the nature of scientific knowledge and scientific modeling, check out the following resources.

Nature of Scientific Knowledge

Understanding Science Website

Available on line at: http://undsci.berkeley.edu/

Evolution and the Nature of Science Institutes

Available online at: http://www.indiana.edu/~ensiweb/

NSTA Position Statement on the Nature of Science

Available online at: http://www.nsta.org/about/positions/natureofscience.aspx and in 'Resources' section of binder.

Next Generation Science Standards, Appendix H: Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Available online at http://www.nextgenscience.org/next-generation-science-standards,

click on Appendix H: Nature of Science and in 'Resources' section of binder.

Models and Modeling in the Science Classroom

"Engaging Students in Scientific Practices: What does constructing and revising models look like in the science classroom? Understanding *A Framework for K-12 Science Education*"

Available online at: http://nstahosted.org/pdfs/ngss/resources/201203_Framework-KrajcikAndMerritt.pdf and in 'Resources' section of binder.

Models and Modeling: An Introduction

Available online at: http://tools4teachingscience.org/pdf/primers/Models%20and%20Modeling-%20An%20Introduction.pdf and in 'Resources' section of binder.

"A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas"

Free pdf download available online at: http://www.nap.edu, type "*A Framework for K-12 Science Education*" in search bar.

Preparation Before Class Begins

Material preparation before students arrive:

- Have a plan for placing students in 10 groups (2-4 students/group)
- Have a white board and dry-erase marker available for each group
- Have the following ready for each group to access when it comes time to make a physical model of the Mystery Tube:
    - At least 1 paper roll per group (you have a few extra if groups need more than one)
    - Pair of scissors for each group to cut pieces of string
    - String
- One copy of the student worksheet "Mystery Tubes Student Worksheet" for each student

Mystery Tube Activity Facilitation Guide

- Pass out Mystery Tubes to each group of students (2- 4 students per group). Tell the students to examine the Mystery Tube. Encourage them to pull on the strings and observe how the Mystery Tube responds. Tell students they cannot open the Mystery Tubes.

- Next, ask the students to work together within their groups to explore and discuss how they think the Mystery Tube works. That is, what does the internal construction of the Mystery Tube look like?

- Have each student draw a model (diagram) on their student worksheet that depicts what they think the inner workings of the Mystery Tube look like. The model should include any labels, arrows, descriptions, etc. necessary to clearly communicate the group's ideas. Students should be encouraged to share ideas within their groups, but it is not necessary that they all come up with an identical model.

- At this point, ask your students how confident they are in their explanation for how the tube works. Ask them *why* they are, or are not, confident in their explanations. Some students will likely say they are very confident, but will not have a good scientific reason why they are confident. They may say because they "just know theirs is right" or that they "guessed" or that "other people have the same explanation, so it must be right". During this discussion, it is important to connect what the students are doing (looking for an explanation for how the Mystery Tubes are built) to what scientists do (seek mechanistic explanations for natural phenomenon). You can challenge students to think about what makes scientists confident in their conclusions (the amount of data and evidence that support their explanations).

- After discussing how confident the students are in their models, ask them if there is anything else they can do that might increase their confidence in their current explanation. They may come up with different ways (ask other people, look up information on the web, etc.). Ask them if they can think of any ways they could generate data to evaluate their model. The idea you would like them to get to is that they can build a physical model of the Mystery Tube that will allow them to test and see if it behaves similarly to the actual Mystery Tube.

- At this point, you will want to take advantage of the opportunity to explore with your students how and why scientists use models (see Teacher Introduction and Resource section for information on this topic). You can begin the discussion by asking students to think about and discuss the following questions:
    - What is a model in science?
    - How and why do scientists use models?
    - Can you think of at least three examples of models used by scientists?

  We suggest using a discussion technique that allows the students opportunities to think about their own ideas, listen to and hear about their peers ideas, and encourages discussion, questioning and debate amongst and between the students (not just with the teacher). Be prepared to help facilitate this discussion by asking probing questions, asking for clarification and challenging them to think more deeply. See the 'Discussion Techniques' section of the binder for a variety of discussion techniques you may choose to use.

