Introducing Inquiry In A Biology Lab For Non-Majors

Phyllis S. Laine and Linda J. Heath

Department of Biology
Xavier University
3800 Victory Parkway
Cincinnati, OH 45207-4331
513-745-3623
Fax: 513-745-1079
Laine@xu.edu
Heath@xu.edu

Both Phyllis Laine and Linda Heath are currently faculty members in the Biology Department at Xavier University. Dr. Laine has BS in Medical Technology from Pennsylvania State University, an MPS in Microbiology Education from Cornell University, and an MS and PhD in Cell Biology from the University of Cincinnati. Ms. Heath has BS in Biology from Georgetown College and MS in Botany from the University of Kentucky. They each have taught undergraduate biology for over 25 years and actively support K-12 science education by conducting workshops and in-services. For four years Dr. Laine was the Science Educator for the Southwest Region of Ohio in the NSF-funded Project Discovery which implemented Inquiry in Middle School classrooms. This led to their current NSF-supported project (DUE #99-50373) incorporating inquiry and technology in an undergraduate biology laboratory. They are available as consultants to others interested in accepting this challenge.

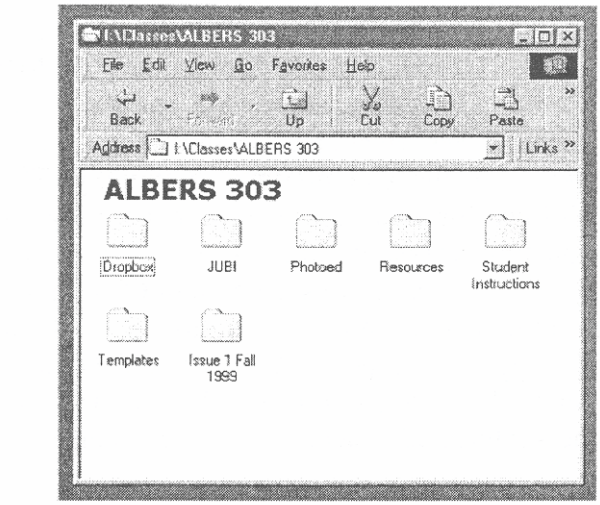
Reprinted From: Laine, P. S. and L. J. Heath. 2000. Introducing inquiry. Pages 417-423, *in* Tested studies for laboratory teaching, Volume 22 (S. J. Karcher, Editor). Proceedings of the 22nd Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 489 pages.

Introduction

In this mini-workshop, the participants experienced a laboratory activity using the inquiry approach. This activity is used to introduce inquiry to non-major students including pre-service teachers, in a one-credit Biology laboratory. The new lab emphasizes scientific inquiry and critical thinking skills especially needed by the elementary education majors. The laboratory course, adapted from an NSF funded investigative, non-major Biology laboratory at Clemson

University, includes inquiry investigations in a computer-based facility in which the computer serves as the laboratory notebook.

The course is organized into three phases: [1] introduction, [2] practice, and [3] performance. Students work in teams of 3-4 for each of the phases. During the first phase students are introduced to the process skills needed to do science inquiry. The inquiries are guided and students complete this phase with a journal article that documents the evidence that they gathered answering a question asked by the instructor. During phase 2 the research teams investigate aspects of growth and development of *Brassica rapa*. They must decide on a research question, develop a proposal, do the experiment and present the results in the form of a journal article submitted to the electronic class journal JUBI, the Journal of Undergraduate Biological Inquiry. In the final phase of the course the teams select an organism via a lottery. The organisms chosen include representatives of the five kingdoms of living things. Research teams must design and execute an original inquiry after they collect background information from electronic resources as well as a lab library. The final results from the inquiry are submitted to JUBI and presented during a class Poster session. Throughout the lab all inquiry information is entered in their computer notebook. At various times the research teams are required to present their work using a computer projection system. Results of the pilot can be seen at:
http://www.xu.edu/biology_dept/.



