

# Science as Inquiry

Transparency #1/Hand-out #1

## Session Overview

In this session, participants assess their prior knowledge of the definition of Science as Inquiry, use two scenarios to gain a real-world understanding of the NLIST definition of Science as Inquiry, and finally participate in an activity that is then compared to the NLIST definition.

## SAI Session At-a-Glance

Phase of Instructional Model	Session Activity (Participants will: )	Suggested Time
Engage Learner connects past and present learning experiences and organizes own thinking toward learning outcomes of this session	Brainstorm and chart in responses to “How would you define Science as Inquiry?” Then, compare charted responses to NLIST’s definition.	15 minutes
Explore Concepts, processes, and skills are identified and developed	Participants read two real-world excerpts of Science as Inquiry and, in groups of 3-4, match up parts of the definition to examples in the excerpts.	20 minutes
Explain Learners demonstrate their conceptual understanding, process skills, or behaviors.	Discuss how the groups’ matched-up the definition to the two excerpts.	20 minutes
Elaborate Extend conceptual understanding and skills' new experiences allow for deeper understanding, more Information, and adequate skills.	Participate in a “hands-on” activity and then compare what occurred during that activity to the NLIST definition.	30 - 40 minutes
Evaluate Learners assess own understanding and abilities.	Discuss which parts of the definition of inquiry were present in this activity and which were missing based on their understanding of NLIST’s definition of Science as Inquiry.	20 minutes

**Intended Audience**

The intended audience is anyone who wishes to gain a further understanding of the operational definition of science as inquiry and its applicability to scientific investigations.

**Background Of Science as Inquiry Definition:**

An initiative entitled Networking for Leadership, Inquiry and Systemic Thinking (NLIST) was launched to facilitate the implementation of inquiry at the classroom level. The Council of State Science Supervisors (CSSS) and the National Aeronautics and Space Administration (NASA) sponsored this initiative jointly.

Over the period of one year beginning in March of 1999, working in both face-to-face meetings and through distance communication technologies, NLIST sponsored the Science as Inquiry Working Group (SIWG) to define "Science as Inquiry." The SIWG consisted of eleven members representing the Council of State Science Supervisors, The American Academy for the Advancement of Science, the National Science Teacher's Association, and the National Research Council.

The NLIST group devoted days of study and discussion to the effort of understanding the inquiry process and to identify appropriate inquiry outcomes for students in modern society. Beginning with the brief definition of inquiry science learning given in *Inquiry and the National Science Standards*, they synthesized current inquiry literature and crafted a definition for science inquiry that would serve as the foundation for the reform phases that constitute this professional development package.

This definition embodies an operational description of inquiry science learning, increasing the chances that all stakeholders may understand it. The definition also contains a delineation of ways to demonstrate the successful attainment of inquiry teaching and learning. After months of construction work, the definition underwent review by individual experts and through focus groups at the NASA Langley Research Center in Hampton, Virginia. The final version of the definition is given below:

Inquiry is the process scientists use to learn about the natural world. Students can also learn about the world using inquiry. Although they rarely discover knowledge that is new to humankind, current research indicates that students engaged in inquiry discover knowledge new to themselves.

Student inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of the student's experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanation, and predictions; and communicating the results. Inquiry requires of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

As a result of participating in inquiries, students will increase their understanding of the science subject matter investigated, gain an understanding of how scientists study the nature world, develop the ability to conduct investigations, and develop the habits of mind associated with science (Beyers, 2001) .

### **Grouping**

Participants will work individually, in groups of two to four, and as a large group.

