ABSTRACT

This life science activity investigates the behavior of earthworms. Students recognize that an organism's behavior is a response to an environmental stimulus and that an organism's behavior evolves through adaptation to its environment. In a cooperative-learning laboratory setting, students measure the physical activity of earthworms using a motion sensor under various controlled temperatures to simulate seasonal differences in the environment. After collecting and analyzing the data, students predict the most suitable temperature for earthworms, then test their predictions in the worm's natural habitat.

TIES TO CURRICULUM

Most middle-level students learn best when a teacher facilitates an inquiry-based activity, using the appropriate time, materials, and technology. This lesson gives students hands-on technology experience.

Worm Weather Predicted satisfies several components of the *National Science Education Standards*, and incorporates science with several standards of the National Council of Teachers of Mathematics, such as Uses of Mathematics, Problem-Solving, and Application of Basic Concepts of Data Analysis. Students often have difficulty applying mathematical concepts to a scientific problem-solving exercise. This activity integrates the two disciplines and encourages students to communicate these concepts.

LEARNING OBJECTIVES

Students will

- apply an inquiry approach toward the investigation by examining a problem, collecting data, organizing information to formulate an explanation, and analyzing the inquiry;
- demonstrate appropriate cooperative learning skills by performing tasks within a group-style investigation;
- interpret and apply mathematical and technology skills by graphing collected data; and
- infer that biological adaptations include changes in behavior that enhance survival in a particular environment.

NUMBER OF LAPTOPS AND GROUP SIZE

It is ideal to use one laptop per group of four students.

TIME REQUIREMENT

Worm Weather Predicted takes approximately two hours.

Task	Time	Location
Introduction	30 minutes	Classroom
Lab activity	30 minutes	Classroom
Field activity	30 minutes	Field
Classroom report	30 minutes	Classroom

LESSON DESCRIPTION

MATERIALS

- Laptop computers
- Spreadsheet software
- Interface 500 – PASCO Science Workshop
- Motion sensor
- Temperature sensor with probe
- Base support and rod
- Earthworms
- Water bath and ice
- Freezer paper
- Shovel/spade
- Sturdy metal bar (e.g., crowbar)
- Hammer
- Meter stick or tape measure

SUGGESTIONS

- Depending on their level, students might design the on-site procedure, although teachers should have a back-up plan.
- If the field activity is not feasible, students can predict the location of the greatest/least physical movement of earthworms, and give an explanation to support the prediction.

Introduction

Introduce the concepts of an organism's regulation and behavior. Discuss the response and behavior of an organism (plants, animals, fungi, etc.) to a constantly changing environment. Consider the need for organisms to adjust and adapt their needs for maintenance and survival under changing conditions.

Introduce the activity to the students, indicating that if one variable is changed, the behavior and response of an organism can be easily observed. Explain that the response to a change in temperature represents an organism's response to seasonal changes. Write out the activity question: "What behaviors does an earthworm exhibit when responding to a change in temperature?" In cooperative groups, students can brainstorm their responses in a journal on the word processor. As a precursor to the activity, students can observe earthworms' behavior and response to touch, light, vinegar, etc. Depending on the level of the class, you may also need to acquaint students with laptop computers, and with temperature and motion sensors.

Divide the class into cooperative groups of four and assign a role to each student in the group: the *Manager* picks up, distributes, and returns materials; the *Communicator* maintains communication within the team and with other teams; the *Tracker* keeps a record of the procedural steps and deadlines; and the *Speaker* is the group spokesperson. The entire group is responsible for collecting and analyzing data.

Lab Activity

Equipment Setup

Demonstrate and then help groups set up the equipment, hardware, and software:

1. Plug in the motion and temperature sensors to the laptop. Click and drag the analog sensor plug icon to the icon of the appropriate analog channel for the motion sensor. Select the motion sensor from the

list of analog sensors. Follow the same procedure with the temperature sensor, selecting a different analog channel.

2. Set the motion sensor on the stand with the sensor's screen aimed directly down at the table surface, allowing room for the water bath apparatus. Open the computer file for motion. Maximize the graph display for motion as distance vs. time. Activate the motion sensor, and check that the motion sensor is working.
3. Create a graph or table display to plot temperature (^{0}C) vs. time (seconds). Scale the x-axis from 1 to 300 seconds and the y-axis from 0^{0}C to 30^{0}C. Check that the temperature probe is working and use the probe to determine the temperature. Have all data displays accessible in the experiment setup window, arranged for comfortable viewing.

