2012

Oregon 4-H Science Rich Handbook Series

Focus on the *4-H Horse* 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. Science Inquiry Flowchart
    d. 4-H Science Logic Model
3. Provide An Example of a Science Rich 4-H Inquiry Activity

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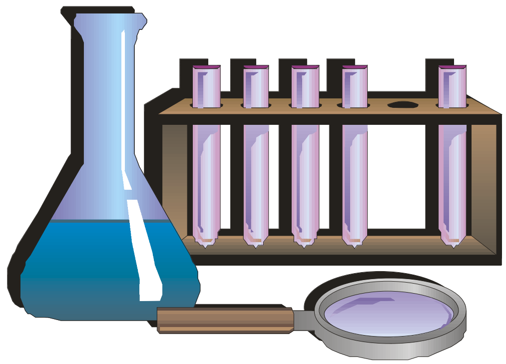


Why 4-H Science?

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 the 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 Horse 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 (of youth development programs) and engages participants in experiential and inquiry based learning.”

Let’s look at what should be 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.

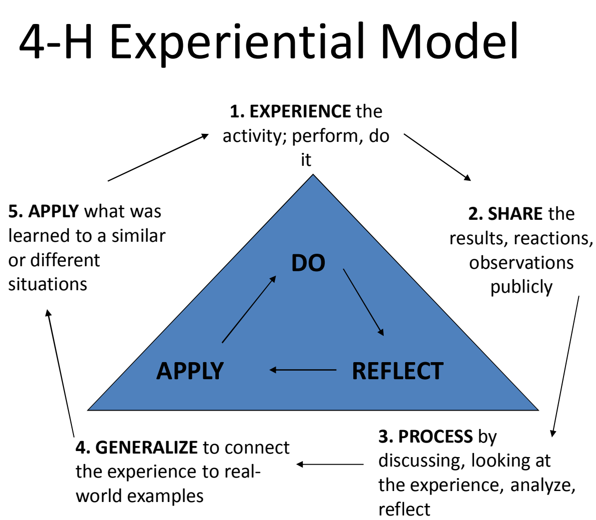
  In 2011 the National Academy of Sciences released *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Future science and engineering education standards will be based on this framework. The framework emphasizes the importance of engaging students in eight foundational practices of science and engineering in the K-12 science and engineering curriculum. These are presented in Section 3 of this handbook.

- ✓ **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 Section 2, 4-H Science Core Concepts: Eight Essential Elements of Youth Development 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, Science Inquiry Flowchart, 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.



- ✓ **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 Science Inquiry Flowchart (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 of Youth Development

One framework for understanding youth development in 4-H are the eight essential elements, which 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. 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 Flowchart (Appendix C) shows the relationship between the 4-H Experiential Learning Model and the steps applied in science inquiry. These steps also align well with the National Research Council's (NRC) eight foundational practices for science and engineering education presented in *A framework for K-12 science education* (2011), see Table 1.

On the Science Inquiry Flowchart (Appendix C), 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. Then the activity should move to a more learner centered model.

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 of science inquiry and science practices. 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 then devise their own procedure to plan and carry out an investigation, analyze and interpret their data, and evaluation and communicate their findings. 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 a science activity 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 and practices 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 in Section 4 of this handbook.

Table 1: Correlation of Foundational Practices for Science & Engineering Education and the Science Inquiry Flowchart

National Research Council's Foundational Practices for Science and Engineering Education	Science Inquiry Flowchart Elements
(1) Asking questions (for science) and defining problems (for engineering)	(3) Team asks a question which can be explored through scientific investigation.
(2) Developing and using models	(4) Team designs a simple scientific investigation.
(3) Planning and carrying out investigations	(4) Team designs a simple scientific investigation.
	(5) Team selects appropriate equipment to collect data, designs a data sheet (if needed).
	(6) Team collects data and completes data sheet.
(4) Analyzing and interpreting data	(7) Team describes their investigation and their results.
	(8) Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.
(5) Using mathematics and computational thinking	(7) Team describes their investigation and their results.
	(8) Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.
(6) Constructing explanations (for science) and designing solutions (for engineering)	(8) Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.
(7) Engaging in argument from evidence	(8) Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.
	(9) Through group discussion team applies findings to everyday experiences or real-world examples.
(8) Obtaining, evaluating, and communicating information	(8) Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.
	(9) Through group discussion team applies findings to everyday experiences or real-world examples.

