

2012

Oregon 4-H Science Rich
Handbook Series

Focus on the
4-H Earth Science
Project



Oregon State University
Extension Service

Welcome to 4-H Science

This handbook series was developed to help Oregon 4-H youth development professionals and volunteers become familiar with the national 4-H science framework and how to think intentionally about 4-H Science programming. It will help improve the understanding and delivery of science within appropriate 4-H projects.

4-H, with its direct connection to the Cooperative Extension System's cutting edge research and the resources of the nation's 106 land-grant universities and colleges, provides youth with hands-on learning experiences that foster exploration, discovery, and passion for the sciences. Science is one of the three national Mission Mandates for 4-H. 4-H Science programs support youth to develop science, technology, engineering and applied math (STEM) skills.

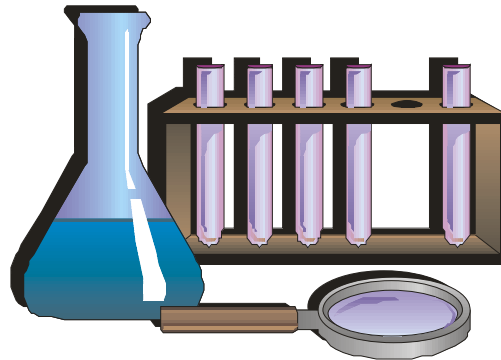
This handbook will

1. Define 4-H Science
2. Introduce tools to focus on 4-H Science in this project area
 - a. 4-H Science Checklist
 - b. 4-H Science Eight Essential Elements
 - c. 4-H Science Inquiry in Action Flowchart
 - d. 4-H Science Logic Model
3. Provide An Example of a Science Rich 4-H Inquiry Activity

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Why 4-H Science?

The National Academy of Science's 2007 *Rising Above the Gathering Storm* report stated that, "the United States presently faces a significant challenge - young people are not prepared with the necessary Science, Engineering and Technology workforce skills to compete in the 21st century." In their 2011 review of America's position five years later, entitled *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, the Academy committee's unanimous view is that our nation's outlook has worsened.

The 2009 National Assessment of Educational Program report indicates Oregon 8th grade students are proficient in math (37%) and science (35%) slightly above the national average. However, just 15% of Hispanics and 12% of Black 8th grade students are proficient in math compared to 41% of White students. For science, just 12% of Hispanics and 13% of Black 8th graders are proficient compared to 40% of White students. The percentage of Oregon 8th grade students who reported they "never or hardly ever" design a science experiment was 35%, compared to 39% nationally. The percent of Oregon 8th grade students who report that they "never or hardly ever" write reports on science projects was 43%, compared to 47% nationally.

The national 4-H Science Mission Mandate targets addressing these needs at the local level through the broad range of 4-H projects which are based on science. 4-H Science programs reach more than 5.9 million youth in urban, suburban and rural communities across the country. 4-H Science programs support youth to develop science, technology, engineering and applied math (STEM) skills. Oregon 4-H youth development professionals and volunteers can help address this need using the resources and tools in this handbook.

1. The 4-H Science Checklist

The 4-H Science Checklist is provided in Appendix A. The checklist includes seven items that have been identified as the most critical program components to include in a 4-H Science Program. You may be thinking, “I don’t lead a 4-H Science Club! I’m just a 4-H Geology club leader.” The goal of the checklist is to help 4-H youth development professionals and volunteers identify and reinforce the science learning opportunities across a variety of 4-H projects.

A paragraph at the top of the check list explains, “A ‘Science Ready’ 4-H experience is a program that is framed in science concepts, based on science standards and intentionally targets the development of science abilities and the outcomes articulated by the 4-H Science Logic Model. Additionally, it integrates the Essential Elements and engages participants in experiential and inquiry based learning.”

Let’s look at what is included in the program components of a “Science Ready” 4-H experience.

- **National Science Education Standards**

These standards are used by Oregon’s Department of Education to develop the science benchmarks for K-12 education. The national standards provide a common and consistent base of quality content on which 4-H program design, development, delivery and assessment is built.