- After students have had a chance to explore the role of models in science, provide students materials to build a physical model they can use to test if their proposed explanation for the inner construction of the Mystery Tube behaves in the same way as their actual Mystery Tube. We have provided basic materials, including paper rolls, string and scissors. You may choose to allow the students to use other materials (e.g. tape, washers, paper clips, etc.) but they should be able to design a functional model with the basic materials provided. Encourage them to work as a group and share and discuss ideas as they work to build their model to test their explanation.

- After groups have had time to build their model and test (maybe re-test if they made changes) their explanations, ask them to draw any changes or refinements they made to their original diagram on their student worksheet. Again, it is important to keep connecting this activity to science and how science works, so you might ask them if, how and why scientists might change their models. For example, scientists may change or alter a model if there is new relevant information, or if their tests did not accurately predict how the phenomenon being modeled behaved.

- Sometimes a group will very quickly build and test a model and say they are done. Challenge them by asking if their model is the only model consistent with the actual Mystery Tube. Have them come up with, and test, alternative models to see if there may be more than one possible explanation. Connect this to science by asking them to consider and discuss how scientists consider multiple explanations for the same phenomena.

- Once all groups have had sufficient time to design, test, (re-design and re-test if necessary), pair two groups together and have them present and defend their explanation to each other, using the physical models they created as evidence for their explanations.

- Finally, have each group share their final model that depicts how they think the Mystery Tube is constructed by drawing their final model on the group white board and displaying somewhere where everyone in the class can view it. It is very likely that there will be differing explanations as to how the Mystery Tube is actually constructed. If there are (and even if there are not), this is an excellent opportunity to ask the students which one is "right". This will likely lead into a lively discussion, often with students wanting to open the Mystery Tubes to see what the right answer is (which they cannot do!). The goal is to facilitate the discussion to cover the following points:

    - How do scientists know when an explanation is "right"? Can scientists 'open the tube' or go to the back of the book to check their answers?

        - *Scientists cannot 'check' their answers in the same sense that many students are able to do when they complete a homework assignment or get graded on a test. In science, "correct" answers are determined by how well the data and evidence support or explain the phenomena. More supporting evidence lend more weight and more confidence to an explanation. Evidence that contradicts, or does not support an explanation can lead to an idea or explanation being rejected. Scientists seek confirmation from multiple lines of evidence when evaluating an explanation or idea.*
        - *At this point, many of your students may become frustrated that they are not allowed to open the Mystery Tubes. This is very common, and can serve as a powerful teachable moment. So many activities that students do in science class have a 'right' answer and this can lead to a naïve view that there is a single correct answer in science. It also can leave students feeling that there is little room for creativity and new ideas in science, a naïve view that may lead to a lack of interest in pursuing science as a field of study or possible career path.*

    - How do scientists evaluate differing explanations for the same phenomena? In other words, what if there are multiple explanations that are supported by evidence? For example, in the case of the Mystery Tubes, what happened in class if there were two different explanations, supported by evidence generated from the physical models as to how they were constructed?

- *Scientists evaluate the data, evidence and reasoning provided for each explanation and choose the explanation they feel provides the strongest argument. Sometimes, scientists may disagree about which explanation is the strongest, as they may have different perspectives, or consider different evidence and reasoning. Scientists may continue to disagree, or may change their mind and support a different explanation if new evidence (or new ways of interpreting the same evidence) are found. Scientists also often apply the rule of parsimony when evaluating explanations and ideas. Parsimony is the idea that a simple explanation is often accepted as more likely than a more complex explanation.*

Wrap-up and Assessment

Ask students to complete the Mystery Tube Reflection Questions (page S - 2). This can be done in class, or assigned as homework.