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

Introduction

Youth who own and work with horses should have some basic knowledge of how to evaluate a horse's general condition. An important part of assessing a horse's health is taking vital sign readings for temperature, pulse and respiration (TPR). Although there are normal ranges for TPR, each horse is unique. Youth need to know what is normal for their horse so that they can tell when something is not right. The better they know their horse, the faster they will notice changes. Spotting trouble early can help prevent more serious problems.

Employing the 4-H Science Checklist

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 and the *Science Inquiry Flowchart* to help design a Science Rich Inquiry experience.

Introducing the Activity

Beginning at step 1 on the *Science Inquiry Flowchart*, the coach will lead a discussion with youth to determine if they know how to measure TPR and why it is important to understand what may affect a horse's TPR. Before moving on to step 2 on the flowchart, provide youth with some information about TPR.

Pass out the *Understanding Temperature, Pulse and Respiration in the Horse* worksheet. Ask youth to work in groups of two or in teams. Using the chart below, ask youth if they notice any relationships between the size of the animals listed and each animal's TPR. Youth can use the following Science Abilities: evaluate, problem solve, infer, interpret/analyze/reason and compare.

Species	Normal Temperature Range in Degrees °F	Normal Resting Pulse Range in **B**eats **P**er **M**inute = **BPM** (Also called Heart Rate)	Normal Resting Respiration Range in Breaths per Minute
Rat	99.5 – 100.5	260-600	85-110
Cat	100.5 – 102.5	110- 140	24-28
Dog	100 - 102	70-160	16-20
Pig	101.5 – 102.5	60-100	16-20
Cow	101 - 103	40-70	10-30

After analyzing the information on the first chart, each team should form and record a hypothesis of the TPR for humans and for horses on the second chart. Next ask youth to take the temperature, pulse, and respiration of one person in each team and record the data. How similar are the readings for each team? Discuss normal variations in a population. Do the teams want to make any changes to their predicted TPR for the horse now that they have a little more data? Here youth can use the Science Abilities collaborate, compare and interpret/analyze/reason.

Measuring TPR in the Horse

Teach youth how to take TPR on a horse.

Materials needed:

- Animal thermometer with a string tied to the end
- Lubricating jelly
- Watch with second hand

Measuring Temperature: Temperature is measured in degrees. Shake the mercury down or use a digital thermometer. Lubricate the thermometer with lubricating jelly. Stand alongside the horse's hip and insert the thermometer into the rectum. Hold for at least three minutes. Gently remove the thermometer and quickly wipe it clean without touching the bulb end. Read the temperature.

Measuring pulse: Pulse is measured in beats per minute. Find the artery at the jawbone where it winds around from the inner side, and feel the pulse with the tips of your index and middle fingers. Using a watch's second hand, count the beats for 30 seconds and then multiply by two.

Measuring respiration: Respiration is measured in breaths per minute. Place your hand on the horse's flank. Using a watch with a second hand, count the rise and fall rate for 30 seconds, then multiply by two.

Each team should then complete the second chart by filling in the TPR of the horse you are studying. How did the TPR data compare to the hypothesis of each team? Ask the teams to think carefully about how they reached their hypotheses. Were there any clues in the data charts that they missed in their first analysis? If youth have not noticed yet, point out that a mammal's resting pulse rate is correlated to the size of its body.

Normal Range	T	P	R
Horse	99-101° F	32-48	8-20

Factors that Affect TPR

Now that learners have a little background on TPR, you can have teams move on to steps 2 and 3 on the *Science Inquiry Flowchart*. Depending on the age and knowledge of your group, you may wish to have youth complete the third chart to learn how activity affects TPR before they begin to ask questions and design an investigation.

Teams can discuss and propose other questions they would like to explore through scientific investigation. Help the teams think about variables they could safely study. What factors affect pulse? Would it be different if you take your horse's pulse first thing in the morning, after it finishes eating, before and after exercise? How does the time length or intensity of exercise affect pulse? How does the air temperature affect pulse? What factors affect temperature? Does the horse's temperature change over the day? Does exercise affect temperature? Does air temperature affect the horse's temperature?

