Training Guide

for The Power of the Wind

90-Minute

Science Process Skills

Adapted for 4-H by the Institute for Inquiry®

from the original:

www.exploratorium.edu/IFI/docs/Process_Skills.pdf

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Acknowledgements

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Support for this publication was provided by the 3M Foundation. The 3M Foundation invests in tomorrow's leaders to support the environment, energy solutions, and engineering.
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***The Power of the Wind* Training Guide would not have been possible without *The Power of the Wind* Youth and Facilitator Guides.**

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This curriculum is a joint project of the Office for Mathematics, Science, and Technology Education (MSTE), the College of Engineering and University Extension at the University of Illinois. Initial funding for the project was provided by Ford and SBC.

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Science Process Skills

Purpose:

- To develop a complete understanding of the process skills of science.
- To see what they look like when youth use them.
- To think about how to help youth develop their process skills.

Time:

90 minutes

Materials:

Trainer Resources

Handouts

Trainer Notes:

This training introduces the science process skills. By understanding these skills and their role in learning scientific ideas, 4-H leaders will increase their capacity to facilitate 4-H SET curriculum including The Power of the Wind so that it provides youth with increased literacy and improved abilities in science, technology, and engineering. Through participating in this workshop, 4-H leaders will understand the science process skills (related to the 30 4-H SET Abilities), and will be able to identify and augment opportunities for learners to use and develop their science process skills.

In the first part of this training, participants work in pairs as they rotate through six stations where they do science activities and identify the principal process skill used in each. Afterward, first in groups of four, then as a whole group, they discuss their findings and any differences of opinion they have. Attempting to understand and resolve these differences in identifying process skills can lead to useful and important changes in the way participants understand the skills.

These discussions prepare participants to compare the way they understand the process skills with the definitions of these skills presented by the facilitator in the second part of the training. Participants sometimes find that their understandings are incomplete or incorrect, in which case they must shift or enlarge their ideas to bring them into line with the standard definitions of the skills. However, without first connecting with their prior understandings and experience, they are unlikely to change their thinking. Providing them with definitions too early in the process could lead participants to merely accept or reject what they've been told rather than developing their own understanding of the skills. In small group discussions, participants work to reconcile their own understandings of the process skills with the definitions they've been given.

In the third part of the training, participants are given two resources for applying ideas about process skills to facilitating The Power of the Wind curriculum. The first resource aligns the seven process skills with the 30 4-H SET Abilities. The second resource provides examples of facilitation questions that target specific process skills. Using these resources, participants examine selected The Power of the Wind activities in order to identify targeted process skills and consider ways to increase opportunities for youth to develop their process skills when facilitating The Power of the Wind activities.

Process Skills
and Inquiry Learning

When learners do inquiry they are making observations, raising questions, planning and carrying out investigations, proposing tentative explanations (hypotheses), testing these explanations by making predictions, interpreting results, and communicating those results to others. Youth don't use process skills merely to be using them. Instead, they use them for the purpose of learning by connecting previous knowledge with current experience. Learners use the process skills to identify and investigate novel experiences, and, from this inquiry, build new ideas.

However, according to Wynne Harlen, noted teacher educator and author, when process skills are not developed to a sufficient degree, learners may "ignore contradictory evidence in interpreting findings and hold on to their initial ideas even though these do not fit the evidence. Thus the extent to which ideas become more scientific (by fitting more phenomena) depends on the way in which the testing of possible explanatory ideas is carried out; that is, on the use of process skills. The development of understanding in science is thus dependent on the ability to carry out process skills in a scientific manner."[1]

Children are natural inquirers. Driven by curiosity, they will instinctively raise questions and begin to investigate things. However, in order for these investigations to lead to productive development of the understanding of science concepts, learners' must be able to use the process skills effectively. Leaders who are charged with teaching science content must pay attention their youth's process skills. Youth inquiry becomes a powerful means of learning science concepts only when the learners' process skills are well developed.

1. Harlen, Wynne. The Teaching of Science in Primary Schools, 2nd ed. (London: David Fulton Publishers, 1996), p.14.

This Science Process Skills section of the Training Guide is written in several sections, with each section divided into a number of steps.

The sections and their timing are as follows:

Section 1:	***Introducing the Training***	***8 minutes***
Section 2:	***Exploring Process Skills***	***20 minutes***
Section 3:	***Small Group Discussions***	***10 minutes***
Section 4:	***Whole Group Discussion***	***20 minutes***
Section 5:	***Process Skill Definitions***	***10 minutes***
Section 6:	***Process Skills in The Power of the Wind Activities***	***20 – 30 minutes***
Section 7:	***Concluding the Training***	***2 minutes***

Section 1
Introducing the Training / 8 minutes

The facilitator explains the purpose of the training, what participants will be doing, and how long it will take.

STEP 1: Set the context for the training.

This part of the training is on the science process skills and their relation to *The Power of the Wind* curriculum. Within *The Power of the Wind* curriculum are listed a number of 4-H SET Abilities for each acivity. By participating in this training, 4-H leaders will be able to understand the 30 SET Abilities in terms of the science process skills described here, and to analyze *The Power of the Wind* activities for opportunities for using and developing learners' science process skills.

The process skills of science are the tools for gathering information, generating and testing new ideas, for building new knowledge, and for learning scientific concepts and constructing scientific explanations of the world. Process skills are especially important in inquiry-based learning because they are the tools that youth use to carry out scientific investigations.

The purpose of this training is to give you the opportunity to:

- develop a richer and more complete understanding of the process skills of science
- see what they look like when youth use them
- think about how to help youth develop their process skills

There are three parts to this training.

