ROOTING INTO INQUIRY:

Student-Designed Projects, the Four Question Strategy and Experimental Design Diagram

Rationale and Objective

The overall goal of the *Coastal Roots* Seedling Nursery Program is to assist students in developing an attitude of stewardship toward our natural resources and to provide a constructive, active learning situation in which they can explore strategies for sustaining our coastal ecosystems.
The **National Science Education Standards** indicate that learning through inquiry is the best way to produce science- literate students capable of solving complex problems.

The objective of this module is to provide students with the skills and active learning situations in constructing inquiry investigations related to environmental limiting-factors or conditions related to successful germination and development of native coastal trees.

Teacher Background

When conducting a student-designed investigative project, students frequently have difficulty in selecting and narrowing topic choices and designing specific experimental tests. To sufficiently narrow their topic choices, students need assistance in choosing the specific variable to test and subject upon which to test it. Time limitations and class size make it difficult for teachers to assist individuals or small groups of students to explore research topic variations. Through use of the prompt questions, the teacher can model the skills. Students can then practice independently or in small cooperative learning groups. As with development of any skill, repeated practice opportunities are required for students to become proficient.

Julia Cothron, Ronald Giese, and Richard Rezba developed the FOUR QUESTION STRATEGY to assist students in developing their problem –solving abilities and to assist teachers in fostering science literacy. The exercises employed here were modified from their work. The Four Question Strategy is included in their books, which are listed in the reference list.

Louisiana Science Benchmarks

SI-H-A1, A2, A3, A4, A5, A6, A7
SI-M-A1, A2, A3, A4, A5, A6, A7, A8
PS-H-A1
And others (depending upon the student selected lab topics)

Procedure

1. Students can use the Coastal Roots project as a platform for inquiry to help other schools do a better job of raising their seedlings. Therefore, introduce the Four Question Strategy as outlined on page 3 of this unit. Use **Student Worksheet #1** (*The Four Question Strategy*) to give students practice at using the Four Question Strategy to design their inquiry project.
2. Have students design an inquiry project based on the Coastal Roots project using another copy of Student Worksheet #1.
3. Have students use **Student Worksheet #2** (*Using the Four Question Strategy to Form an Inquiry Problem Question*). This will help students formulate the title or topic of their inquiry project.
4. Discuss the elements required in an experimental design. Have students review the vocabulary listed at the bottom of Student Worksheet #2.
5. Have students complete **Student Worksheet #3** (*Experimental Design Diagram*). Use page 7 as a guide.

** If you are interested in using rubrics to assist students in refining and/or grading their inquiry problem, refer to Colleen Fiegel's Biology Project Website (listed in on-line resources) for checklists and rubrics that can be adapted to your setting.

Science Project References

The following publications contain useful information for science teachers, students and anyone assisting with student research. They are available from the publisher (Kendall/Hunt), on-line book sellers (such as Amazon), and some libraries and bookstores that carry science education materials. Other books about student research are available from the National Science Teachers Association's Science Store.

Science Experiments and Projects for Students, 3rd edition. 2000. Julia Cothron, Ronald N. Giese, and Richard J. Rezba. Kendall/Hunt Publishing Company; ISBN: 0787264784. 341 pages.
-- Approaches science projects from the perspective of the student researcher.

Science Experiments by the Hundreds. 1996. Julia Cothron, Ronald N. Giese, and Richard J. Rezba. Kendall/Hunt Publishing Company; ISBN: 0787238449.
-- For anyone interested in developing science experiments.

Students and Research: Practical Strategies for Science Classrooms and Competitions**,** 3rd edition. 2000. Julia Cothron, Ronald N. Giese, and Richard J. Rezba. Kendall/Hunt Publishing Co.; ISBN: 0787264776. 342 pages.
-- Lots of practical ideas for science teachers and competition staff.

On-Line Resources

Surf and Master the Web: Teaching With Inquiry
www.science-house.org/workshops/web/inquiry.html. This website offers information on inquiry lessons.

Colleen Fiegel's Biology Project Website (Benjamin Franklin H S, New Orleans),
http://education.zefex.com/BiologyProjects.htm Excellent source of rubrics to guide the development of independent research projects.