- **4-H Science Abilities**

This section includes a list of 30 science abilities or practices that are skills used in science, engineering and technology. These abilities can be used across 4-H project areas to help youth unleash their natural curiosity about the world. Youth will use these skills and understand what it means to think and act like a scientist.

- **Youth Development- Essential Elements**

Oregon 4-H youth development professionals and volunteers are already addressing these opportunities in their work with youth. The four needs of youth to experience mastery, independence, belonging and generosity are supported by the Eight Essential Elements of Positive Youth Development. Specific examples of how 4-H youth development professionals and volunteers can implement these are provided in the 4-H Science: Eight Essential Elements (Section 2) in this handbook.

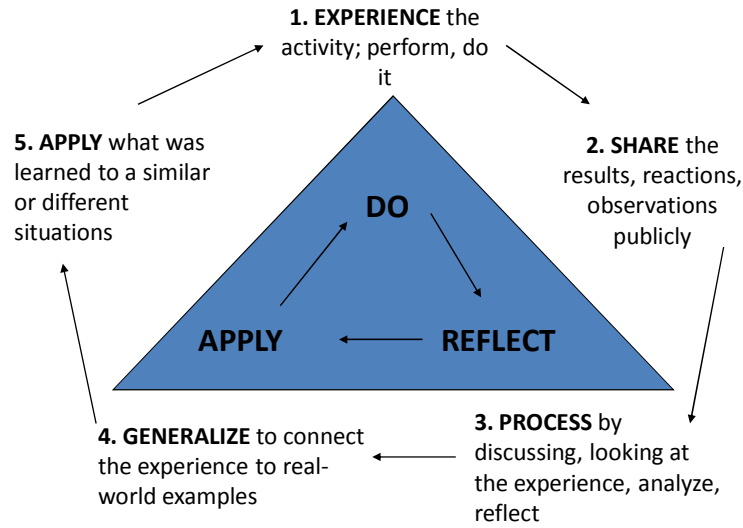
- **Trained, Caring Adults and Volunteers**

Oregon 4-H youth development professionals and volunteers are provided a variety of opportunities, including this handbook, to increase their skills as front-line youth workers. This handbook will help you to incorporate the 4-H Science Checklist, 4-H Science Logic Model, 4-H Science Inquiry in Action Flow Chart, and 4-H Science Core Competencies into your programming.

- **An Experiential Approach**

Oregon 4-H youth development professionals and volunteers are familiar with the 4-H experiential learning model. All 4-H project materials rely on this approach to create and reinforce learning.

4-H Experiential Model



- **Inquiry to Foster Creativity and Curiosity**

“Inquiry is a process that all individuals naturally use in approaching new situations and solving problems in life. By engaging in inquiry, ...children...gain experience...that will improve their capacity to handle life situations and solve everyday problems.” (Edmund Marek and Ann Cavallo, 1997). Inquiry can happen in a variety of ways across 4-H programs. Ideas on encouraging inquiry and use of the Inquiry in Action Flow Chart (Appendix C) will be presented in Section 3 of this handbook.

- **4-H Science Logic Model**

The 4-H Science Logic Model articulates the opportunity to achieve science outcomes across 4-H education programs. It is provided in Appendix D. Outcomes happen at three levels. Short-term outcomes are those that happen immediately after an education experience such as knowledge gains. Intermediate or long-term outcomes happen after the learner has a chance to integrate their new knowledge into different actions.

2. 4-H Science Core Competencies: Eight Essential Elements

One framework for understanding youth development in 4-H is the eight essential elements. This framework provided the structure for development of the 4-H Science Core Competencies. The 4-H Science Core Competencies identify specific actions or behaviors of 4-H youth development workers and volunteers that create a positive atmosphere or context for learning. The four needs of youth to experience **mastery, independence, belonging** and **generosity** are supported by the Eight Essential Elements of Positive Youth Development. These are item 3 on the 4-H Science Checklist. A 4-H Science Competency Self Assessment is provided in Appendix B.