### **Materials**

Copies of all hand-outs, chart paper/markers, overhead project/markers, transparencies, 10 different colors of narrow sticky notes, washers, string, metric ruler, watch with second hand, tape

Transparencies/Hand-outs:

- Session-at-a-glance
- PDWG other resources information sheet (this needs to be created by someone --- all pieces should contain this)
- Initial inquiry brainstorm activity (transparency or chart paper and hand-out for participants)
- NLIST definition of Science as Inquiry
- Inquiry in Science
- Inquiry in the Science Classroom
- Sticky note/NLIST Science as Inquiry key
- Section D of Instructional Materials Rubric
- Pendulum inquiry activity group data recording (transparency or chart paper)
- Pendulum inquiry activity t-chart

Facilitator's Resources:

- Inquiry in Science key
- Inquiry in the Science Classroom key
- Habits of Mind key

### **Procedure**

1. Welcome participants and review housekeeping items (norms, "parking lot" chart, breaks, location of restrooms and fire exits, etc.).
2. Share session overview. The session-at-a-glance (Hand-out #1/Transparency #1) can be used as an agenda for this session. Explain that this is one section of the Professional Development Working Group (PDWG) packet. Share the content explanations for the other sections (Hand-out #2/Transparency #2).

**Engage** – Learners connect past and present learning experiences and organize their thinking toward outcomes of current session.

3. Lead participants in a brainstorm with the following prompt:  
 “What are some common terms/phrases that describe science as inquiry?”
  - Chart responses. (Transparency #3 or chart paper)
4. Compare participants responses to the NLIST definition of Science as Inquiry (Hand-out #4/Transparency #4)

**Explore** – Concepts, processes and skills are identified and developed by the learner.

5. Participants, in groups of two to four, read an excerpt from *Inquiry and the National Science Standards* entitled *Inquiry in Science*. This is the description of a geologist’s search for the answer as to why an entire forest of cedar trees near a shore had died. (Hand-out #5/Transparency #5/Facilitator’s resource #2)
  - As participants read the excerpt they should place the colored sticky notes, which correspond to different parts of the NLIST definition of Science as Inquiry, onto the appropriate place on the hand-out.

**Explain** – Learners demonstrate their conceptual understanding, process skills, and behaviors.

- As a whole group go through the excerpt paragraph by paragraph and discuss where the different aspects of the definition are met.

**Explore** – Concepts, processes and skills are identified and developed by the learner.

6. Participants, in groups of two to four, read an excerpt from *Inquiry and the National Science Standards* entitled *Inquiry in the Science Classroom*. This is the description of a 5<sup>th</sup> grade class’s search for the answer as to why trees on the school grounds appeared to be dying while another flourished. (Hand-out #6/Transparency #6/Facilitator’s resource #3)
  - As participants read the excerpt they should place the colored sticky notes, which correspond to different parts of the NLIST definition of Science as Inquiry, onto the appropriate place on the hand-out.

**Explain** – Learners demonstrate their conceptual understanding, process skills, and behaviors.

- As a whole group go through the excerpt paragraph by paragraph and discuss where the different aspects of the definition are met.

7. Discuss “Habits of Mind” that can be identified in both scenarios using Section D of the Instructional Materials Rubric. (Hand-out #8/Transparency #8)  
 Habits of mind can be a difficult topic to teach but they should develop in an enduring form if they are presented in all elements of science teaching and modeled through classroom practice. As learners

experience the role of investigations and develop their inquiry skill they can be encouraged to practice habits of mind associated with science. When they study the way scientists do their work to better understand the role of inquiry in science they become aware of how scientists demonstrate the values and habits of mind associated with science. These values are interdependent and not mutually exclusive from the development of the other outcomes of inquiry. The variations in this section are based upon Bloom's taxonomy.

**Elaborate** – Extend conceptual understanding and skills; new experiences allow for deeper understanding, more information, and adequate skills.

8. Participants, in groups of two to four, take part in an inquiry-based activity, such as the one below.

Pendulum Inquiry-Based Activity: (Transparency #9 or chart paper/Hand-out and Transparency #10)

**Materials:** washers, string, ruler, watch with second hand, tape

- Participants, in groups of two to four people, construct a pendulum and count the number of swings of their pendulum in 15 second intervals. After each group completes 10 trials ask them to average their results and then have all of the groups come together and record their results on the transparency or chart paper. (The results should be very different among the different groups).

Do not give the groups any specific directions such as length of string, number of washers, or what constitutes one swing of a pendulum.