Procedure: Doing The Inquiry

The following outline summarizes the guided inquiry activity performed by the ABLE participants. It was not conducted using computers as laboratory notebooks. Participants in the workshop acted as students to experience an introduction to inquiry.

SYNOPSIS:

This activity exposes the student to guided inquiry. Just one question is proposed to begin the investigation. Students are not given either a method or procedure. They are given a variety of materials to use, but must design their own approach. After conducting the experiment and collecting data (evidence), they present their conclusions to the other members of the class.

Learning Outcomes

- Student will practice skills needed to conduct an inquiry.
- Student will illustrate (his/her) ability to do inquiry.
- Student will increase (his/her) understanding of scientific inquiry.

Materials

three types of paper toweling
pie pans
water
eye droppers
tape
balances
scissors
rulers
cups
paper clips
transparencies
graduated cylinders
teaspoons
pens for overheads

Procedure

Students working in co-operative groups, will design a method to determine which paper towel is the most absorbent. Students will perform their method(s) and produce data. Students will present their method(s), results (**evidence**), and conclusions orally to the other groups of students using an overhead projector or blackboard.

Safety Precautions

This activity does not contain any dangerous materials or methods.

Teaching Model

The paper towel lesson is an experience in **guided** inquiry where students are given a question and they develop the method for answering that question. Students are asked one question: "Which paper towel is the most absorbent?"

Teacher Preparation

The teacher has available the materials students will use to perform the inquiry. The teacher may want to use this lesson as an example of the scientific method by asking the groups to predict an outcome or state a hypothesis. The teacher could use this lesson to teach the measurement of liquid or to add a math component by looking at the cheapest or the most expensive towel.

Some questions to consider:

- How do paper towels absorb water?
- Why did one absorb more water than another?
- What is the structure of the towel?
- Which towel is best for: wiping spills, drying hands, protecting a surface, holding wet grapes, cleaning, etc.

Other related ideas:

- Absorbency of sponges (real vs. man made), cloth, soils, feather, fur.
- Change the liquid being absorbed; oil, molasses, egg white, etc.

Reference

This activity was developed at the University of California and the Pasadena United School District. The goal was to assess the process skills, observing and inferring.

Results: Experiencing Process Skills

Participants experienced all the process skills used in doing science by the inquiry approach. They are summarized below and included in our laboratory manual under a section called: "To The Student":

Science Process Skills

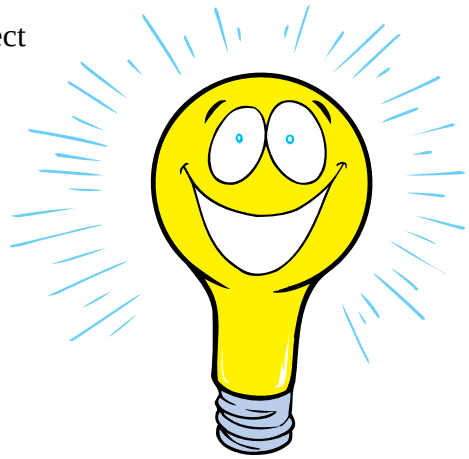
During this course you will experience, practice, and apply the following science process skills.

1. Make observations

2. State a question
   - Must be testable

3. Predict an answer
   - Your educated guess or hypothesis (if…then statement)

4. Design a method to answer a question. The team will:
   - Define variables
   - Changing one factor (independent variable) that may affect what you measure (dependent variable).
   - Determine a control.
   - Select standard to which you compare your experiment.
   - Do several trials.
   - Use an appropriate sample size.



5. Conduct the experiment
   - Make adjustments.

6. Collect data (results or evidence)
   - Compile, analyze, construct a graph or table.

7. Analyze data (results) to form conclusions
   - Did the evidence support your prediction?

- Can you explain unexpected results?
- How might you improve the method?
- What would you do next?