Caring Adult (Belonging)

4-H youth development professionals and volunteers understand that each young person benefits from a positive relationship with a caring adult by:

1. Communicating the capacity of all youth to learn and experience success.
2. Being willing to learn alongside youth.
3. Being comfortable not having all the answers.
4. Demonstrating support for all youth.
5. Understanding and caring about youth and their families.
6. Appreciating the context in which youth and families live.

Safe Environment (Belonging)

4-H youth development professionals and volunteers create an emotionally and physically safe learning environment by:

1. Modeling strategies for conflict resolution.
2. Encouraging youth to share new ideas and different perspectives.
3. Modeling and facilitating how to give and receive constructive criticism.

Inclusive Environment (Belonging)

4-H youth development professionals and volunteers design inclusive learning environments by:

1. Promoting teamwork and cooperation.
2. Providing opportunities for youth to teach and learn from each other.
3. Demonstrating respect for others.
4. Fostering an environment of mutual respect for others.

See Oneself in the Future (Independence)

4-H youth development professionals and volunteers nurture an atmosphere of optimism and a positive belief in the future by:

1. Encouraging the belief that all youth can learn science or pursue science careers.
2. Creating a science-friendly learning environment.
3. Promoting science careers for all youth, regardless of their gender, race, or ethnicity.
4. Demonstrating how science can improve the world.

Values and Practices Service to Others (Generosity/ Mastery)

4-H youth development professionals and volunteers encourage an ethic of caring and civic responsibility by:

1. Helping youth connect to the community through service projects.
2. Encouraging empathy for others.
3. Engaging youth in real world science activities that consider the needs of others.
4. Understanding the positive and negative effects that science has on humans.

Opportunities for Self-Determination (Independence)

4-H youth development professionals and volunteers encourage and support independence in youth by:

1. Designing experiential, inquiry-based opportunities for youth to learn 4-H Science skills.
2. Challenging youth to explore new or different 4-H Science projects and areas of learning.
3. Supporting youth in achieving their goals in the face of setbacks.
4. Knowing how to foster an increasing development of skills in youth.

Opportunities for Mastery

4-H youth development professionals and volunteers provide opportunities for youth to develop skills, competence, and expertise by:

1. Designing experiential, inquiry-based opportunities for youth to learn 4-H Science skills.
2. Challenging youth to explore new or different 4-H Science projects and areas of learning.
3. Supporting youth in achieving their goals in the face of setbacks.
4. Knowing how to foster an increasing development of skills in youth.

Engagement in Learning (Mastery)

4-H youth development professionals and volunteers encourage youth to direct and manage their own learning by:

1. Assisting youth in setting realistic goals of their own choice.
2. Encouraging an inquiry approach to learning and exploration.
3. Providing sufficient time and an appropriate environment for thorough learning.

3. 4-H Science Inquiry in Action

The *National Science Education Standards* (1996) employ Science as Inquiry as a skill across all science content areas. Like life skills in traditional 4-H projects, the process of using inquiry supports content learning. Oregon's 4-H Science Inquiry in Action Flowchart (Appendix C) shows the relationship between the 4-H Experiential Learning Model and the steps applied in science inquiry.

On the Inquiry in Action flowchart, note that the first two steps in the process are lead by the coach or leader. These are, "1. Determine what learners know or have observed. Identify knowledge gaps or misunderstandings." and, "2. What do learners want to know? What questions do learners have?" These two steps are where the leader introduces the topic and engages the learners in using their inquiry process skills.

Learning to lead learner-centered, inquiry based activities can be a challenge for 4-H youth development professionals and volunteers who are more familiar with prescribed project activities which follow cookbook-like steps to a known outcome. With repeated application of the inquiry model – learning by doing – leaders and learners become familiar with the steps applied in science inquiry. Learners will soon take initiative and become engaged in designing their own learning experiences.