Virginia Institute of Marine Science, Marine Advisory Program,
http://www.vims.edu/adv/ed/stu.html. This webpage gives excellent links to resources for student independent research projects.

NOTE: The COASTAL ROOTS activity module, WHEN THE HABITAT GETS SALTY, incorporates the use of the Four Question Strategy and Experimental Design Diagram.

Using the Four Question Strategy

Use the Four Question Strategy sample below to model the topic-narrowing process with your students. While possible answers are provided to assist you, student background and creativity may result in multiple "correct" answer choices.

FOUR QUESTION STRATEGY

Four Question Strategy: An Example

Example test subject: *SEEDS*

1. What materials are readily available for conducting experiments on your test subject?

SEEDS *WATER* *CONTAINERS* *SOIL* *LIGHT* *FERTILIZER*

2. How will the subject respond?

SEEDS WILL GERMINATE AND GROW

3. How can you change the set of materials to affect the response of your subject?

SEEDS	*SOIL*	*LIGHT*
KIND	*AMOUNT*	*NATURAL OR ARTIFICIAL*
NUMBER	*TYPE*	*DURATION*
ORIENTATION IN SOIL	*STERILITY*	*INTENSITY*
SPACING	*MOISTURE CONTENT*	*WAVELENGTH*

4. How can you measure or describe the response to the change?
(This will be the dependent variable.)

COUNT THE NUMBER OF SEEDS THAT GERMINATE	*MEASURE STEM LENGTH*
DETERMINE GERMINATION RATE	*MEASURE GROWTH RATE*
CALCULATE PERCENTAGE OF SEEDS THAT GERMINATE	*MEASURE ROOT LENGTH*

After class discussion of the sample, distribute STUDENT WORKSHEET 3. As students will be carrying out their self-designed investigations, the teacher may wish to suggest general topics for which materials are available and which can be carried out within the time allotted. At the teacher's discretion, students may work individually or in small, cooperative groups. Circulate among groups to monitor understanding.

While most science texts have units on the Scientific Method, students may not have accurate operational definitions of inquiry-related vocabulary. Students should not be expected to memorize the definitions here but rather, to develop their own working definitions.

ROOTING INTO INQUIRY: The Four Question Strategy

Student Name: _____

When conducting a student-designed investigative project, students frequently have difficulty in narrowing topic choices and designing specific experimental tests. The FOUR QUESTION STRATEGY is designed to assist you in focusing your choices.

Review the focus questions (below) and then complete and discuss the example with your classmates.

1. What materials are readily available for conducting experiments on your test subject?
2. How will the subject respond?
3. How can you change the set of materials to affect the response of your subject?
4. How can you measure or describe the response to the change?

FOUR QUESTION STRATEGY

Example test subject: SEEDS

1. What materials are readily available for conducting experiments on your test subject?

2. How will the subject respond?

3. How can you change the set of materials to affect the response of your subject?

4. How can you measure or describe the response to the change?

ROOTING INTO INQUIRY: **Student Name: _____**

Using the Four Question Strategy to Create an Inquiry Problem Question

Create your Inquiry Problem Question by selecting a category answer from your Four Question Strategy Worksheet, Question #3, and relating it to a corresponding response in Question #4.

For example: *What affect does pH of water (listed under materials in Question #3) have on number of mosquito eggs that hatch?*

Use this format to help:
What affect does (fill in a choice from Question #3) *have on* (enter a response from Question #4)?

Now you try!

What affect does _____ have on _____?

Viola! You have an Inquiry Problem Question!

You will need to review some vocabulary in order to move on to the Experimental Design Worksheet. Review the following terms:

Hypothesis

Independent variable

Levels of independent variable

Dependent variable

Constants

Control group

VOCABULARY:

Hypothesis The hypothesis is a statement that shows the relationship between the independent (or manipulated variable) and the dependent (or responding variable). The hypothesis is frequently stated as a "If… then …" statement. The "If" portion states the independent variable. The "then" portion predicts the outcome of the experimentation with regard to the dependent variable. For example, "If bald cypress seeds are presoaked in various salt concentrations, then the lower the salt concentration the greater the percentage of seeds germinating".