Before they will be able to engage in their inquiry, they will need to collect the baseline data for each horse they want to investigate. They will need to collect data for six or more days to get an idea of what is "normal" for their animal. They will need to collect the data at the same time and under the same conditions (always before the morning feeding, always before exercise, etc.) Have the youth work in teams to design a chart to collect TPR data. They should bring their completed chart to the next meeting. Advise youth to include a column on their charts to calculate the average for their recorded TPR readings.

Inquiry into Factors that Affect TPR

Before learners design experiments (step 4 on the *Science Inquiry Flowchart*), lead a discussion to check for understanding of experimental design. Remember that it is perfectly acceptable to let youth investigate a hypothesis that the adult leader knows will be proved wrong. This is a form of learning too. Scientist's hypotheses are also not always right. Ensure that youth do not propose activities that will be harmful to the horse.

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 remain the same. As an example, one group might state the following hypothesis: "**If** we feed a horse a specific serving size of oats at a meal, **then** the horse's temperature will be higher than its normal baseline temperature for two hours after it finishes eating."

- Independent variables answer the question "What do we change or add?"
    - The amount of oats eaten by the horse is the independent variable.
- Dependent variables answer the question "What do we observe?"
    - The horse's temperature is the dependent variable.
- Controlled variables answer the question "What do we keep the same?"
    - As much as possible, all the conditions (air temperature, access to water, shelter, etc.) should be the same as when the baseline data were collected.

Learners can now move through steps 4 through 11 of the *Science Inquiry Flowchart*. Science Abilities they have an opportunity to use in an open inquiry activity 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 flowchart, 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, “Team re-designs the question or asks a new question which can be explored through scientific investigation.” This is the cyclical nature of science. In formal education settings, youth rarely have the chance to re-design an investigation or re-do a project. Allowing learning by trial and error supports the experiential learning model and gives youth control of their experience.

As youth learn to think and act like scientists, they also need to learn how to communicate ideas and discoveries. Youth have the opportunity to practice many of these important skills by creating a Science Investigation Display for a 4-H fair. 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.

Extension: How do metabolism, body temperature, and respiration work in the mammalian body?

Worksheet: Understanding Temperature, Pulse and Respiration in the Horse

Species	Normal Temperature Range in Degrees °F	Normal Resting Pulse Range in **B**eats **P**er **M**inute = **BPM** (Also called Heart Rate)	Normal Resting Respiration Range in Breaths per Minute
Rat	99.5-100.5	260-600	85-110
Cat	100.5-102.5	110- 140	24-28
Dog	100-102	70-160	16-20
Pig	101.5-102.5	60-100	16-20
Cow	101-103	40-70	10-30

Our Hypothesis and Data Collection at Rest

Species	T = Temperature Range in Degrees °F	P = Resting Pulse Range in **B**eats **P**er **M**inute = **BPM**	R = Resting Respiration Range in Breaths per Minute
Human: Hypothesis			
Human: Actual			
Horse: Hypothesis			
Horse: Actual			

Our Hypothesis and Data Collection after Activity

One volunteer will do 10- 15 jumping jacks. How will this affect the person's TPR?

Human Volunteer Name:	T = Temperature Degrees °F	P = Pulse in **B**eats **P**er **M**inute = **BPM**	R = Respiration in Breaths per Minute
Resting Readings			
After Exercise: Hypothesis			
After Exercise: Actual			

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…

☑	**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/**
☑	**Are you providing children and youth opportunities to improve their Science Abilities?** 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

☑	**Are you providing opportunities for youth to experience and improve in the Essential Elements of Positive Youth Development?** 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?
☑	**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?**
☑	**Are activities led with an experiential approach to learning?**
☑	**Are activities using inquiry to foster the natural creativity and curiosity of youth?**
☑	**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?**