In part one, you'll begin by working in pairs, rotating through six very short hands-on activities that require the use of a variety of process skills. You will do just enough of each activity to identify the main process skill that it requires. Then, you and your partner will discuss your conclusions with

another pair. Even though you may come into this training having used process skills language before, you will likely find that you have differences of opinion. After groups of four talk, the conversation continues in the whole group.

We'll begin part two by giving you the standard definitions of the process skills. We wait to give you these definitions until you have had the opportunity to experience using the process skills and to discuss with each other your own ideas about them. Those discussions are meant to help you for build your own understanding rather than just memorizing definitions handed to you.

In the third part of the training, we'll practice applying ideas about process skills to facilitating *The Power of the Wind* curriculum.

STEP 2: Call attention to flipchart you've prepared: "Process Skills".

Give the group a chance to read it. Explain that for the purpose of manageability, there are only seven basic categories and explain that the 4-H SET Abilities (30) can be collapsed into these seven areas of skills used in this training.

There are other equally valid lists with more categories, but they include skills that can be subsumed under one or another of these seven. For instance, comparing can be considered a sub skill of observing; controlling variables can be considered a sub skill of planning and investigating.

STEP 3: Call attention to the flipchart you prepared: "Take-Home Messages."

You'll be working through direct experience and discussion to develop your own understanding of the ideas that these messages express.

Read the take-home messages aloud.

- Learners use process skills to build a conceptual understanding of science content.
- Process skills are not used separately but as intertwined, coherent sets of skills.
- Instructors can facilitate activities in ways that help learners develop stronger process skills.

STEP 4: Explain to participants why you chose to present this training, describing how the training relates to the SET initiative and *The Power of the Wind* curriculum.

An important part of any SET curriculum like *The Power of the Wind* are the process skills that youth learn as a result of experiencing the activities. This is a key component for the SET Checklist and after your experience with the stations and our discussions, we will go back to *The Power of the Wind* curriculum to see directly how these process skills are used. This portion of the training will help you think more deeply about how you can be intentional with these activities when working with youth.

STEP 5: Explain that this training is designed for professional development only.

Remember that this training is designed to develop and deepen your own understanding of the process skills of science. The activities at the stations are not intended to be replicated with your youth. You will find complete activities in *The Power of the Wind* curriculum that provide opportunities for youth to strengthen their science process skills.

STEP 6: Address the training schedule.

The entire training will take approximately 90 minutes.

Share with participants a breakdown of the training agenda.

Science Process Skills Agenda:

Introducing the Training	8 minutes
Exploring Process Skills	20 minutes
Small Group Discussions	10 minutes
Whole Group Discussion	20 minutes
Process Skill Definitions	10 minutes
Process Skills in *The Power of the Wind* Activities	20 – 30 minutes
Concluding the Training	2 minutes

Section 2
Exploring Process Skills / 20 minutes

In this part of the training, participants do brief science activities connected with The Power of the Wind that requires use of various science process skills. They do so in order to have a concrete, experiential reference for identifying, discussing, and refining their understanding of the skills in subsequent parts of the training. Doing the tasks and using the skills help participants think about the process skills in terms of actions rather than abstract definitions. One of the central aims of the training is to have participants describe skills 'in action'. This will help them recognize the process skills when they see youth using them.

There are six activities in all. At each station, there are simple materials the activity requires and a "task card" with directions for doing the activity. It's important that participants focus on process skills, not on learning about the scientific phenomena the activities address. After doing each activity, participants fill in the handout "Process Skills Identification Form," indicating the primary process skills required by the activity.

STEP 1: Tell participants that they will be working in pairs to identify the main process skills used in the underlined parts of each of the six tasks.

You can go to the six stations in any order, but it's important that you keep moving quickly so that you get to all of the activities. It isn't necessary to finish doing each activity. Just do enough to get a good idea of the main skill that's required.

STEP 2: Distribute the "Process Skills Identification Form" handout.

Use this form to indicate the main process skill required by the underlined part at each station. There may be several skills you use at each station, but indicate the main skill by circling it.

STEP 3: Tell participants that they'll have about 20 minutes to sample the six activities.

Have them choose partners and go to their first station.

STEP 4: Remind participants to concentrate on the main skill required of each activity.

Circulate among groups. If you see participants identifying more than one skill, remind participants to focus on the underlined part of the task card to identify the main skill required. Identifying the primary skill demands that participants think more carefully about what they understand that skill to be.

Participants may find the activity at a particular station very engaging and want to remain at that station. However, encourage them not to linger at any one station.

STEP 5: Give a five-minute warning.

About five minutes before time is up, let participants know how much time they have to complete their work.

STEP 6: Announce when time is up.

Go on to the small group discussion.

Section 3
Small Group Discussions / 10 minutes

Participants meet in groups of four to discuss which main process skills they've identified for the six activities. Grounding the discussion in the concrete experience at the stations encourages participants to discuss process skills as they are actually practiced, rather than in the abstract.

Differences in identification may arise for a number of reasons. First, many people may have incorrect or incomplete understandings of how to define the process skills. In addition, when you do any activity, you inevitably use a number of skills, often simultaneously. For instance, observing is part of just about anything you do. Therefore, it may be difficult to "pull apart" the skills being used in order to identify the primary one. Finally, people may have legitimate differences of opinion about what actions actually indicate the use of particular skills.

Participants' disagreements prompt them to probe their own thinking about process skills as they try to articulate their reasons for choosing the skills they did.