- After analyzing the results, ask the groups to hypothesize why there are differences. This should lead to a discussion of the need to follow some common agreed upon procedures e.g. length of string, number of washers, definition of a swing, etc...
- Give the groups time to experiment to come up with the answer to “What determines the frequency of a swinging pendulum?” (Answer: length of the string)

**Evaluate** - Learners assess own understanding and abilities.

9. After completing the activity, chart which aspects of the NLIST definition of Science as Inquiry were touched upon in this activity and which ones were missing. This portion of the activity is intended to assess participants' new understanding of the NLIST definition of Science as Inquiry. (Hand-out #10/Transparency #10)

10. **Transparency/Hand-out/Facilitator's Resources Follow:**

## Transparency #2/ Hand-out #2

### **Instructional Materials Rubric**

The Instructional Materials Rubric is a tool that has been developed to reflect the instructional perspective of the NLIST definition of Science as Inquiry as it relates to instructional materials. The Instructional Materials Rubric may be used to assess materials such as texts or procedural manuals in order to determine the level of science as inquiry being practiced in a classroom setting. Assistance in using this tool is provided in the Assessing Instructional Materials for Inquiry Workshop component of the NLIST Advancing Science as Inquiry professional development package.

### **Assessing Instructional Materials for Inquiry: Workshop**

This document is designed to be used with a group of teachers in a workshop setting. The Assessing Instructional Materials for Inquiry workshop is most appropriate for practicing teachers. However, administrators, science curriculum directors, pre-service teachers, and graduate students (teachers working on advanced degrees in science education) would also benefit, especially if the facilitator adapts the instruction for the specific audience.

### **Inquiry Instruction Rubric**

The Inquiry Instructional Rubric is a tool that has been developed to reflect the instructional perspective of the NLIST definition of Science as Inquiry. The Inquiry Instructional Rubric may be used to assess individual or departmental science instruction to determine the level of science as inquiry being practiced in a classroom setting. Assistance in using this tool is provided in the Assessing Instruction for Inquiry workshop component of the NLIST Advancing Science as Inquiry professional development package.

### **Assessing Instruction for Inquiry: Workshop**

In the Assessing Instruction for Inquiry Workshop, teachers assess their prior knowledge of teaching through inquiry and assess several activities including their own teaching for essential features of facilitating classroom inquiry. They become familiar with the use of the Inquiry Instructional Rubric, another tool provided in this NLIST Advancing Science as Inquiry professional development package.

### **Professional Development Rubric**

This tool should be used to evaluate the effectiveness of science as inquiry professional development workshops. The tool can be used to help professional development providers adjust their designs to meet client needs and reflect on the effectiveness of that design; by the client to provide feedback to the provider throughout the contract period; by the facilitator to evaluate implementation.

Transparency #3/ Hand-out #3

Common terms/phrases that describe science as inquiry

Transparency #4/ Hand-out #4

**NLIST definition of Science as Inquiry:**

Inquiry is the process scientists use to learn about the natural world. Students can also learn about the world using inquiry. Although they rarely discover knowledge that is new to humankind, current research indicates that students engaged in inquiry discover knowledge new to themselves.

Student inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of the student's experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanation, and predictions; and communicating the results. Inquiry requires of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

As a result of participating in inquiries, students will increase their understanding of the science subject matter investigated, gain an understanding of how scientists study the nature world, develop the ability to conduct investigations, and develop the habits of mind associated with science (Beyers, 2001).

## Transparency #5/ Hand-out #5

**Inquiry in Science**

*Inquiry and the National Science Education Standards p1-5 (2000)*

1

A geologist who was mapping coastal deposits in the state of Washington was surprised to discover a forest of dead cedar trees near shore. A significant portion were still standing, but they clearly had been dead for many years. He found similar stands of dead trees at other places along the coast in both Oregon and Washington. He wondered, "What could have killed so many trees over so wide an area?"