Steps 3 through 10 of the flowchart are intended to be primarily learner driven. For ease of management, youth can be put into teams to work on an inquiry activity. There are a variety of ways the leader can proceed with facilitating inquiry. In *Guided Inquiry*, learners are provided with a problem to investigate and the materials necessary to carry out the investigation. The learners devise their own procedure to solve the problem. The state 4-H project page for Science, Engineering and Technology (<http://oregon.4h.oregonstate.edu/science-engineering-and-technology>) has a link to ten videos that show examples of how to lead guided inquiry activities in a selection of 4-H projects.

A second way of facilitating is called *Open Inquiry*. The learners formulate their own problem to investigate and devise strategies to carry out their investigation (Steps 4-6). This can include determining which equipment to use to collect information from a selection provided and creating their own data chart to record information.

Science education can be improved by immersing learners in the process of using scientific knowledge to "do" science. Informal learning environments are ideal settings for learners to practice skills necessary for scientific inquiry. Experiential learning may be defined as learning based on personal experiences or direct observation. Experience and observation are key to the scientific inquiry process. An example of a project activity using inquiry will be presented next in this handbook.

4. An Example of a Science Rich 4-H Earth Science Inquiry Activity

In this section, a lesson in the Oregon 4-H Earth Science Project Leader Guide (4-H 340L) will be adapted to be Science Rich. As written the lesson is to be done as a demonstration of density by the leader.

Employing the 4-H Science Checklist

Remember, the 4-H Science Checklist (Appendix A) includes seven items that have been identified as the most critical components to include in a 4-H Science Program, so this is a good place to start when planning to teach a lesson.

Let's begin with the Science Abilities list. What abilities will youth practice in this lesson as written? As a leader demonstration youth can only Predict and Observe. Is there an opportunity to include more of the science abilities and let youth design some experiments to learn about density? YES! Using the list of Science Abilities and the Inquiry in Action Flowchart an *Open Inquiry* experience that is more Science Rich can be created.

Reinventing the Activity

Beginning at step 1 on the Inquiry in Action flowchart, the coach will lead a discussion with youth to determine if they know why it is important to understand density in Earth Science. The movement of tectonic plates is governed by their densities. When two of Earth's tectonic plates collide, the less dense plate rides over the more dense plate. The mathematical formula for density is: $\text{Density} = \text{Mass}/\text{Volume}$.

On the western coast of the North American continent, mountains such as the Cascade Range are uplifted. This is the result of the continental plate riding over the oceanic crust. Continental plates have a thick crust composed of granitic rocks, which are made up of relatively lightweight minerals such as quartz and feldspar. By contrast, oceanic plates are denser and heavier, because they are composed of iron-rich basaltic rocks.

Generally tectonic plates move slowly. The massive plates can build up tremendous pressure as they move past each other. Sometimes the pressure built up over time is released suddenly causing an earthquake. Both volcanic and earthquake activity are common along the plate boundary marking the rim of the Pacific Ocean. Oregon regularly experiences both types of geologic events.

At step 2 of the Inquiry in Action flowchart the leader is to ask youth what questions they have about density. However, this may be a difficult concept for youth to understand without some additional help. One way to help learners begin to understand density is to have two items of the same mass, such as a piece of wood and a rock. Weigh both items separately on a scale so learners understand they have the same mass. Ask the youth what will happen if the wood and the rock are both placed into a tub of water. Perform this demonstration.

At step 3 of the Inquiry in Action flowchart, youth are to ask a question that can be answered through a scientific investigation. To assist youth to ask a question, have them identify all the things they might investigate about density using a variety of materials such as:

- containers of water at room temperature
- raw eggs
- hard boiled eggs
- **thick skinned** oranges – these float with the skin one, like a life jacket, and sink if peeled
- salt
- spoons

Before learners design experiments, step 4, lead a discussion to check for understanding of experimental design. In an experiment, the *dependent variable* is the event studied and expected to change when the *independent variable* is changed. *Controlled variables* are the things that are the same.

A team of youth might state their hypothesis, for example, as “**If** we place one raw egg each into two glasses of water and add salt to one glass **then** the egg in the salt water will float as the density of the water rises.”