STEP 1: Have participants compare their findings in groups of four.

Ask each pair to join another pair, then distribute the handout "Directions for Activities at the Stations" to help participants recall the six activities. For your preparation for this section, you might want to review the Facilitation Hints for Small Group Discussion Training Resource.

Tell participants to take 10 minutes to discuss what they identified as the main process skill at each station, noting areas of agreement and disagreement.

Section 4
Whole Group Discussion / 20 minutes

During the whole group discussion, the facilitator takes on a more central role: guiding the conversation, eliciting opinions about the skills, asking participants to explain their thinking, inviting expression of differences of opinion, and encouraging participants to compare their views with those of others. Through this whole group dialogue, participants begin to experience changes in their own thinking. In some instances, they shift from defining process skills abstractly to describing them in action. In others, they may actually change their understanding of the meaning of the process skill terms. In both cases, participants develop a more complete and accurate understanding of the science process skills, preparing them to adopt commonly held definitions of the process skills that will be presented later in the training.

For your preparation for this section, review the Facilitation Hints for Whole Group Discussion and the Process Skills at the Stations Training Resources.

STEP 1: Discuss the main skill for each station.

We will discuss each station, not just to come up with the "answer," but also to identify skills that were most difficult so we can discuss them. To do this, we'll go through each station asking for what someone identified as the main skill and why, and then if anyone else identified different skills and why. Out of these disagreements, we'll try to sort out the hallmarks of each skill and why some are difficult to distinguish. Let's start with station 5, which probably had a lot of agreement.

Begin with station 5 (Pinwheels and Scissors) on questioning. Then, move through each of the stations, asking:

What did you identify as the main skill at (a particular station)? Why did you identify it as _____ (e.g. questioning)?

Ask for a show of hands if others agree.

Did anyone identify a different main skill for this station, and why?

If people mention skills that are not the intended main skill, try to acknowledge how you think the skill they mentioned could be involved in the activity. If it is part of the activity that is not underlined, articulate where it could be part of the activity, but then emphasize that the underlined part asked for something different. If the skill mentioned is closely related to the intended main skill, articulate how the skill mentioned is involved in the activity but not the main skill.

For example, "Interpreting is involved in this activity (station 6B, the # of blades station) because you have to interpret your findings in order to be able communicate them. However, communication was designed as the main skill because you were asked to make a drawing that shows your ideas, and the 'showing to others' part emphasizes the communication aspect in this task."

In the process of going through each station and articulating why it was designed to be one skill rather another, you are likely to need to address the differences between specific skills, especially between hypothesizing, predicting, and interpreting. See the Training Resource – Facilitation Hints for the Whole Group Discussion for tips.

STEP 2: Wrap up the discussion.

It's not surprising when there are disagreements or difficulties in identifying individual process skills. Sometimes it's hard to identify a single process skill for each of the underlined directions because in practice, process skills are not used one at a time. The science process skills are not applied separately from each other in a prescribed step-by-step order.

In actual practice, what we call process skills are not individual skills but combinations, or blends, of several skills. But, as leaders, we need to address the skills separately so that we can identify where youth are in their development of each skill in order to focus on helping them strengthen particular skills.

You've discussed your own understandings of the process skills and have seen how difficult it can be to define them. Next, we will look at standard definitions of the process skills. Those definitions can help us resolve any remaining disagreements and lead to some new understandings of process skills.

Section 5
Process Skill Definitions / 10 minutes

All of the discussion and activity to this point has prepared participants to think deeply about process skills and to consider whether their previous understandings of these skills are accurate or need to be reconsidered. In this part of the training, the facilitator presents standard definitions of process skills, and participants spend time discussing the definitions and comparing them to their ideas. Doing this helps participants develop a common language about process skills, and to develop deeper understanding that they will apply to the rest of the training and to the work they'll do when they implement The Power of the Wind.

STEP 1: Explain why a common language for the process skill is important.

You've done a great deal of thinking and talking so far, exploring your own and each other's ideas about process skills. In doing so, you have likely come to a deeper understanding of their meaning. However, in order to work effectively with process skills when you facilitate and to discuss process skills productively with other facilitators, it's important to develop a common language when we describe these skills.

STEP 2: Distribute the "Process Skills: Definitions and Examples" handout and have participants discuss.

These definitions and examples that we are handing out represent commonly accepted uses of the process skills terms. They are based on a number of sources, including the National Science Education Standards, the American Association for the Advancement of Science Benchmarks for Science Literacy, noted science educator Wynne Harlen's book *The Teaching of Science in Primary Schools*, and others. In some cases, these definitions will simply expand your current understanding. In other cases, they may challenge you to reconsider your views.

Now in your groups of four, spend five minutes discussing these definitions and examples.

- How do these definitions fit with your own understanding of the skills? In your discussion, pay particular attention to those skills where you had disagreements or confusion.

STEP 3: Reconvene the whole group and have participants share ideas and questions from their groups of four.

- Do you have any questions or differences of opinion remaining about any of these skills?

If so, say

- Can anyone help resolve these differences or answer these questions?

STEP 4: Distribute the handout "How Hypothesizing, Predicting, and Interpreting Differ".

It's very common for people to have questions about the definitions of hypothesizing, predicting, and interpreting or the differences among them. Distribute and review the handout, "How Hypothesizing, Predicting, and Interpreting Differ" to address any remaining questions.