2

Reflecting on his knowledge of earthquakes, crustal plate boundaries, and subsidence along coastlines, the geologist searched for possible explanations. "Did the trees die at the same time?" "Was their death related to nearby volcanic activity or some kind of biological blight?" "Given their coastal location, was there some relationship between the salt water and the destruction of the forests?"

3

He pursued his first question by dating the outer rings of the trees using carbon 14 radiometric methods. He found that they all had died about 300 years ago. As for the cause of the trees' death, his mapping indicated no evidence for widespread volcanic deposits in the areas of the dead forests. Furthermore, the trees were not burned, nor did careful examination indicate any evidence of insect infestation.

4

The geologist began thinking about the possible role of salt water in killing the trees. He recalled that a large section of the Alaskan coast dropped below sea level in 1964 when the tectonic plate that underlies much of the Pacific Ocean

5

plunged beneath the North American tectonic plate that Alaska sits on as the result of a major "subduction zone earthquake." Many square miles of coastal forests in Alaska died when the coastline dropped and they were submerged in salt water following the earthquake. He knew that a similar subduction zone lies beneath the Washington and Oregon coasts and gives rise to the volcanoes of the Cascade Mountains. He wondered whether the trees in Washington and Oregon might have been drowned by seawater when a large section of the coast subsided during an earthquake 300 years ago.

6

To check this explanation, he collected more data. He examined the sediments in the area. Well-preserved sections of sediment exposed in the banks of streams inland from the stands of dead trees showed a clean layer of sand below the soil – unlike any of the dark, clay-rich soil above and below the sand. "Where did the white sand come from?" he wondered.

7

The geologist knew that subduction zone earthquakes often produce tsunamis – tidal waves. He thought the sand layer could be sand washed ashore during a tsunami. If so, this would be further evidence of a major coastal earthquake. Fossils recovered from the sand layer indicated the sand came from the ocean rather than being washed down from inland, supporting the tsunami hypothesis.

8

He published several articles in peer-reviewed scientific journals hypothesizing that the dead trees and sand layer found along the coast were evidence that a major earthquake

occurred about 300 years ago, just before European settlers arrived in the region (Atwater, 1987; Nelson et al., 1995).

9

Several years later a Japanese seismologist, who was studying historic tide gauge records in Japan to document tsunamis from distant sources, identified a major earthquake somewhere along the Pacific rim on January 17, 1700, but the source of the earthquake was open to debate. Using historical records he was able to eliminate the possibility of a large earthquake from most known earthquake source regions around the Pacific. Aware of the geologist's work on dead forests in the Pacific northwest, the Japanese seismologist suggested that the source of the tsunami was a large subduction zone earthquake beneath present day Oregon and Washington (Satake et al., 1996).

Now the geologist had more evidence supporting his explanation that the sand layer was caused by a tsunami that accompanied an earthquake.

10

Further examination of coastal sediments uncovered additional, but older, remains of dead trees and sand layers. He now thinks that earthquakes producing very large tsunamis, like the one he first identified, have repeatedly struck the Pacific Northwest coast in the past thousand years, just as these large earthquakes strike other subduction zones beneath Japan, the Philippines, Alaska, and much of Western South America. The coastal subsidence caused by the earthquake submerged the trees in salt water, which led to their death

## Transparency #6/ Hand-out #6

**Inquiry in the Science Classroom**

Excerpt taken from: Inquiry and the National Science Education Standards p6-10 (2000)

1

Several of the children in Mrs. Graham's fifth grade class were excited when they returned to their room after recess one fall day. They pulled their teacher over to a window, pointed outside, and said, "We noticed something about the trees on the playground. What's wrong with them?" Mrs. Graham didn't know what they were concerned about, so she said, "Show me what you mean."

2

The students pointed to three trees growing side by side. One had lost all its leaves, the middle one had multicolored leaves – mostly yellow – and the third had lush, green leaves. The children said, "Why are those three trees different? They used to look the same, didn't they?" Mrs. Graham didn't know the answer.