Once students have had a chance to individually answer the questions, put the students in small groups (these can be different from the groups they worked with earlier in the activity). Ask the students to share and discuss their responses. See the 'Discussion Techniques' section of the binder for ideas to help facilitate and encourage discussion among the students.

Collect the students written responses and use them to formatively assess your students' understanding of the nature of scientific knowledge. As with any concept you are trying to teach, it is important to know your students current level of understanding. You might notice that despite having just engaged in the Mystery Tubes activity that is meant to convey informed ideas about the nature of scientific knowledge, your students still struggle to answer these types of questions, or answer with naïve conceptions. Don't be discouraged! Students need lots of opportunities to think about these ideas and come to their own understanding. A one-time discussion about the empirical nature of scientific knowledge or the role of models in science is not going to be enough for students to really understand these concepts.

Continue to follow-up and circle back to these ideas about the nature of scientific knowledge throughout the school year. Whenever possible, introduce real-life science examples that illustrate some of these ideas. For example, popular news will often have stories of new discoveries in science that were unexpected or contradicted previous findings. These stories provide excellent opportunities for students to explore the idea that science it is tentative (but durable). The next time students are using models (in another assignment or lab activity), ask them to reflect on how they are using models and how it is similar to what scientists do. This will allow the students more opportunities to think not only about scientific content and 'facts' but also about the way in which this knowledge was developed.

Student Worksheet Answers: Mystery Tube Reflection Questions

1. How do scientists know when they have a 'right' answer?

Informed answers may include the following:

- *Scientists rely on data and evidence.*
- *The strength of scientific explanations and arguments increase as the amount of supporting evidence increases.*
- *Multiple lines of evidence increase scientists' confidence in their explanations.*

Naïve answers may include the following:

- *Scientists are able to definitively check their answer.*
- *Science is a democratic process and the number of scientists supporting an idea (as opposed to the strength of the evidence) determines which ideas are correct in science.*
- *Scientists can definitely prove an answer, and once proven, that idea can never be questioned or changed.*

2. Can scientific ideas ever change? Explain why you think they do or do not. Make sure to include at least one example to support your answer.

Informed answers may include the following:

- *Because science is empirical, all scientific ideas are open to revision based on new evidence and/or new ways of interpreting existing evidence.*
- *The tentative nature of scientific knowledge is a strength, not a weakness, as it means science is always open to finding the best explanation (the one with the most evidence) for a phenomena.*
- *There are many possible examples of science changing.*

Naïve answers may include the following:

- *Scientific knowledge can be proven, and once proven, will never change.*
- *The tentative nature of science is a weakness.*

3. An important scientific practice is developing and using models. Give at least two ways in which scientists use models and include one real-world example of a scientific model.

Informed answers may include the following:

- *Scientists use models to communicate or explain ideas.*
- *Scientists use models to make and test predictions.*
- *See Teacher introduction for a few examples of models. There are many, many possible answers.*

Naïve answers may include the following:

- *Students may confuse scientific models with the common use of models (e.g. fashion, toy car models, etc.)*
- *While not a naïve answer per se, many might readily identify the use of models to explain or communicate ideas (e.g. a globe or a model of a cell made of different types of candy). More informed answers will also include using models to make and test predictions.*

4. How is what you did today similar to what scientists do? Give at least three ways in which it was similar and make sure to explain fully the connection between what you did in the Mystery Tube activity and what scientists do.

Answers may vary greatly and not all will be represented here. Some informed answers may include the following:

- *Sought evidence (from the model they constructed) to support a tentative explanation (their original idea of how the Mystery Tube was constructed).*
- *Worked as teams, and shared and communicated ideas.*
- *Engaged in argument from evidence (used data from the model to support their argument for how the Mystery Tube was constructed).*
- *Developed and used a model (cardboard tube with strings) to make and test predictions (of how the Mystery Tube was originally designed).*
- *Refined original idea (first explanation of how Mystery Tube worked) based on data and evidence from a model.*
- *Sought an explanation for a phenomena (how is the Mystery Tube constructed).*
- *Could not check answer (cannot open tubes), but instead had to rely on evidence in deciding what the best explanation (how the tube was constructed) was.*
- *Analyzed and interpreted data (compared how the model tube behaved compared to the Mystery Tube).*

Naïve answers may include the following:

- *Students might struggle to connect this somewhat artificial activity (they might view it as more of a game or silly challenge) with actual scientific practices. To address this, teachers can make explicit efforts throughout the school year to connect more contextualized science activities (labs they do, or readings about science discoveries) to the types of processes they engaged in while completing this activity.*

Mystery Tubes Student Worksheet

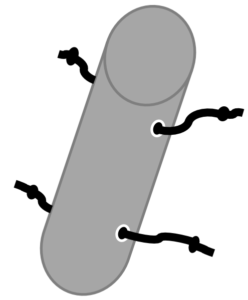
Name:____________________

1. Draw a model (diagram) of how you think the Mystery Tube is constructed.

2. Use the space below to write your ideas (and notes from your class discussion) about what a scientific model is, and how and why scientists use models.

3. Draw your final model in the box below that represents your explanation for how the Mystery Tube is constructed.

Mystery Tubes Reflection Questions



1. How do scientists know when they have a 'right' answer?

2. Can scientific ideas ever change? Explain why you think they do or do not. Make sure to include at least one example to support your answer.

3. An important scientific practice is developing and using models. Give at least two ways in which scientists use models and include one real-world example of a scientific model.

4. How is what you did today similar to what scientists do? Give at least three ways in which it was similar and make sure to explain fully the connection between what you did in the Mystery Tube activity and what scientists do.

Discussion Technique

Discussion techniques collection and summary provided by science coaches in Prince George's County Public School System.

Socratic Seminar

Background Information:	Socratic Seminars are the result of the work of Mortimer Adler, Director of the Institute for Philosophical Research in Chicago. Adler published *The Paideia Proposal* (1982) and *Paideia Problems and Possibilities* (1983) in which he argued that education should be rooted in three goals: the acquisition of knowledge, the development of intellectual skills, and the enlarged understanding of ideas and values. The Socratic method of teaching is based on Socrates' theory that it is more important to enable students to think for themselves than to merely fill their heads with "right" answers.
Purpose:	To engaged students in intellectual discussion by responding to questions with questions, instead of answers. This method encourages the students to think for themselves rather than being told what to think.
How does this work?	**The Socratic Seminar consists of the four following elements:** A) The **Text-** The text is drawn from readings in science, literature, history, philosophy, works of art, or current events. The texts are chosen for their richness in ideas, issues, and values in a particular text. B) The **Question**- The opening question is open-ended. It has no right or wrong answer. A good opening question leads participants back to the text as they speculate, evaluate, define, and clarify issues involved. C) The **Leader**- The leader is a teacher or student. He/she has a dual role as leader and participant. This task is easier if the opening question truly interests the leader as well as the participants. D) The **Participants**- Good seminars occur when participants study the text closely in advance, listen actively and share-out. **NEXT…** •Please listen and look at each other when you speak. •One person speaks at a time. •Each person will have a chance to ask a question. •Respond to the person who asks the question. •Use evidence from the text to support yourself. •Always treat each other with mutual respect. *In Socratic seminars, students perform in a "variety of thought-demanding ways to explain, muster evidence, generalize, apply concepts, analogize, represent in a new way..." (Perkins 1993). In other words, they engage in active learning. The assumption is that when students actively and cooperatively*

Accountable Talk Moment: To facilitate further thinking and processing, Use accountable talk moves and maneuvers to ask another student to build upon what a previous student shared.

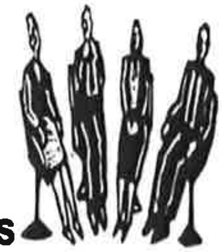
Discussion Technique

	develop knowledge, understanding, and ethical attitudes and behaviors, they are more apt to retain these attributes than if they had received them passively. *Students learn to paraphrase, defer, and take turns, as well as to deal with frustration when waiting. They do not raise their hands, but use body language, eye contact, and mutual respect to "read" the seminar process. Teachers in other classes report that students in these seminars exhibit these practices more frequently than do those who have not had the benefit of seminars.*
Classroom Arrangement	*Circle* 
When:	After Reading
Advantages:	• Time to engage in in-depth discussions, problem solving, and clarification of ideas • Building of a strong, collaborative work culture • Enhanced knowledge and research base • Increased success for all students • Teaching respect for diverse ideas, people, and practices • Creating a positive learning environment for all students
Source(s):	http://www.studyguide.org/socratic_seminar.htm http://www.talkscience.org.uk/techniques/6.aspx www.nwabr.org/education/pdfs/PRIMER/.../SocSem.pdf http://www.middleweb.com/Socratic.html

Accountable Talk Moment: To facilitate further thinking and processing, Use accountable talk moves and maneuvers to ask another student to build upon what a previous student shared.

Discussion Technique

Four Corners



Background Information:	Unknown
Purpose:	The Four Corners Discussion strategy offers an alternative to traditional debates. Instead of staking out and defending a position, a Four Corners Discussion encourages students to listen attentively to others and to reconsider their position based on new evidence or convincing arguments presented. The Four Corners Discussion encourages students to use evidence to support a point of view, carefully listen to other points of view and remain open-minded as they reflect on the evidence and arguments presented.
How does this work?	Label each corner of the classroom with one of the following labels (ex. This can be written chart paper.) 1.Strongly Agree 2.Agree 3.Disagree 4.Strongly Disagree Provide the class with a statement on a pertinent issue. (Ex. Do you believe that Global Warming Exists?) Invite students to consider the statement and then move to a corner of the room that best represent their position on the issue. Ask students to turn to one another in their corner and ask each partner to take 30 seconds to provide an explanation for his or her choice. If any student finds that his or her views are inconsistent with the group, he or she may want to consider moving to another corner. •Invite a student from the STRONGLY AGREE corner to explain why they chose that corner. •Remind students that they must support their position with accurate and relevant evidence and must be consistent in their position. •Continue this pattern until students from all four corners have made statements •Continue the discussion by invited students from all corners to join the discussion. *REMIND students that are encouraged to change corners if they hear new evidence or convincing arguments that cause them to alter their point of view.*

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Discussion Technique

Classroom Arrangement	Create four in the classroom and place one title for each corner: STRONGLY AGREE, AGREE, DISAGREE and STRONGLY DISAGREE.
When:	At anytime during the lesson.
Advantages:	Encourages students to be open-minded, actively listen and use evidence to defend their position.
Source(s):	http://vels.vcaa.vic.edu.au/support/tla/collab_strategies.html http://www.beesburg.com/edtools/glossary.html www.ece.gov.nt.ca/.../Four%20Corners/Four%20corners%20discussion.doc http://www.learnalberta.ca/content/sssm/html/fourcornersdiscussion_sm.html

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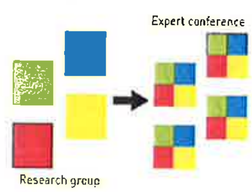
Discussion Technique

Marketplace

Background Information:	Unknown
Purpose:	This technique is a great way of using small group discussion to disseminate a large amount of information to the whole class. Making students 'experts' on one particular area of a topic means that they all have relevant information to contribute to the discussion. The technique allows for a wide range of activities to be used to assimilate the different viewpoints including creating posters, short films on mobile phones and short role plays.
How does this work?	• The class is divided into 4–6 research groups. • Each research group is given information about the topic, from a specific subtopic or viewpoint, e.g. different cloning methods. • Each group's members research and discuss their allocated area and become 'experts' on their topic. • The groups are rearranged to create new groups with one representative from the original groups, forming an expert conference. • The 'experts' share and discuss their research with each other, so that by the end everybody has information from all topic areas. • If there is time, an open discussion can take place to involve the whole class.
Classroom Arrangement	
When:	During the lesson.
Advantages:	The 'Marketplace' or 'Envoy' is a good format to use when there are several different angles or ideas to be explored.
Source(s):	http://www.talkscience.org.uk/techniques/6.aspx