Section 6

Process Skills in *The Power of the Wind* Activities / 20 minutes

In this section, participants have an opportunity to apply their understanding of the science process skills to The Power of the Wind activities. Participants are first asked to analyze an activity to identify opportunities for youth to use specific process skills. Then, participants try to think of ways to increase opportunities for using science process skills by adding a question that encourages the use of a process skill to an activity. Participants are given two resources to support them in identifying opportunities for using process skills in The Power of the Wind activities: the Aligning 4-H SET Abilities to Process Skills, and the Questions to Encourage Process Skills handouts.

The Power of the Wind Curriculum provides many opportunities for youth to use (and thereby develop) their science process skills. These opportunities come from the design of the activities themselves and from many questions written into the activities. Instructors who can analyze which process skills are encouraged, as well as which are not, by the activities and questions in each The Power of the Wind activity can effectively choose questions to highlight, reinforce or add to promote a balanced use of process skills and to tailor the activities to the abilities of the group they are facilitating.

STEP 1: Explain how the process skills apply to *The Power of the Wind* curriculum.

Now we want to look at selected *The Power of the Wind* activities to look for opportunities for youth to use their science process skills. Once we understand which process skills are encouraged in an activity, as well as which are not, we can facilitate in a more effective way. For example, many of the activities include lists of questions for youths to consider. We can identify which skills those questions encourage and emphasize those questions that provide a balanced variety of process skills. We can also consider adding questions that encourage skills that are not evident in an activity.

To help us in looking for process skills in the activities, we'll look at two resources. A handout aligning the 30 4-H SET Abilities referred to in *The Power of the Wind* Curriculum with the seven science process skills we've discussed, and a handout showing examples of questions that encourage particular process skills.

STEP 2: Distribute the handout: "4-H SET Abilities Related to the Science Process Skills".

This handout shows the 4-H SET Abilities listed under a related science process skill. Remember that some skills are a sub skill of another skill. You can see that there are many sub skills involved in Planning and Investigating. *The Power of the Wind* Facilitator's Guide lists which 4-H SET Abilities each activity encourages. This document is meant to help you align what is written in the curriculum with the skills we've just discussed.

STEP 3: Distribute the handout: "Questions that Encourage Process Skills".

This handout shows a number of ways that you can word a question to encourage a particular process skill. Although these questions are written in the context of an activity involving youth planting seeds, they are meant to provide you with ways of wording questions that can be used in any topic. Let's use these to help us look at the questions in a The Power of the Wind activity to identify which process skills are encouraged.

STEP 4: Identify opportunities for process skills in a *The Power of the Wind* activity.

Refer people to the Pinwheel Investigation on page14–15 of The Power of the Wind Facilitator's Guide.

Let's start by analyzing what skills these questions encourage. Can you find a question that encourages observation skills?

Give participants a minute or two to find examples of questions that encourage observation skills. Share the examples below if participants don't mention them.

- What happens when you blow into the back of the pinwheel or if you blow into the sides?
- What happens when you make another pinwheel from a larger square?
- Does it turn faster or slower?[2]

Then ask,

- Can you find an example of a question that encourages communication skills?

Give participants a minute or two to find examples of questions that encourage communication skills. Share the examples below if participants don't mention them.

- How can you help younger children to design pinwheels?
- How can you teach them how pinwheels work?
- Can you create a short lesson for children in your neighborhood?[3]

STEP 5: Add questions to encourage additional process skills.

Now that we've practiced analyzing what skills the questions in the Guide provide opportunities for, we can consider adding questions that provide additional or richer opportunities for learners to use their process skills. We're not doing this because the lessons are necessarily in need of improvement; it's because when a facilitator understands how to encourage the use of process skills, they can take advantage of opportunities that arise during the lesson to deepen learners' thinking.

For example, if someone expresses that something is interesting, you can ask if they have any questions about it. If they have a question or hypothesis such as "I wonder if this is happening because … ?", you can ask them if they can plan an investigation to answer their question or test their hypothesis. Once they've done an investigation, you can ask them what they concluded. By asking questions that encourage process skills, you can help youth become more skilled at finding answers to their own questions.

2,3 Sebestick, J. *The Power of the Wind* Youth Guide. University of Illinois, 2008, p. 15.

Let's look again at the Pinwheel activity on page 15. The skill of questioning isn't explicitly encouraged. Can you design a question that encourages learners to ask questions about pinwheels? Work with a partner and use the handout on Questions that Encourage Process Skills if you need help.

Give participants a few minutes to design a question that encourages youth to use their questioning skills. Share the examples below if participants don't mention them.

- What questions do you have about pinwheels?
- What else do you want to know about pinwheels?
- What questions could you answer by making different pinwheels?

These are questions that you could use after learners have some experience with making pinwheels that would tell you what they were interested in. Once you know their interests, you can ask them what they could do to try to answer their questions. Let's try another.

Refer participants to Which Turbine Design is Better for the Job? lesson in The Power of the Wind Facilitator's Guide, pages 20 – 21.

In this lesson, learners are given a procedure for comparing low and high solidity windmills and to fill out a data table. Can you think of a question to ask or some other way to encourage learners to use their investigation planning skills?

Have partners or groups talk for two to three minutes and then take responses. Share the examples below if participants don't mention them.

- What could you do to find out whether a low or high solidity windmill spins faster or lifts weight better?
- How could you determine the relationship between the solidity of a windmill and its speed or the solidity of a windmill and how much weight it can lift?

Have learners follow the "Try-It" procedure but make their own data table. (This promotes planning skills because, to make a data table, they need to determine what to observe or measure and how many trials to run).

Section 7
Concluding the Training / 2 minutes

This brings us to the end of this training on Science Process Skills. So far, we've tried to understand the science process skills and distinguish them from each other through doing and discussing activities that were designed specifically to emphasize particular skills. Then, we practiced analyzing *The Power of the Wind* lessons for the opportunities for encouraging process skills. Finally, we practiced adding questions to lessons to increase opportunities for using process skills.

This training was meant to help you create greater opportunities for learners to develop their SET abilities and increase their science literacy.

Summarize the main ideas that came up during the training by reading aloud the take-home messages on the flip chart and adding in key comments from the participants.

Observing

Questioning

Hypothesizing

Predicting

Planning and Investigating

Interpreting

Communicating

TRAINER RESOURCE Take-Home Messages for Flip Chart

Learners use process skills to build a conceptual understanding of science content

Process skills are not used separately but as intertwined, coherent sets of skills.

Instructors can facilitate activities to help learners develop stronger process skills.

Process Skills Stations

1. Pinwheel And Cup Turbine

Materials needed:

- scissors
- straight pins
- pencil with eraser
- pinwheel pattern from Appendix A or B
- 5 oz. paper cup
- masking tape
- drinking straw
- bamboo skewer
- copy of station 1 task card

Set-up:

Make the pinwheel following the directions on page 16 of The Power of the Wind Youth Guide.

To make a "Savonius" cup turbine

- cut a 5 oz paper cup in half, cutting down the side and across the bottom of the cup
- tape the edge of one of the half cups to the straw
- tape the other half cup, upside down along the opposite side of the straw so it appears "s"-shaped when viewed from above
- Put the bamboo skewer through the straw, hold either end of the skewer, and blow

Set up both assembled turbines and the task card at the station.

2. Big And Small "Boats"

Materials needed:

- one 8 oz. paper cup and one 16 oz. paper cup
- ruler or meter stick
- copy of station 2 task card

Set-up:

- Place the cups upside down on the table with the ruler and task card at the station

3. Pinwheel And Straw

Materials needed:

- scissors
- straight pins
- pencil with eraser
- pinwheel pattern from Appendix A or B
- drinking straws
- copy of station 3 task card

Set-up:

- Make the pinwheel following the directions on page 16 of *The Power of the Wind* Youth Guide.
- Set up the assembled pinwheel, enough drinking straws for each participant, a trash can, and the task card at the station.

4. High Speed Turbine

Materials needed:

- copy of station 4 task card

Set-up:

- This station only needs a task card

5. Pinwheel And Scissors

Materials needed:

- scissors
- straight pins
- pencil with eraser
- Pinwheel pattern from Appendix A or B for each pair
- copy of station 5 task card

Set-up:

- Make one pinwheel following the directions on page 16 of *The Power of the Wind* Youth Guide.
- Set up the assembled pinwheel and the pinwheel materials so each pair can make their own pinwheel to compare to the pre-made one. Also, set up a trash can and the task card at the station.

6. Number of Blades

Materials needed:

- scissors
- straight pins
- pencil with eraser
- Pinwheel pattern from Appendix B and Appendix C for each pair
- extra paper for participants to draw on or to make additional pinwheels
- copy of station 6 task cards

Set-up:

- Make two pinwheels following the directions on pages 16 and 18 of *The Power of the Wind Youth Guide*. Set up the assembled pinwheels and the pinwheel materials out so each pair can make additional pinwheels. Also, set up a trash can and the task card at the station.

Background for Facilitators

Facilitation Hints for Exploring Process Skills

Knowing the tasks and the intended main skill at each station will help you facilitate both the work at the stations and the subsequent discussions.

Participants, however, may identify different skills, either because of inaccurate understandings of the process skills or because of legitimate differences of opinion about which process skills are actually required to complete these tasks. Since the point of this part of the training is to uncover participants' initial ideas, it's not important that they identify the process skill needed exactly as they appear below.

1. Pinwheel And Cup Turbine
Intended main skill:
Observing

Other skills: Planning and Investigating

2. Big and Small "Boats"
Intended main skill:
Predicting

Other skills: observing

3. Pinwheel And Straw
Intended main skill:
Hypothesizing

Other skills:
Observing, Planning, and Investigating

4. High Speed Turbine
Intended main skill:
Interpreting

5. Pinwheel And Scissors
Intended main skill:
Questioning

6. Number of Blades
A. Intended main skill:
Planning

B. Intended main skill:
Communicating

Other skills: Interpreting

TRAINER RESOURCE Facilitation Hints for Small Group Discussions

Listen for Interesting Conversations

Circulate among groups, assist any that need help, and listen for interesting discussions or disagreements that you can refer to during the whole group discussion. You may want to make notes as you move around the room.

Keep Discussions Going

Groups sometimes finish their conversations very early. They may say that they agreed on everything. To get their conversations restarted, you can ask:

> *Was there anything you initially disagreed about? If so, how did you come to agreement?*

You can also ask:

> *What did you do at (a particular station) that indicated you were using the process skill you identified?*

Asking about actions participants took helps move their thinking about process skills out of the abstract and also encourages them to examine the reasoning behind their choices.

Uncover Reasons for Opinions

If groups are stuck in disagreement, encourage each group member to articulate the thinking underlying his or her opinion.

Defer Giving Definitions

Sometimes groups will ask you for a definition of one of the process skills. Remind them that at this point in the training, you want them to clarify and examine the ideas they bring to the discussion from their previous experiences. Giving them a definition would short-circuit that process. Ask them to note their ideas and differences of opinion so they can bring them to the whole group discussion where they can work at coming to some resolution.