Appendix B- 4-H Science Competency Self Assessment

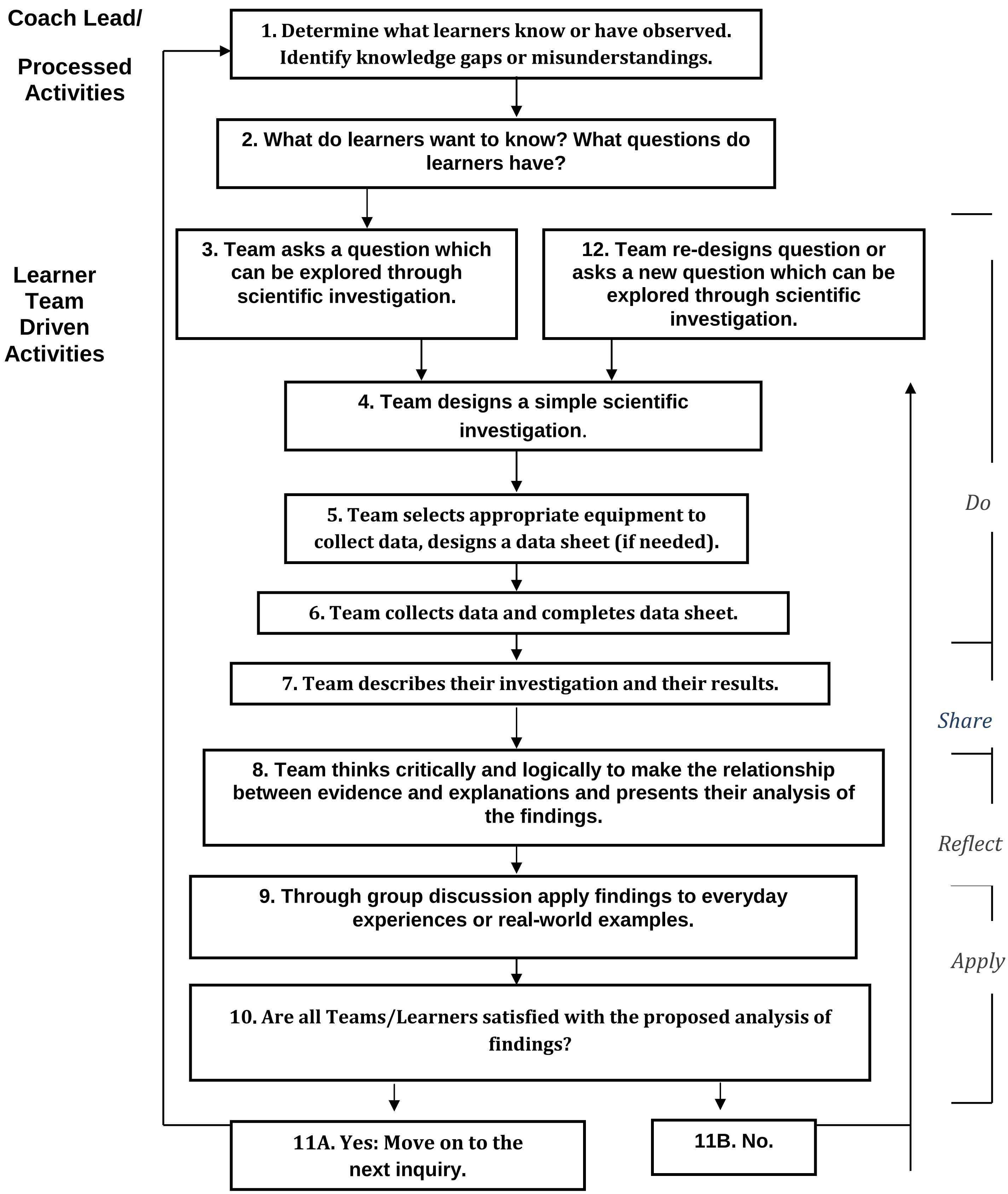
Please fill in the circle that tells you how much you are capable of using the knowledge and skills in each of these areas when you work with youth in 4-H Science programs.