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Discussion Technique

Jigsaw/Carousel

Background Information:	The jigsaw technique was first developed in the early 1970s by Elliot Aronson and his students. The Jigsaw Strategy is an efficient way to learn course material in a cooperative learning style.
Purpose:	Jigsaw learning allows students to be introduced to material and yet maintain a high level of personal responsibility. The purpose of Jigsaw is to develop teamwork and cooperative learning skills within all students.
How does it work?	1. Divide students into 4, 5, or 6 person jigsaw groups. 2. Appoint one student from each group as the leader. Initially, this person should be the most mature student in the group. 3. Divide the lesson into 5-6 segments. For example, if you want science students to learn about Cells, you might divide a short passage about organelles into several parts: (1) mitochondria (2) endoplasmic reticulum, etc. 4. Assign each student to learn one segment, making sure students have direct access only to their own segment. 5. Give students time to read over their segment at least twice and become familiar with it. 6. Form temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment. Give students in these expert groups time to discuss the main points of their segment and to rehearse the presentations they will make to their jigsaw group. 7. Bring the students back into their jigsaw groups. 8. Ask each student to present his/her segment to the group. Encourage others in the group to ask questions for clarification. 9. Float from group to group, observing the process. If any group is having trouble (e.g., a member is dominating or disruptive), make an appropriate intervention. Eventually, it's best for the group leader to handle this task. 10. At the end of the session, assess the students' knowledge.
When:	During cooperative groups.
Advantages:	The jigsaw process encourages listening, engagement, and empathy by giving each member of the group an essential part to play in the academic activity. Group members must work together as a team to accomplish a common goal; each person depends on all the others. This cooperation by design" facilitates interaction among all students in the class, leading them to value each other as contributors to their common task. Using the jigsaw teaching strategy is one way to help students understand and retain information, while they develop their collaboration skills. Students often feel more accountable for learning material when they know they are responsible for teaching the content to their peers.
Source(s):	http://www.jigsaw.org/ http://olc.spsd.sk.ca/de/pd/instr/strats/jigsaw/

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Discussion Technique

Think-Pair-Share

Background Information:	**Think-Pair-Share** is a cooperative discussion strategy developed by Frank Lyman and his colleagues in Maryland. It gets its name from the three stages of student action, with emphasis on what students are to be DOING at each of those stages.
Purpose:	Think-Pair-Share is helpful because it structures the discussion. Students follow a prescribed process that limits off-task thinking and off-task behavior, and accountability is built in because each must report to a partner, and then partners must report to the class.
How Does It Work?	**1) Think.** Stimulate/Provoke students' thinking with a question or prompt or observation. Give the students a few moments (not minutes) just to THINK about the question. Employ appropriate wait time (~15-30 seconds). **2) Pair.** Using designated partners, nearby neighbors, or a deskmate, have students PAIR up to talk about the answer each came up with. Have students compare their mental or written notes and identify the answers they think are best, most convincing, or most unique. **3) Share.** After students talk in pairs for a few moments (again, use appropriate wait time), ask for pairs to SHARE their thinking with the rest of the class. You can do this by going around in round-robin fashion, calling on each pair; or you can take answers as they are called out (or as hands are raised). Record student responses on the board or on the overhead.
When:	Note check, Vocabulary review, Quiz review, Reading check, Concept review, Lecture check, Outline Development, Discussion questions, Partner reading, Topic development, Agree/Disagree, Brainstorming, Simulations, Current events opinion, Conceding to the opposition, Summarize, Develop an opinion (http://olc.spsd.sk.ca/DE/PD/instr/strats/think/)
Advantages:	Quick, requires little teacher prep time, personal interaction with other students motivates interest in topic for discussion, varying levels of questions can be asked, engages the entire class at the same time and you can make formative assessments of students understanding in real time.
Source(s):	http://www.readingquest.org/strat/tps.html http://olc.spsd.sk.ca/DE/PD/instr/strats/think/