TRAINER RESOURCE Facilitation Hints for Small Group Discussions

Expect Some Agreement with the Process Skills in Action

Participants may recognize elements of the "Process Skills in Action" that confirm their own views but are stated in a different way (e.g., "Make use of several senses in exploring objects or materials" will agree with most people's idea of observing). They may also find descriptions that expand their thinking (e.g., "Distinguish from many observations those which are relevant to the problem in hand" clearly has to do with observation, but will not have been considered previously by most people). For many people, the "Observing Process Skills in Action" handout gives them a way of thinking about describing process skills with more precise and concrete language.

Also Expect Some Disagreement

On the other hand, participants may find that they disagree with the way certain behaviors are described (e.g., "Use patterns in information or observations to make justified interpolations or extrapolations" is given as a prediction skill, but many participants may regard using patterns as an interpretation skill). Whether they agree or disagree with the descriptions, participants will have examined their current thinking in light of the new information presented in the handout.

TRAINER RESOURCE Facilitation Hints for Whole Group Discussion

Be Prepared

Typically, the conversation and the confusion in the large group discussions center around the skills of hypothesizing, predicting, and interpreting. It is essential that the facilitator of this conversation have a firm grasp of these terms beyond simply how they are defined, so that he or she can help deal with any confusion that arises.

Address the Term Hypothesis

The term hypothesis may be confusing for participants because there are differences in how science educators use it. Simply put, hypothesizing is an attempt to answer the question "Why . . . ?" In other words, a hypothesis is a tentative explanation of an event or phenomenon. A hypothesis is not necessarily correct, but it should be reasonable in terms of available evidence and science concepts. In addition, a hypothesis is testable— there must be a way to prove it wrong. Some people refer to a hypothesis as an "educated guess." Although that's technically correct, using the word guess tends to confuse people about how much knowledge and evidence is required to form a good hypothesis.

Address the Term Predicting

There may also be a good deal of confusion about the meaning of predicting. Many people regard a prediction as "just a guess," in contrast to a hypothesis as an "educated guess." In fact, a prediction is based on knowledge about what has happened before, a pattern of evidence, or a hypothesis. It is a response to the question, "What will happen in this particular instance if . . . ?" When a prediction is based on a hypothesis, it can serve as a test of that hypothesis. An incorrect prediction demonstrates that the hypothesis is incorrect. A correct prediction strengthens confidence that the hypothesis is valid. But it does not prove conclusively the validity of the hypothesis because further predictions based on the hypothesis may turn out to be incorrect.

TRAINER RESOURCE Facilitation Hints for Whole Group Discussion

Address the Term Interpreting

Interpreting can get confused with hypothesizing since sometimes interpretations lead to tentative explanations. Interpreting is distinguished by the assessment of data, checking for reliability, and looking for patterns or other meaning. Interpreting may involve organizing, analyzing, and synthesizing data using statistical analysis, tables, graphs, and diagrams. Although interpreting data may result in a set of facts that lead to a hypothesis, it is not the formation of a hypothesis.

Distinguish between Predicting and Hypothesizing

Making the distinction between predicting and hypothesizing clear generally requires a good deal of discussion with reference to the particular activities that use those skills. In general, a prediction refers to a particular case. A hypothesis is a proposed explanation that can be applied to a broad range of cases.

Distinguish between Hypothesizing and Interpreting

As mentioned above, there is often confusion between hypothesizing and interpreting. It is important to bring to light what people think about different sorts of evidence (or data) and different uses of that evidence in the process of doing science. In general, interpreting involves finding a pattern or other meaning in a collection of data.

TRAINER RESOURCE How Hypothesizing, Predicting, and Interpreting Differ

Hypothesizing

Answers the question
Why. . . ?

(E.g., Why does the sweater keep me warm?)

A hypothesis proposes an explanation (based on observation, evidence, and past experience) of events or phenomena.
(A hypothesis may or may not be correct.)

EXAMPLE:
Sweaters and other warm things keep me warm because they make heat.

Predicting

Answers the question
What will happen in this particular instance if. . . ?

(E.g., What will happen if I put a thermometer in my sweater and let it sit there for several hours?)

A prediction takes experience into account and is often based on a hypothesis.

EXAMPLE:
If I put a thermometer in my sweater and leave it there for several hours, it will show an increase in temperature.

Interpreting

Answers the question
What do my data tell me?

(E.g., What does the fact that the temperature did not go up after several hours tell me?)

An interpretation is a conclusion based on analysis and assessment of the data.

EXAMPLE:
The fact that the temperature did not go up after several hours tells me that either there was a flaw in my experiment or sweaters don't make heat.

Station 1 TASK CARD

1. Pinwheel And Cup Turbine

What is the main process skill you would use to carry out the directions in the underlined phrase?

Blow on both turbines soft and hard.

Can you think of other ways to compare the two turbines?

What similarities and differences

do you notice between the two turbines?

Station 2 TASK CARD

2. Big and Small "Boats"

What is the main process skill you would use to carry out the directions in the underlined phrase?

Place the cups face down on the table.

Blow on the big boat as hard as you can and measure the distance it travels.

How far do you think the small boat will go if you blow on it the same way?

Station 3 TASK CARD

3. Pinwheel And Straw

What is the main process skill you would use to carry out the directions in the underlined phrase?

Blow on different parts of the pinwheel with a straw.
What do you notice?

Use your observations to explain which parts of the pinwheel you think are most responsible for making it turn in the wind?

Station 4 TASK CARD

4. High-Speed Turbine

What is the main process skill you would use to carry out the directions in the underlined phrase?