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

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	O	O	O	O	O
I voice support for giving back to the community through service	O	O	O	O	O
I believe in science's role in improving communities	O	O	O	O	O
I provide opportunities for youth to link their experiences to citizenship	O	O	O	O	O
I identify opportunities for youth to become civically engaged	O	O	O	O	O
OPPORTUNITIES FOR SELF-DETERMINATION					
I provide experiences that encourage youth to share evidence	O	O	O	O	O
I identify opportunities for youth to compare claims with each other	O	O	O	O	O
I articulate strategies for data collection and analysis	O	O	O	O	O
I work with youth to identify sources of information	O	O	O	O	O
I actively consult, involve, and encourage youth to contribute to others	O	O	O	O	O
I provide opportunities for youth to determine program expectations and direction	O	O	O	O	O
ENGAGEMENT IN LEARNING					
I guide youth in learning for themselves	O	O	O	O	O
I create opportunities for problem solving via discussion, debate, and negotiation	O	O	O	O	O
I work with youth to establish appropriate goals for their age	O	O	O	O	O
I provide opportunities for youth to link their experiences to the real world	O	O	O	O	O
I use a variety of questioning and motivational approaches	O	O	O	O	O
I use multiple learning approaches to meet learners' needs	O	O	O	O	O
OPPORTUNITIES FOR MASTERY					
I suggest challenges that can be explored by direct investigation	O	O	O	O	O
I encourage youth to make predictions	O	O	O	O	O
I assist youth in developing hypotheses related to their investigations	O	O	O	O	O
I allow youth to conduct formal and open-ended tests and experiments	O	O	O	O	O
I have youth discuss their finding with each other and evaluate evidence critically	O	O	O	O	O
I encourage youth to share their knowledge by teaching others and leading new activities	O	O	O	O	O
I help youth see setbacks as opportunities for new explorations	O	O	O	O	O
I support youth to set new goals, and try new ideas and approaches	O	O	O	O	O
I provide opportunity for youth to use appropriate technology	O	O	O	O	O

Appendix C- Science Inquiry Flowchart

Science Inquiry Flowchart



Appendix D- 4-H Science Logic Model

4-H Science Logic Model

Situation → Inputs → Activities → Outputs → Outcomes

Situation

Description of challenge, problem, or opportunity:

- Unsolved worldwide social problems need to be addressed by science.
- In the US, shortage of scientists & people understanding science.
- Under-representation of women and minorities in science careers.
- Need a diverse pool of trained scientists to frame and solve problems & educate others.
- General population in the US (& worldwide) lacks basic understanding of science methods and content ("science literacy")

Inputs

What we invest:

- Federal, state and private funds.
- 4-H Infrastructure
- Land Grant University Support
- County Extension administrators and agents, program coordinators, and specialists
- Training
- Knowledge
- Collaborations with external researchers
- Collaborations with science industry leaders

Activities

What we do:

- Select and develop 4-H Science curricula
- Select and train volunteers

Market 4-H Science to increase participation

Conduct non-formal education (learning and teaching, facilitated inquiry and discovery)

- Facilitate question formation and problem solving through guided activities
- Provide or supplement math programming
- Teach youth about academic and career choices, requirements

Who we reach ***(Participation):***

- Extension administrators, LGU and Extension faculty and staff)
- Youth (grades 3-5, 6-8, 9-12)
- Federal, state & private funders
- Partners
- Public

Outputs

What we produce:

- 4-H Science curricula
- New instructional methods
- Trained staff and volunteers
- Adult participants engaged
- Youth participants engaged
- Partners (Other Federal agencies, science museums, youth organizations, etc.) collaborating
- Marketing materials
- Evaluation materials

Outcomes

Knowledge

Occurs when there is a change in knowledge or the participants ***learn****:*

- Increased awareness of science among youth
- Improved science skills (scientific methods) and knowledge (content areas) among youth
- Increased awareness of opportunities to contribute to society using science skills
- Increased life skills (self-efficacy) among youth

Actions

Occur when there is a change in behavior or the participants act upon what they've learned and:

- Youth apply science learning to contexts outside the 4-H courses (e.g., school classes, science fairs, invention contests, etc.)
- Youth adopt and use new methods or improved technology
- Youth express interest/demonstrate aspirations towards science careers (career fairs, job shadowing, volunteer work or internships)
- Youth raise questions and identify problems to be addressed using science

Conditions

Occur when a ***societal condition*** *is improved due to a participant's action taken in the previous column:*

- Increased number and more diverse pool of youth pursuing education and careers in science related fields
- Increased and more diverse pool of trained teachers, educators, scientists
- Increased innovation addressing social problems using science