Science education can be improved by immersing learners in the process of "doing" science. Informal outdoor learning environments, such as a school pond and outdoor learning center, are ideal settings for learners to practice the skills used in scientific inquiry. This kind of learning is called **experiential learning**. Personal experience and direct observation are the basis of experiential learning and are key to the scientific inquiry process.

Science as inquiry

The *National Science Education Standards* (National Academy Press, 1996) are organized into seven content areas. These are:

1. Science as Inquiry
2. Physical Science
3. Life Science
4. Earth and Space Science
5. Science and Technology
6. Science in Personal and Social Perspectives
7. History and Nature of Science

Science as Inquiry is used as a skill in each of these content areas. According to the national standards, "Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others." Learners work toward the ability to do full inquiry by "doing" science that is within their developmental capabilities at each grade level.

Content standard for science as inquiry: fundamental abilities necessary to do scientific inquiry

Grades K–4

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Use simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.
- Communicate investigations and explanations.

Grades 5–8

- Identify questions that can be answered through scientific investigation.
- Design and conduct a scientific investigation.

  Use appropriate tools and techniques to gather, analyze, and interpret data.

- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Introducing Oregon's Scientific Inquiry Scoring Guides to assess skills

Beginning in the 2003–2004 school year, inquiry will become the focus of learner assessment in science. Scientific Inquiry work samples assessed with a Scientific Inquiry Scoring Guide (as adopted April 26, 2001) will be required by the Oregon Department of Education (ODE).

Scoring guides, or rubrics, contain the criteria for assessment of activities, events, conceptual development, or goals for learners. In addition to its use as an assessment tool, a scoring guide should communicate goals and desired learner outcomes to the learners.

The ODE Scientific Inquiry Scoring Guides are composed of four dimensions:

- Forming a question or hypothesis
- Designing an investigation
- Collecting and presenting data
- Analyzing and interpreting results

The ODE Scientific Inquiry Scoring Guide (4/26/01) for Benchmark 2 (Grade 5) is provided in Appendix I.

Each of the four dimensions of the scoring guide are rated on a 6-point scale, with 6 being the highest score and 1 the lowest. A rating of 4 or higher is considered satisfactory. Teachers are expected to provide instruction and classroom assessment in all four dimensions of the scoring guide. "Forming a question or hypothesis" is not added to the work sample assessment until Benchmark 3 (Grade 8).

Scientific Inquiry work samples are assessed beginning at Benchmark 2 (Grade 5). They are reported for school district work sample management on the following implementation schedule.

2003–2004	***2004–2005***	***2005–2006***
Collecting	Designing Collecting	Designing Collecting Analyzing

Let the inquiry begin!

A class of fifth graders plans to visit the pond. The theme for the lesson is, "A pond community is made up of many unique and interesting plants and animals."

What might a scientific inquiry program at the habitat area pond look like? See the 4-H Science Inquiry Model (Figure 1, page 7).

Choosing questions

Begin in the classroom. Ask learners what they know about life in and around ponds. This helps determine the skills and understanding the learners already have. Record the learners' answers on the board. Now you can identify any gaps in the learners' knowledge or any misconceptions they may have about ponds (Figure 1, box 1). How should these gaps be filled?

Ask learners what they would like to know about the plants and animals in the pond community. What questions do they have (Figure 1, box 2)? You can guide their thinking by asking questions, too. Do we know which plants and animals are there? How does water get into the pond? Does the pond's water level ever get low? Why? Record the learners' questions on the board. Their responses will help you plan how to unfold the lesson.

Now, divide the group of learners into several small work teams. Ask each team to choose one of the questions on the board to investigate at the pond. The leader takes on the role of facilitator and coach, directing the selection of investigative topics and helping each team to refine its question. Help the teams focus by framing questions using cognitive terminology such as *classify, analyze, predict*, and *create*. Through this interactive process, the learners are engaged in planning and directing their own learning experience.

Once each team has chosen a question (Figure 1, box 3), members of the team design a simple investigation determining what information and data they must collect to answer their question (Figure 1, box 4). They make a list of the equipment they need to collect the data and design a data sheet to record the data (Figure 1, box 5).

The class is now ready to go out to the pond, taking along the equipment—nets, pans, thermometers, water-quality test kits, binoculars, and field guides—that they will need to complete their proposed investigation (Figure 1, box 6).