A farmer wondered if her turbine was working well at high speeds. Here is a chart showing her energy output at different wind speeds.

Wind speed	Energy output
5 mph	10 KW/H
10	80 KW/H
20	640 KW/H
40	1020 KW/H

Do you think that there might be any problem at 40 MPH?

Station 5 TASK CARD

5. Pinwheel and Scissors

What is the main process skill you would use to carry out the directions in the underlined phrase?

Cut any shape out of one pinwheel pattern and make a pinwheel. Blow on it and compare it to the assembled pinwheel.

Given your observations, what more do you want to know?

Station 6 TASK CARD

6. Number of Blades

What is the main process skill you would use to carry out the directions in the underlined phrase?

You want to find out the impact of the number of blades on the speed of a pinwheel (using a triangle, square, pentagon, etc.)

A. How many blades would you try?
How big would each shape be?
How many tests would you do?
How hard would the wind be?

B. Think about what you found out from your investigation on the impact of the number of blades on the speed of a pinwheel. Make a series of drawings with labels that shows the results of your investigation.

HANDOUT Process Skills Identification Form

Identify the main process skill needed to complete the underlined directions in each activity.

PROCESS SKILL	1. Pinwheel & Cup Turbine	2. Big & Small "Boats"	3. Pinwheel & Straw	4. High Speed Turbine	5. Pinwheel & Scissors	6. Number of Blades A B
Observing						
Hypothesizing						
Planning						
Interpreting						
Communicating						
Questioning						
Predicting						

HANDOUT Directions for Activities at the Stations

1. Pinwheel And Cup Turbine

Blow on both turbines soft and hard.

Can you think of other ways to compare the two turbines?

What similarities and differences do you notice between the two turbines?

2. Big And Small "Boats"

Place the cups face down on the table. Blow on the big boat as hard as you can and measure the distance it travels.

How far do you think the small boat will go if you blow on it the same way?

3. Pinwheel And Straw

Blow on different parts of the pinwheel with a straw. What do you notice?

Use your observations to explain which parts of the pinwheel you think are most responsible for making it turn in the wind

4. High Speed Turbine

A farmer wondered if her turbine was working well at high speeds. Here is a chart showing her energy output at different wind speeds.

Wind Speed	*Energy Output*
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40	1020 KW/H

Do you think that there might be any problem at 40 MPH?

5. Pinwheel And Scissors

Cut any shape out of one pinwheel pattern and make a pinwheel. Blow on it and compare it to the assembled pinwheel.

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6. Number of Blades

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A. How many blades would you try?
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How many tests would you do?
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B. Think about what you found out from your investigation on the impact of the number of blades on the speed of a pinwheel. Make a series of drawings with labels that shows the results of your investigation.

4-H SET Abilities Related to the Science Process Skills

The 30 4-H SET abilities are listed below each underlined process skill.

Observing

- Observe
- Compare

Questioning

- Question
- State a problem

Hypothesizing

- Hypothesize
- Troubleshoot *(can also be a planning skill if done systematically)*

Predicting

- Predict
- Test *(a prediction can be used to test a hypothesis)*

Planning and Investigating

- Plan an investigation
- Use Tools
- Develop Solutions
- Design Solutions
- Problem Solve
- Measure
- Draw/Design *(can also be a communication skill)*
- Build/Construct
- Collect Data
- Invent/Implement Solutions
- Redesign
- Optimize *(can also be interpreting when related to how the data points to the best solution or design)*

Interpreting

- Categorize/Order/Classify
- Organize
- Infer
- Evaluate
- Research a Problem
- Interpret/Analyze/Reason
- Optimize *(can also be planning if it involves planning what to do to find out the best design or solution)*

Communicating

- Model/Graph/Use Numbers
- Summarize/Relate
- Demonstrate/ Communicate to Others
- Collaborate *(can also be planning if it involves working together to solve a problem)*

HANDOUT Process Skills: Definitions and Examples

The science process skills are the tools that students use to investigate the world around them and to construct science concepts, so it's essential for teachers to have a good understanding of these skills. However, identifying and defining the process skills is not always a simple task.

The first problem is that the skills aren't practiced discretely. When you look at a real-life situation, you're likely to find several related skills being used more or less at the same time. Consider, for example, trying to explain why water drops appear on the outside of a can filled with ice: You're observing the phenomenon, you're interpreting what your observation means, and you're proposing a hypothesis, or explanation. It can be challenging to tease out separate skills because to a certain extent the boundaries are artificial. But it's necessary to be able to distinguish individual skills in order to work effectively with students.

The second problem concerns how broadly or narrowly the skills should be defined. The skill of classifying, for example, while often found listed as a separate skill, can also be viewed as a subskill of observing. Because it can be quite cumbersome to work with a long list of narrowly defined skills, this document presents seven broadly defined skills and indicates subskills where appropriate.

The definitions and examples given below are based on a number of sources and represent commonly accepted uses of the process skill terms.

OBSERVING

Using the senses and appropriate tools to gather information about an object, event, or phenomenon.

> **SUBSKILLS** include collecting evidence, identifying similarities and differences, classifying, measuring, and identifying relevant observations.
>
> **EXAMPLE:** Listing the similarities and differences of a cube of ice and a ball of ice.

HANDOUT Process Skills: Definitions and Examples

QUESTIONING

Raising questions about an object, event, or phenomenon.

SUBSKILLS include recognizing and asking investigable questions; suggesting how answers to questions can be found; and turning a noninvestigable question into a question that can be acted upon.