Earthworm Motion

Note: Do not leave earthworms at extreme temperatures for a long period of time. Warn students that earthworms cannot survive if frozen (0^{0}C) or exposed to high heat (27^{0}C) conditions.

1. Record data with the probe to establish water temperature.
2. Float a 15 cm x 15 cm piece of freezer paper on the surface of the water bath. Position the earthworm on the paper. Allow five minutes for the worm to acclimate to the water temperature. Record earthworm motion for three to five runs.
3. Add one cup of ice, wait five minutes, and record the new temperature. Position the earthworm, allow it to acclimate, and record motion as before.
4. Repeat the process of recording earthworm motion using four additional water baths ranging from 0^{0}C to 30^{0}C. Add either ice or warm water to the existing water baths to change the temperature.
5. Record motion on a data table established in your journal at the five different temperatures.

REFERENCES

Books

American Association for the Advancement of Science. *Benchmarks for Science Literacy-Project 2061*. New York: Oxford University Press, 1993.

Aldridge, Bill. *Course 1: Science Interactions*. Westerville, OH: Glencoe/McGraw-Hill, 1995.

Larson, Gary. *There's a Hair in My Dirt: A Worm's Story*. San Francisco: Harper-Collins Publishers, 1998.

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: NCTM, 1989.

National Research Council. *National Science Education Standards*. Washington DC: National Academy Pres, 1996.

National Science Teachers Association. *NSTA Pathways to the Science Standards, Middle School Edition*. Arlington, VA: NSTA, 1998.

Various Authors. *Investigating Patterns of Change. Biological Sciences Curriculum Study*. Dubuque, IA: Kendall/Hunt Publishing Co., 1994.

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6. Using the data table, find the average motion at each temperature, then graph the data: temperature (x-axis) vs. movement (y-axis).

Using the graph, determine the most suitable temperature or range of temperatures for an earthworm. Compare the physical activity of the earthworm with the prescribed estimate of comfortable temperature conditions for earthworms (13^0C to 25^0C). Predict the most appropriate location of earthworms in soil during seasonal changes, based on temperature differences. Discuss and outline the procedure to use to determine soil temperature and locate earthworms on-site.

Field Activity

Take the appropriate materials to the on-site location. Set up the laptop computer, and plug in the temperature sensor following the same procedure as in the laboratory setting. Drive the metal bar 20 cm into the soil and take a temperature reading of the soil at that depth, using the temperature probe. Drive the bar another 20 cm down and take a temperature reading at 40 cm. Continue down until a depth of 120 cm is reached, and record the temperature at each 20 cm increment in a table.

Based on the temperature-motion graph developed in the lab, each group should determine the depth where earthworms would most likely be found. Dig to that particular depth to see if earthworms are present. If earthworms are not found, discuss what other variables might be at play, such as water, food, soil chemistry, or soil structure.

Report

Back in the classroom, groups can spend time creating a final report including preliminary data, predictions of worm locations, and final results. From the data and evidence, predict earthworms' response to a change in the external environment, especially seasonal changes.

REFERENCES, cont'd

Web sites

NASCO's Home School Internet Catalog: http://www.homeschool-nasco.com/

PASCO Scientific: http://www.pasco.com/

Worm World: http://www.nj.com/yucky/worm/

ASSESSMENT

Use the following rubric to assess student performance in each component of the activity.

Components	Exemplary	Acceptable	Unacceptable
Examine question	Identify question	Incomplete identification of question	No identification question
Collect data	Collect all data	Collect sufficient data	No data collected
Organize information to formulate explanation	Exemplary organization	Sufficient organization	No evidence of organization
Formulate explanation	Accurately formulate explanation	Formulate explanation with some level of accuracy	Formulation of explanation incomplete or missing
Analysis of inquiry	Inquiry analysis completely accurate	Inquiry analysis with sufficient accuracy	Inquiry analysis incomplete or missing
Cooperative learning	Totally responsible	Sufficient responsibility	Not accepting of responsibility
Technology use Setup	Setup with complete accuracy	Setup with some assistance	Require assistance with most technology setup
Technology application	Apply technology accurately	Apply most technology accurately	No application of technology
Graph data	Exemplary application of graphing data	Sufficient application of graphing data	Incomplete application of graphing data
Infer behavior adaptation to environmental changes	Accurate inferences	Some level of accurate inferences	Inferences not accurate or appropriate
Record keeping	Complete and neat	Sufficient	Missing or incomplete