- Independent variables answer the question “What do we change?”
 - The amount of salt in the water is the independent variable.
- Dependent variables answer the question “What do we observe?”
 - The change in the relationship between the density of the egg and the water.
- Controlled variables answer the question “What do we keep the same?”
 - The volume and temperature of the water in the two glasses should be the same.

Learners can now move through steps 4 through 11 of the Inquiry in Action flow chart. Science Abilities they have an opportunity to use in Open Inquiry include Question, Infer, State a Problem, Predict, Hypothesize, Plan an Investigation, Cooperate, Test, Measure, Use Tools, Observe, Collect data, Organize, Summarize/Relate, Interpret/Analyze/Reason, Communicate, Compare and Redesign.

At step 10 on the flow chart the question is, “Are all Teams/Learners satisfied with the proposed analysis of findings?” If the answer is, “yes” they can move on to the next inquiry. If the answer is, “No,” the flowchart takes them up to step 12. At step 12 “Team re-designs question or asks a new question which can be explored through scientific investigation.” This is the cyclical nature of science. In formal education youth rarely have the chance to re-design a project. Allowing learning by trial and error supports the experiential model and gives youth control of their experience.

Remember that item three on the 4-H Science Checklist is the Essential Elements. In this activity 4-H youth development professionals and volunteers can create a positive learning environment by being willing to learn alongside youth and by being comfortable with not having all the answers.

An important skill for youth to practice as they learn to think and act like a scientist, is how to communicate ideas and discoveries. Youth have the opportunity to practice many of the science abilities on the 4-H Science Checklist by creating a Science Investigation Display for a 4-H fair event. A description of the fair class, the display requirements and the judging criteria are provided in the Science section of the State 4-H Fair book.

Reference

Jamison, K. & Walahoski, J., 2010. 4-H Science 101: Development, Delivery and Assessment of 4-H Science Programs. National 4-H Council.

National Research Council (NRC). 2011. *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.



Appendix A








4-H Science Checklist

A “Science Ready” 4-H experience is a program that is framed in Science concepts, based on Science standards and intentionally targets the development of science abilities and the outcome articulated by the 4-H Science Logic Model. Additionally, it integrates the Essential Elements and engages participants in experiential and inquiry based learning. In addition to the following criteria below, it’s also recommended that science programs offer a sustained learning experience which offers youth the opportunity to be engaged in programs with relevant frequency and duration. Utilize the following checklist to self assess the program you deliver.

To meet the needs of children, youth and the nation with high-quality science, engineering and technology programs...

	<p>Are you providing science, engineering and technology programs based on National Science Education Standards - Science education standards are criteria to judge quality: the quality of what young people know and are able to do; the quality of the science programs that provide the opportunity for children and youth to learn science; the quality of science teaching; the quality of the system that supports science leaders and programs; and the quality of assessment practices and policies. http://www.nap.edu/readingroom/books/nses/</p>
	<p>Are you providing children and youth opportunities to improve their Science Abilities?</p> <p>Predict, Hypothesize, Evaluate, State a Problem, Research Problem, Test, Problem Solve Design Solutions, Measure, Collect Data, Draw/Design, Build/Construct, Use Tools, Observe, Communicate, Organize, Infer, Question, Plan Investigation, Summarize/Relate, Invent/Implement Solutions, Interpret/Analyze/Reason, Categorize/Order/Classify, Model/Graph/Use Numbers, Troubleshoot, Redesign, Optimize, Collaborate, Compare</p>

	<p>Are you providing opportunities for youth to experience and improve in the Essential Elements of Positive Youth Development?</p> <p>Do youth get a chance at mastery – addressing and overcoming life challenges in your programs? Do youth cultivate independence and have an opportunity to see oneself as an active participant in the future? Do youth develop a sense of belonging within a positive group? Do youth learn to share a spirit of generosity toward others?</p>
	<p>Are learning experiences led by trained, caring adult staff and volunteers acting as mentors, coaches, facilitators and co-learners who operate from a perspective that youth are partners and resources in their own development?</p>
	<p>Are activities led with an experiential approach to learning?</p>
	<p>Are activities using inquiry to foster the natural creativity and curiosity of youth?</p>
	<p>Does your program target one or more of the outcomes on the 4-H Science Logic Model and have you considered the frequency and duration necessary for youth to accomplish those outcomes?</p>

Appendix B- 4-H Science Competency Self Assessment

Please fill in the circle that tells you how much you are capable of using the knowledge and skills in each of these areas when you work with youth in 4-H Science programs.