3

Mrs. Graham knew that her class was scheduled to study plants later in the year, and this was an opportunity to investigate questions about plant growth that they had originated and thus were especially motivated to answer. Although she was uncertain about where her students' would lead, Mrs. Graham chose to take the risk of letting her students pursue investigations under her guidance. After all, they had some experience last year in examining how seeds grow under different conditions. She hung up a large sheet of butcher paper where all the students could see it and said, "Let's make a list of ideas that might explain what's happening to those three trees outside." A forest of hands went up:

It has something to do with the sunlight.

- It must be too much water.
- The trees look different. They used to look the same.
- It's the season, some trees lose their leaves earlier than others.
- There is poison in the ground.
- The trees have different ages.
- Insects are eating the trees.
- One tree is older than the others.

4

When the students were satisfied that they had enough ideas, Mrs. Graham encouraged them to think about which of their ideas were possible explanations that could be investigated and which were descriptions. She then invited each student to pick one explanation that he or she thought might be the answer. She grouped the students by choices: There was a "water group", a "seasons" group, an "insects" group, and so on. She asked each group to plan and conduct a simple investigation to see if they could find any evidence that answered their question. As they planned their investigations, Mrs. Graham visited each group of students and carefully listened as they formulated their plans. She then asked each group to explain their ideas to their classmates, resulting in further refinement. Using this quick and public assessment of where they were, she was able to help them think about the processes they were using to address their question and consider whether other approaches might work better.

5

For the next three weeks, science periods were set aside for each group to carry out its investigation. The groups used a variety of sources to gather information about characteristics of trees, their life cycles, and their environments. For example, the "different ages" group answered their

question fairly quickly. They contacted the PTA members who were involved in planting that part of the playground and found the original receipts for the purchase of the trees. A check with the nursery indicated that all three trees were identical and of approximately the same age when purchased. As some groups completed their investigations early, Mrs. Graham invited other members to join other groups still in progress.

6

The water group decided to look at the ground around the trees every hour that they could. They took turns and jointly kept a journal of their individual observations. Since some students lived near the school, their observations continued after school hours and on weekends. They missed some hourly observations, but they had sufficient data to report to the class. “The tree without leaves is almost always standing in water, the middle tree is sometimes standing in water, and the green tree has damp ground but is never standing in water.”

7

One of the students recalled that several months ago the leaves on one of his mother’s geraniums had begun to turn yellow. She told him that the geranium was getting too much water. Mrs. Graham gave the group a pamphlet from a local nursery entitled “Growing Healthy Plants.” The water group read the pamphlet and found that when plant roots are surrounded by water, they cannot take in air from the space around the roots and they essentially “drown.” Based on their observations and the information they obtained from the pamphlet, the students concluded that the leafless tree was drowning, the middle tree was “kinda” drowning, and the third one was “just right.”

8

The water group continued its work by investigating the source of the water.

They found that the school custodian turned on a lawn sprinkler system three times a week. He left it running longer than necessary, and the excess water ran off the lawn and collected at the base of the trees. Since the ground was sloped, most of the water collected at the end of the tree-growing area. Together with the other groups, they reported their results to the rest of the class.

9

As different groups gave their reports, the class learned that some observations and information – such as those from the group investigating whether the trees were different – did not explain the observations. The results of the investigations, such as the idea that the trees could have a disease, partly supported the observations. But the explanation that seemed most reasonable to the students, that fit all the observations and conformed with what they had learned from other sources, was too much water. After their three weeks of work, the class was satisfied that together they had found a reasonable answer to their question. At Mrs. Graham’s suggestion, they wrote a letter to the custodian telling him what they had found. The custodian came to class and thanked them. He said that he would change his watering procedure and he did. Mrs. Graham then asked the students how they could find out if their explanation was correct. After some discussion they decided that they would have to wait until next year and see if all the trees got healthy again.

10

The following year, during the same month that they had observed the discrepancy, all three trees were fully clothed with green leaves. Mrs. Graham’s former students were now even more convinced that what they had concluded was a valid explanation for their observations.