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Discussion Technique

<table>
<tr><td colspan="2"> Fish Bowl </td></tr>
<tr><td>Background Information:</td><td>A Fishbowl Discussion is a scholarly discussion of an essential question in which student opinions are shared, proven, refuted, and refined through dialogue with other students.</td></tr>
<tr><td>Purpose:</td><td>The purpose of a fishbowl discussion is to improve student critical thinking, reading, listening, and speaking skills.</td></tr>
<tr><td>How does it work?</td><td>The fishbowl discussion strategy involves one group of students (observers) looking in on another smaller group of students (participants) in a manner not unlike watching fish through the clear glass of an aquarium. The small group carries on a conversation about an issue or topic while the outside group listens and prepares questions and comments for whole class discussion that follows. These roles are frequently rotated so as to ensure all students play an active part in discussing, listening, and questioning.

Fish Bowl Discussion as a Participant
Assign 3-4 students a controversial topic.
Have those students become an “expert” on these subjects by reading, looking up pertinent information, etc. Each student may bring up to three note cards for reference. If they quote statistics, they must have the reference available for challenge. The students should be arguing for the side deemed most controversial.
The “experts” will form a circle in the center of the class and each will speak for three minutes on the topic.
Anytime after the three-minute speeches, an audience member may temporarily join the inner circle and pose a question or make a comment. The “experts” will need to be able to respond. They may use their notes.
Fish Bowl Discussion as an Observer
Have the class prepare two questions or comments on the topic for the day. Each observer will be allowed to contribute only two comments/questions per fish bowl session.
The observers will assess each participant using an appropriate rubric.</td></tr>
<tr><td>When:</td><td>During small group discussions.</td></tr>
<tr><td>Advantages:</td><td>An advantage of a fishbowl conversation is that it is suitable for whole-class participation.</td></tr>
<tr><td>Source(s):</td><td>http://www.fcpsteach.org/docs/Fishbowl%20Discussion.doc
http://jove.geol.niu.edu/faculty/kitts/GEOL401/DiscussTechniques.doc
http://cord.org/txcollabnursing/online_fishbowl.htm</td></tr>
</table>

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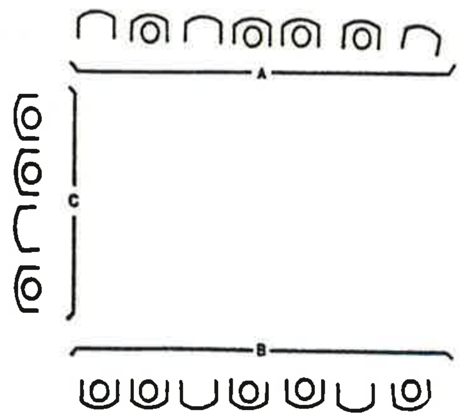
Discussion Technique