EXAMPLE: Asking "Will ice melt faster with or without salt sprinkled on it?"

HYPOTHESIZING

Giving a tentative explanation, based on experience, of a phenomenon, event, or the nature of an object. A hypothesis is testable. A hypothesis is not the same thing as a prediction, which is the expected outcome of a specific event. However, a hypothesis can be used to explain specific events.

SUBSKILLS include inferring, constructing models to help clarify ideas, and explaining the evidence behind a hypothesis.

EXAMPLE: Increased surface area causes faster melting. (This explains why crushed ice will melt faster than a block of ice of the same mass.)

PREDICTING

Forecasting the outcome of a specific future event based on a pattern of evidence or a hypothesis (an explanation). A prediction based on a hypothesis can be used in planning a test of that hypothesis. NOTE: A prediction is not a wild guess.

SUBSKILLS include justifying a prediction in terms of a pattern in the evidence, and making a prediction to test a hypothesis.

EXAMPLE: Water flowing from a height of eight inches will wash away more sand than water flowing from a height of six inches. This prediction is based on the pattern that water flowing from six inches washed away more sand than water flowing from four inches, and water flowing from four inches washed away more sand than water flowing from two inches.

HANDOUT Process Skills: Definitions and Examples

PLANNING AND INVESTIGATING

Designing an investigation that includes procedures to collect reliable data. Planning includes devising a way to test a hypothesis. NOTE: Planning is not always formal.

SUBSKILLS include identifying and controlling variables, and using measuring instruments.

EXAMPLE: Deciding to put a teaspoon of salt on one ice cube and a teaspoon of sugar on another identical ice cube; setting them side by side, and observing their relative melting rates in order to determine if one melts faster than the other.

INTERPRETING

Considering evidence, evaluating, and drawing a conclusion by assessing the data, In other words, answering the question, "What do your findings tell you?" Finding a pattern or other meaning in a collection of data.

SUBSKILLS include interpreting data statistically, identifying human mistakes and experimental errors, evaluating a hypothesis based on the data, and recommending further testing where necessary.

EXAMPLE: After observing the melting rates of an ice cube sprinkled with salt and one without salt, concluding that salt reduces the freezing point of water.

COMMUNICATING

Representing observations, ideas, theoretical models, or conclusions by talking, writing, drawing, making physical models, and so forth.

SUBSKILLS include talking with a more knowledgeable person, using secondary sources, presenting reports, constructing data tables, and creating charts and graphs.

EXAMPLE: Describing the relationship between the melting time for an ice cube and amount of salt sprinkled on the cube by writing about it or by constructing a graph.

NOTE: These definitions are adapted from the following sources:

American Association for the Advancement of Science. "The Nature of Science."

Chap. 1 in *Benchmarks for Science Literacy*. New York: Oxford University Press, 1993.

The American Heritage Stedman's Medical Dictionary. Boston: Houghton Mifflin, 2002.

Harlen, Wynne. *The Teaching of Science in Primary Schools*. 3rd ed. London: David Fulton Publishers, 2000.

National Research Council. "Science Content Standard." Chap. 6 in National Science Education Standards. Washington, DC: National Academy Press, 1996.

Ostlund, Karen. "What the Research Says About Science Process Skills." *Electronic Journal of Science Education* vol. 2, no. 4 (June 1998) http://unr.edu/homepage/jcannon/ejse/ostlund.html.

Padilla, Michael J. "The Science Process Skills." *Research Matters–to the Science Teacher* no. 9004 (March 1, 1990) http://www.educ.sfu.ca/narstsite/publications/research/skill.htm

HANDOUT Questions for Encouraging Process Skills

Process-centered questions ask students to use their process skills when exploring. These kinds of questions can be valuable in many different teaching situations. The examples here, for instance, would be appropriate to ask at different points during an exploration about planting and growing different kinds of seeds.

OBSERVING

- What do you notice that is the same about these seeds?
- What differences do you notice between seeds of the same kind?
- Could you tell the difference between them with your eyes closed?
- What do you see when you look at the seeds with a magnifying glass?

QUESTIONING

- What questions would you like to ask about seeds?
- What questions could you answer by planting and observing the seeds?

HYPOTHESIZING

- Why do you think the seeds are not growing now?
- What do you think will make the seeds grow faster?
- Why do you think that would that make them grow faster?
- Why do you think the soil will help the seeds to grow?
- Why do you think these plants are growing taller than those?
- What do you think has happened to the seeds?
- Where do you think these leaves came from?

HANDOUT Questions for Encouraging Process Skills

PREDICTING

- What do you think the seeds will grow into?
- What do you think will happen if the seeds have soil but not water?
- What do you think will happen if we give the seeds more (or less) water/light/warmth?

PLANNING

- What will you need to do to find out… (if the seeds need soil to grow)?
- How will you make it a fair test (make sure it's the soil, and not something else, making the seeds grow)?
- What materials will you need?
- What will you have to look for to answer your question?

INTERPRETING

- Did you find any connection between …
  (how fast the plant grew and the amount of water/light/warmth it had)?
- Is there a connection between the size of the seed and the size of the plant?
- What made a difference in how fast the seed began to grow?
- Was soil necessary for the seeds to grow?

COMMUNICATING

- How are you going to keep track of what you did in the investigation and what happened?
- How can you explain to the others what you did and found out?
- What kind of chart/graph/drawing would

4-H Pledge

I Pledge my **Head**
to clearer thinking,

my **Heart** to greater loyalty,

my **Hands** to larger
service,

and my **Health** to
better living,

for my club, my community, my country, and my world.