## Transparency #7/ Hand-out #7

Phrases from NLIST Science as Inquiry Definition	Corresponding Sticky Note Color
Making observations	Light blue
Posing questions	Light yellow
Reviewing what is already known	Light pink
Gathering/analyzing/interpreting data	Light green
Critical and logical thinking	Light purple
Proposing answers/prediction/explanation	Dark blue
Consideration of alternative explanation	Fluorescent pink
Engaged in inquiry – discover knowledge new to themselves	Dark purple
Planning investigations	Fluorescent green
Communicating results	Fluorescent orange

Transparency #8/Hand-out #8

<b>D1. Developing the habits of mind associated with science</b>				
<b>Descriptor</b>	<b>Variations</b>			
<b>Material...</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
<b>D1a.</b> ...promotes the questioning of assumptions (skepticism)	...does not address the need to evaluate or consider the underlying assumptions of an investigation.	...provides explanations or examples of assumptions in scientific investigations.	...prompts learners to consider the assumptions inherent in a scientific investigation or to consider the consequences of the lack of skepticism in scientific investigations.	...prompts learners to reflect in oral or written form on the thinking involved in the assumptions underlying their own investigations and conclusions and to defend their thinking process.
<b>D1b.</b> ...presents science as open and subject to modification based on communication of new knowledge and methods (openness)	...contains no references to the idea of challenging previous scientific knowledge.	...prompts learners to examine previously established scientific ideas, and provides explanations or examples that illustrate how new information can modify accepted scientific knowledge.	...engages learners in analyzing the basis for conclusions in other investigations or in considering the consequences of the lack of openness to modification in scientific knowledge.	...prompts learners to reflect on the reasoning leading to their own conclusions and to defend their thinking process.
<b>D1c.</b> ...promotes longing to know and understand (curiosity)	...does not mention or prompt learners to explore the possibility of future investigations stemming from the current inquiry or observations.	...provides explanations and/or examples of how questions for further investigations can spring from a completed inquiry or interesting observations.	...engages learners in analyzing investigations for further questions or to consider the consequences of the lack of curiosity in science.	...prompts learners to reflect on their own development of ideas for investigations and to defend their reasoning.
<b>D1d.</b> ...promotes respect for data (honesty)	...does not promote respect for data.	...explains and/or provides examples detailing the use of honest and dishonest data from scientific investigations.	...engages learners in analyzing the validity of data in other investigations or in considering the consequences of dishonest data in science.	...prompts learners to reflect on the importance of reporting and recording observations accurately (vs. reporting what they think it should be) and to articulate the bias and limitations of their data.

Transparency #9

**Pendulum Activity Group Data Recording Chart**

<b>Group</b>	<b>Average Number of Swings in 15 seconds</b>

Transparency #10/Hand-out #10

**Aspects of Inquiry-Based Activity Which**

**Match NLIST Definition  
of Science as Inquiry**

**Do Not Match NLIST Definition  
of Science as Inquiry**

## Resources

National Research Council. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*, National Academy Press, Washington, D.C.

*Inquiring into Inquiry Learning and Teaching in Science*, Edited by Jim Minstrell and Emily H. van Zee, AAAS, Washington DC, 2000

*Foundations, Volume II, A monograph for professionals in science, mathematics, and technology education: Inquiry, Thoughts, Views, and Strategies for the K-5 Classroom*, Division of Elementary, Secondary, and Informal Education, Directorate for Education and Human Resources, National Science Foundation, Arlington, VA, 1999

*Science for All Children: A Guide to Improving Elementary Science Education in Your School District*, National Science Resources Center, National Academy of Sciences, Smithsonian Institution, National Academy Press, Washington DC, 1997

*Achieving Science Literacy: From Purposes to Practices*, Roger W. Bybee, Heinemann, Portsmouth, NH, 1997

*Benchmarks for Science Literacy*, AAAS, Project 2061, Oxford University Press, NY, 1993

*National Science Education Standards*, National Research Council, National Academy Press, Washington DC, 1996

*Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*, National Research Council, National Academy Press, Washington DC, 2000  
Al and Mary Ann's NLIST: A New Approach to Inquiry-Based Learning

Deborah's AFI piece

Instructional Materials Rubric