8. Communicate the results.

Application To The Laboratory: A Team's Example

The following is a completed Team Lab Notebook report on this exercise. It includes a warm-up activity and the group's reflection on the inquiry process. The Student Instructions for this exercise can be obtained by contacting Pearson Custom Publishing at www.pearsoncustom.com. Students have given permission for their names to be used. Student work appears in italics. There were four activities to complete.

Team Lab Notebook (TLNB)

EXERCISE 1 Introduction to Inquiry Process

A Classic Guided Inquiry
(Enter the names of your team members)

By: *Sarah Wood*
Katie Basista
Stephanie Schultz

Date: *January 13, 2000*

Introduction:
In this lab, our team conducted a guided inquiry to experience the process skills of science.

Activity 1: Biology Thoughts on Water

As a warm-up activity, our team brainstormed why water is required for life on the planet Earth. We came up with the following list: *Hydration of all mammals for survival; Photosynthesis for plant life; Oxygen; Bodies of water provide habitat for aquatic life; Temperature/Weather conditions of the Earth; Creating energy (dams, factories powered by steam); Transportation (barges)*

Activity 2: A Guided Inquiry

Before beginning our hands-on inquiry, our team generated the following prediction about which paper towel would hold the most water.
The flowered paper towel will hold the most water. Second will be the stars and moons and third will be the vegetables.

Activity 3: Reporting Evidence

After conducting our inquiry, we prepared statements to be presented to the class:
(Enter team statements in response to the prompts below.)

1. State the question you investigated. *Which paper towel will absorb the most water?*

2. State your team's prediction. *The paper towel with the flowers (3) would be the most absorbent, the stars (2) would be second most absorbent, and the vegetables (1) will be least absorbent.*

3. Describe the method used to answer the question.

   #1 W*e used 12.5 cm. X 12.5 cm sections of each paper towel. Marked the exact center of the paper towel. Placed one drop of water on the center and let sit for 1 minute. Measured the distance water traveled from the center within one minute.*

   #2 *Cut 12.5 cm. X 12.5 cm sections of each paper towel. Rolled the towels and placed in 25 mL graduated cylinders. Poured 25 mL of water into the cylinders and let sit for 30 seconds.*
   Removed towel and measured the amount of water remaining.

4. Describe the data you collected. (include units of measurement)

   #1: *Paper towel 1: water spread 3 cm diameter*
   Paper towel 2: water spread 2 cm vertically and 2.5 cm horizontally
   Paper towel 3: water spread 2.5 cm vertically and 3 cm horizontally
   #2: *Paper towel 1: 20 mL water remaining*
   Paper towel 2: 18.5 mL water remaining
   Paper towel 3: 19 mL water remaining

5. State your conclusion.

   Paper towel 1 (vegetables) was the least absorbent. For small amounts of water, paper towel 2 (stars) was most absorbent. For large amounts of water, paper towel 3 (flowers) was most absorbent. Thinner towels absorb less water.

6. Provide evidence supporting your conclusion.

   The vegetable towel was evidently the least absorbent – it absorbed the least amount of water in both experiments.

7. Evaluate your experimental design:
   What would you do differently? *Do it another time.*
   What would you do next? *Test towels with a middle amount of water.*

Activity 4: Reflections

Prepare a team statement about performing a guided inquiry lab with respect to the following: the advantages and disadvantages of teams using different methods; keeping records of all the data in the experiment; the importance of sharing procedures and evidence; and any other thoughts.

Advantages of using different methods: You can test in many different ways, and the more times you test, the more accurate your results will be. Disadvantages of using different methods: You can come up with different results which can disprove your hypothesis, and this leads to inconsistent conclusions.

Keeping records is useful and helpful in being able to examine the exact results of our experiment, and they are helpful for future use. Sharing procedures and evidence helps in recognizing that there could be several different ways of collecting data and, in turn, several different results. It helps to see if your results were consistent with others', and it also helps to perfect methods.

Acknowledgement

The authors wish to thank Deborah Kostoff for her constant support and help in the development of the new laboratory, "Discovering Life Science".