	0 Never	1 Sometimes	2 Usually	3 Most of the Time	4 Always
CARING ADULT					
I use language of respect	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I listen to youth in a nonjudgmental way	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I demonstrate shared leadership through youth-adult partnerships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I encourage youth to think about what they are learning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I make verbal contact with all youth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I encourage learners when they experience setbacks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I offer praise and encouragement when youth take initiative and leadership	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I identify, build on, and celebrate the potential of all youth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I respect youth of different talents, abilities, sexual orientations, and faiths	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
INCLUSIVE ENVIRONMENT (BELONGING)					
I help youth feel welcome and part of a group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I establish a climate of fairness and openness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I respond positively to the ranges of youths' feelings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I cultivate a sense of togetherness among youth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I value and act upon the ideas of others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I serve as a role model for inclusion and tolerance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I initiate, sustain, and nurture group interactions and relationships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SAFE ENVIRONMENT					
I conduct myself in a calm manner	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I reduce or eliminate physical and environmental hazards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I re-emphasize ground rules related to conduct	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I intervene when safety demands it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SEE ONESELF IN THE FUTURE					
I project an optimistic, positive manner	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I reinforce the idea that all youth can succeed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I offer positive encouragement and support even in the face of setbacks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I talk about the future and youth's role in it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

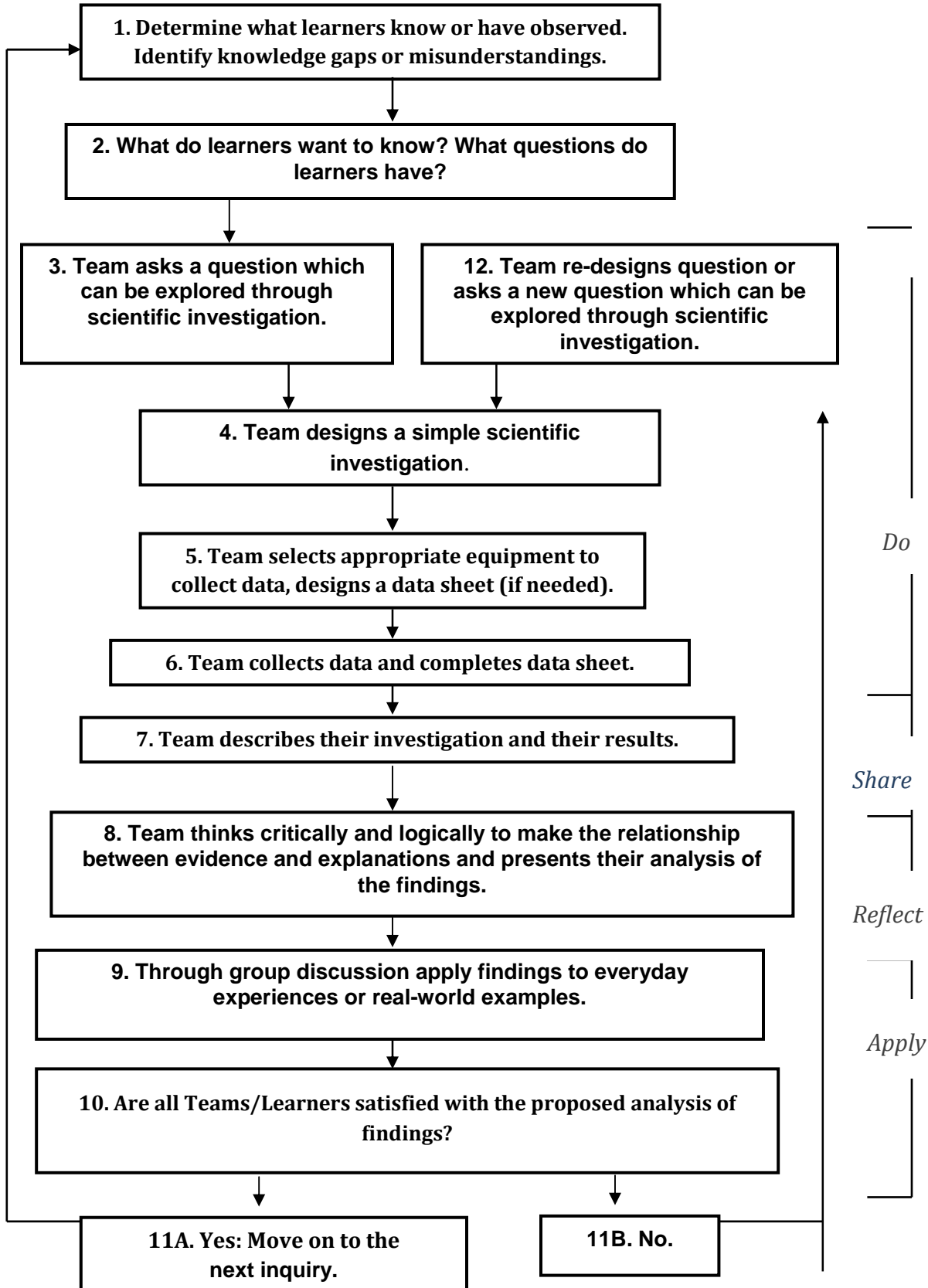
VALUES AND PRACTICES SERVICE TO OTHERS	0 Never	1 Sometimes	2 Usually	3 Most of the Time	4 Always
I encourage youth to contribute to the communities in which they live	0	0	0	0	0
I voice support for giving back to the community through service	0	0	0	0	0
I believe in science's role in improving communities	0	0	0	0	0
I provide opportunities for youth to link their experiences to citizenship	0	0	0	0	0
I identify opportunities for youth to become civically engaged	0	0	0	0	0
OPPORTUNITIES FOR SELF-DETERMINATION					
I provide experiences that encourage youth to share evidence	0	0	0	0	0
I identify opportunities for youth to compare claims with each other	0	0	0	0	0
I articulate strategies for data collection and analysis	0	0	0	0	0
I work with youth to identify sources of information	0	0	0	0	0
I actively consult, involve, and encourage youth to contribute to others	0	0	0	0	0
I provide opportunities for youth to determine program expectations and direction	0	0	0	0	0
ENGAGEMENT IN LEARNING					
I guide youth in learning for themselves	0	0	0	0	0
I create opportunities for problem solving via discussion, debate, and negotiation	0	0	0	0	0
I work with youth to establish appropriate goals for their age	0	0	0	0	0
I provide opportunities for youth to link their experiences to the real world	0	0	0	0	0
I use a variety of questioning and motivational approaches	0	0	0	0	0
I use multiple learning approaches to meet learners' needs	0	0	0	0	0
OPPORTUNITIES FOR MASTERY					
I suggest challenges that can be explored by direct investigation	0	0	0	0	0
I encourage youth to make predictions	0	0	0	0	0
I assist youth in developing hypotheses related to their investigations	0	0	0	0	0
I allow youth to conduct formal and open-ended tests and experiments	0	0	0	0	0
I have youth discuss their finding with each other and evaluate evidence critically	0	0	0	0	0
I encourage youth to share their knowledge by teaching others and leading new activities	0	0	0	0	0
I help youth see setbacks as opportunities for new explorations	0	0	0	0	0
I support youth to set new goals, and try new ideas and approaches	0	0	0	0	0
I provide opportunity for youth to use appropriate technology	0	0	0	0	0

Appendix C- Inquiry in Action Flowchart

4-H Science Inquiry Model

**Coach Lead/
Processed
Activities**

**Learner
Team
Driven
Activities**



Appendix D- 4-H Science Logic Model

4-H Science Logic Model