Explaining findings

Will all the questions selected by the teams be answered on their first trip to the pond? Probably not. When they return to the classroom, learners can use their data to formulate an explanation of their findings. They also may generate new questions. Teams may collaborate and share data. For instance, one team may realize that they should have taken the water temperature at the pond; but, another team has done so and can share their results.

With the assistance of the teacher, learners may do library research or design further investigations at the pond to continue the learning. They also may create models to test new explanations.

If the group or a team is not satisfied with the findings, they may refine the question (Figure 1, box 11B to box 12) and design a new investigation (Figure 1, box 4). If they are satisfied with the findings, they may begin an inquiry on a different topic (Figure 1, box 11A to box 1).

To complete the scientific inquiry process, learners describe their investigations and communicate their analysis of the results through written reports, posters, displays, or presentations (Figure 1, boxes 7 and 8).

Learner-centered and inquiry-based

Is it easier and faster to hand learners data sheets or checklists and ask them to fill in the blanks? Of course. Guiding learner-centered, inquiry-based investigations requires the leader to have tolerance for a certain level of chaos. It also is a challenge to learners who are used to leader-directed lessons. But, with **repeated** application of the inquiry-learning model, learners will become familiar with the steps and take more initiative. Education theory tells us students learn best when we capture their attention and arouse their interest. Learners will be more engaged in collecting the data if they help design the question for their own inquiry.

Lessons for practicing leading and learning skills

The lessons in this Guide provide learners with opportunities to practice inquiry skills. Each lesson targets a different theme for inquiry at the pond. The "Extend the learning" section in each lesson references selected activities from *Project WILD Aquatic Education Activity Guide* (available from your local OSU Extension office after you've participated in a Leader Training Workshop) and art enrichment activities from *A Palette of Fun* (4-H 713L) (available from OSU Extension and Experiment Station Communications). In some lesson units, this section also lists additional activities for older learners.

There are several lessons in the 4-H Wildlife Stewards curriculum that primarily allow learners to practice some of the skills needed in scientific inquiry. These lessons have more impact when leaders remember their role as coach in guiding learners to design their own experiences in the process of inquiry. Unit 1 is an example of how to present these lessons for learner-centered, inquiry-based investigation.

For OSU Extension and Experiment Station Communications price and ordering information: see the online catalog (**http://eesc.oregonstate.edu**) or fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

4-H Wildlife Stewards Classroom Curriculum for Grades K–3

- Observing
  - Patterns in Nature
  - The Unnature Trail Game
- Observing, Communicating
  - Walking in the Rain
  - My Very Own Tree
- Observing, Measuring (temperature), Experimenting, Communicating
  - Sun Power

4-H Wildlife Stewards Classroom Curriculum for Grades 4–6

- Observing
  - Blind Trail
- Observing, Measuring (height)
  - How Tall is That Tree?
- Observing, Inferring
  - Insect Bingo
- Observing, Experimenting, Identifying, and Controlling Variables
  - Powerful Plants
  - Energy for Tree Growth

The 4–H Experiential Learning Model

The habitat area pond can provide the context for a real-world application of science as inquiry at any grade level. The lessons in this book provide content themes. It is up to the leader to present them in such a way that learners can practice the skills they need to do scientific inquiry and become more scientifically literate. To accomplish this goal, take the learning that begins at the pond to the next step. Remember to ask learners, "How does what we learned today **apply** to your world beyond the school?" (Figure 1, box 9). To complete the 4-H Experiential Learning Model, learners must have the opportunity to apply what they learn in this inquiry to a similar or different applicable situation.

In *Assessing Student Understanding in Science* (2001), Enger and Yager state, "Although there is no consensus regarding what kinds of science content are necessary for scientific literacy, a scientifically literate person is believed to be one who appreciates the strengths and limitations of science and who knows how to use scientific knowledge and scientific ways of thinking for living a better life and for making rational social decisions." Learners have the opportunity to build their scientific knowledge and to think scientifically as they investigate the question, "What can we learn at the pond?"

References

Assessing Student Understanding in Science, A Standards-Based K–12 Handbook. 2001. Enger, S.K. and R.E. Yager. Thousand Oaks, CA: Corwin Press, Inc.

Inquiry and the National Science Education Standards. 2000. National Research Council. Washington, D.C.: National Academy Press.

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