Philosophical Chairs

Background Information:	This model was developed by philosophy professor Zahary Seech and adapted for classroom use by Dale Fountain of Mount Tahoma High School in Tacoma, Washington.
Purpose:	This is a technique that allows students to critically think, verbally hold discussions and write their beliefs.
How does it work?	After a topic has been introduced and students have the opportunity to read, research and think. (This is a great technique for students that are kinesthetic learners.)
How does it work?	Two rows of chairs are set up, each row facing the other. A third row is then set up at one end of the first two rows, perpendicular to them. A statement is presented to the students. The statement must divide the class. There should be at least several students whose initial inclinations are to agree with the statement and several whose initial inclinations are to disagree.  As shown in the illustration to the right, students then seat themselves in Row A or Row B, depending on which side of the issue their inclinations dictate. Those who prefer to declare themselves undecided sit in Row C. Someone from the pro side begins the discussion with an argument in favor of that position. Then someone from the *con* side responds to that argument, explaining why it does not sway him or her. "Undecideds" are encouraged to state their concerns or reservations at any time. Anyone can change seats at will. When someone on the pro side finds his mind changed by the course of the discussion, he moves to a seat on the con side. The discussion and movement goes on for a specified period of time, perhaps one fifty-minute class period. Then the discussion might be just cut off wherever it is. Alternatively, each person might be given an opportunity to make a final statement about how he or she sees the current state of the discussion.
When:	During debates/issues such as: Evolution, Global Warming, or Stem Cell Research
Advantages	Philosophical Chairs includes a movement component, which can be particularly beneficial to some students who are kinesthetic learners.
Source(s):	http://www.sdcoe.net/lret/avid/Resources/Philosophical_Chairs.pdf http://www.crfc.org/pdf/chairs.pdf http://www.fremonths.org/ourpages/auto/2006/8/20/1156050858242/Philosophical%20Chairs%20format.doc

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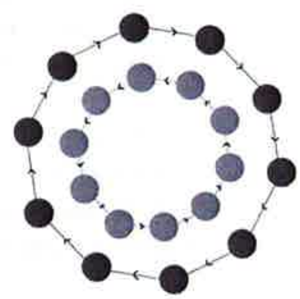
Discussion Technique

Just A Minute/Speed Dating

Background Information:	"Just a Minute" was adapted from a radio game show broadcast over the British Broadcasting Corporation (BBC). The strategy, "Speed Dating" that is used for classroom discussions was adapted from a Jewish tradition, established by Rabbi Yaacov Deyo in 1999.
Purpose:	To generate ideas focused on topics, practice dialogue, to ensure every student in a group participates/talks.
How does this work?	1. Develop appropriate questions/prompts. 2. Count off by two. Form an inner and outer circle in the middle of the classroom. 3. Have the outer circle turn and face the students in the inner circle and identify their partner. 4. Give the class the discussion question and use a timer to tell them when to start. 5. Let the conversation go from 2-5 minutes. 6. Rotate (the inner circle can move one step clockwise and the outer circle move one step counter clockwise to line-up with their new partner). Continue rotation until students end-up with the first partner. 7. Debrief with the class.  *Illustration A*
When:	After a topic has been introduced to the students or at the end of a lesson to summarize a topic.
Advantages:	Focuses on specific topics, raising questions and encouraging groups to solve problems through discussion.
Source(s):	http://www.talkscience.org.uk/techniques/7.aspx http://www.aisa.or.ke/_downloads/ZolaImprovingDiscussion.pdf

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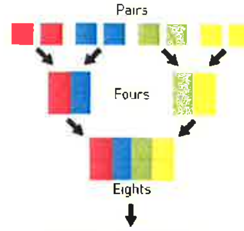
Discussion Technique

Snowball

Background Information:	Unknown
Purpose:	Snowball allows students to voice their opinions in smaller groups first and build-up in stages to a whole-class discussion.
How does this work?	Using key word or statement activities in which students have to reduce a list to the single most important word or statement that works extremely well with this technique. 'Snowball' is a good format to help quieter students voice their opinions in smaller groups and build up to a whole-class discussion. • To start, individuals should think about the topic before joining someone else to make a pair. • The pair then join another pair to make a four, and so on until the whole-class is back together. • Students can summarize their points.
Classroom Arrangement	
When:	Snowball can be used as a starter, a short activity to break up a lesson or as a plenary.
Advantages:	Snowball is a good technique to use with mixed ability classes and ESOL students because it allows them to talk and express their opinions in the safety of a smaller group. It is also a great way to encourage less confident students to participate.
Source(s):	http://www.studyguide.org/socratic_seminar.htm http://www.talkscience.org.uk/techniques/6.aspx

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