Independent variable The independent variable is manipulated (changed) by the investigator in order to measure the effect on another variable. It is also known as the manipulated variable,

Levels of independent variable These are the various quantities or variations of the independent variable. (For example, 2 ppt, 4 ppt, 6 ppt salt concentration.)

Dependent variable Also known as the responding variable, the dependent variable is the one that changes in response to the independent variable.

Constants These are the variables held constant in each level of the independent variable. For example, if given the problem, "What affect does water salinity have on cypress germination?" the type of container, the amount of light received, and the temperature would all be constants.

Control group The control group does not contain the independent variable. All other factors are identical to the experimental groups. It is used as a standard of comparison against which to measure the effect of the independent variable.

Skills Resources

The Experimental Design Diagram is one of numerous teaching strategies available for assisting students in developing an understanding of the nature of science through problem-solving experiences. The book Students in Research (Julia Cothron, Ronald Giese, and Richard Rezba, Kendall/Hunt, 1989) provides teachers with opportunities to explore these strategies and with lab activities and suggestions for putting them into classroom use.

Project Tellus is a six-module program of interactive video lessons and lab activities. Each module examines concepts as they relate to the states bordering the Gulf of Mexico. Module one of this program, "Tellus About Science", focuses on science processes and skills. For information on obtaining these materials, contact Dr. Pam Blanchard at Louisiana Sea Grant (pamb@lsu.edu)

Sea Grant Louisiana | Barataria-Terrebonne National Estuary Program | Coalition to Restore Coastal Louisiana | LSU AgCenter Research & Extension

ROOTING INTO INQUIRY:

Student-Designed Projects, the Four Question Strategy and Experimental Design Diagram

An Experimental Design Diagram provides a standardized format that assists students in communicating their ability to apply inquiry-related concepts. The copy below may be useful to you in teaching Experimental Design Diagram use.

Title (Inquiry Problem Question): In an inquiry investigation, the title is frequently stated as a question. It states the question under consideration.

Purpose: (On a page you attach to this sheet, describe in one or more paragraphs, the real-world reason for selecting this particular project. Include background information.)

Hypothesis: The hypothesis is a statement that shows the relationship between the independent (or manipulated variable) and the dependent (or responding variable). The hypothesis is frequently stated as a "If… then …" statement. The "If" portion states the independent variable. The "then" portion predicts the outcome of the experimentation with regard to the dependent variable. For example, "If bald cypress seeds are presoaked in various salt concentrations, then the lower the salt concentration the greater the percentage of seeds germinating".

Independent Variable: manipulated (changed) by the investigator in order to measure the effect on another variable. It is also known as the manipulated variable.						
Levels of the <u>Independent</u> Variable EXAMPLE…….Salt concentration Units of Measurement: parts per thousand (ppt)						
1 ppt	2 ppt	3 ppt	5 ppt			
Number of Repeated Trials x sample size: EXAMPLE… (If there were 4 trials and 50 plants/trial/level)						
4x50	4x50	4x 50	4x 50			

<u>Dependent</u> Variable: The dependent variable is the one that changes in response to the independent variable.

Constants: These are the variables held constant in each level of the independent variable. For example, if given the problem, "What affect does water salinity have on cypress germination?" the type of container, the amount of light received, and the temperature would all be constants.

Control Group: It is used as a standard of comparison against which to measure the effect of the independent variable.

ROOTING INTO INQUIRY: Experimental Design Diagram

Student Name: _____

Title (Inquiry Problem Question):

Purpose: On a page you attach to this sheet, describe in one or more paragraphs, the real-world reason for selecting this particular project. Explain how this project will help other Coastal Roots nurseries do a better job raising their seedlings. Include background information.

Hypothesis:

If…..

then,

Independent Variable:						
Levels of the <u>Independent</u> Variable Units of measure						
Number of Repeated Trials x sample size:						
___ x ___	___ x ___	___ x ___	___ x ___	___ x ___	___ x ___	___ x ___

<u>Dependent</u> Variable:

Constants:

Control Group: