INCREASED COMPREHENSION OF THE SCIENTIFIC METHOD USING INQUIRY-BASED LABS.

Allison D'Costa & Mark Schlueter

Georgia Gwinnett College, Lawrenceville, GA 30043

ABSTRACT:

Knowledge and ability to correctly apply the scientific method is a skill not possessed by most first-year students. We had 2 main goals for the current study. The first goal was to identify which specific elements of the scientific method were poorly understood by students. The second goal was to develop a method or activity that would improve a student's use and understanding of the scientific method. It was believed that inquiry- based labs were the best method to accomplish this second goal. In order to explore these questions, we used two groups of freshman students; the control group spent the semester doing only standard "cookbook" labs, while the experimental group was exposed to inquiry- based labs. Both groups of students were taught by the same instructor in two different sections of the same course. Knowledge and comprehension of the scientific method was measured by a scientific method assessment exam. Both groups of students were assessed prior to the laboratory activities (pre-test) and after the laboratory activities (post-test). We compared pre and post test scores for each student in both groups. Statistical analysis of the results showed that the students in the experimental group demonstrated better understanding of the scientific method after inquiry- based labs (t-value = 3.784, p value = 0.0013), while students in the control group did not after improve in their understanding of the scientific methods completing standard "cookbook" labs (t-value = 0.8148, p value = 0.4258). We also discovered that students had the most difficulty with correctly identifying the independent variable and dependent variables in scientific experiments. This study has helped us identify areas needing more emphasis while teaching students the scientific method. In addition, the study provides support that inquiry- based laboratories increase a student's understanding of the scientific method.

WHAT ARE INQUIRY-BASED LABS?

- Student- driven
- Investigative and research-oriented

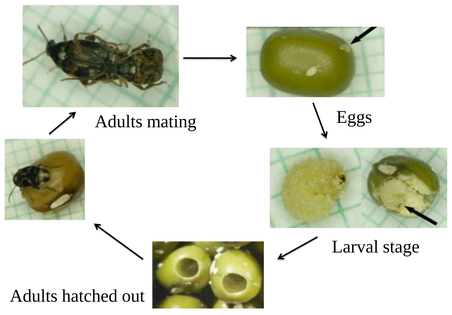
-Student groups create their own hypothesis and design their own experiments using the scientific method

-Students apply concepts and techniques they have previously learned

WHY ARE BEAN BEETLES A GOOD MODEL ORGANISM FOR INQUIRY- BASED LABS?

- Cheap
- Easy to grow on beans (mung, adzuki, black-eyed peas)
- Easy to use and handle
- Easy to sex
- Don't take up much space in lab

BEAN BEETLE LIFECYCLE, *Callosobruchus maculatus* (Coleoptera: Bruchidae) (Photographs courtesy of www.beanbeetles.org)



OUR STUDY

Hypothesis: Students who are given the chance to create their own hypothesis, and design and implement their own experiments, will better understand the scientific method.

Experimental design:

Experimental Group: Students exposed to inquiry - based labs

Control group: Students **not** exposed to inquiry- based lab

Controlled variables:

1)Both groups BIOL 1108 students

2)Both groups taught by same teacher

3)Both groups taught the Scientific method

Inquiry-based lab approach:

STEP 1 : Introduction to the scientific method using a staged experiment.

Question: *Does the bean a female hatches from (natal bean) influence her choice of where she will lay her eggs?*

STEP 2 : Independent inquiry- based group experiments

Students create their own hypotheses and design their own experiment within a narrow framework.

The framework contains:

1)A list of 8-10 questions for novice students. *The limited questions gives the student guidance in what topic to pursue.*

2) A list of materials available to them to conduct an experiment. *This helps the student design a practical experiment that could actually be performed in the laboratory.*

List of 8-10 observations or questions

Observations about Bean Beetles

Males are driven to find females and mate with them. Typically, males find females and begin mating in 15 minutes in small containers. Male beetles have been observed attempting to mate with other male beetles.

1) What senses do males use to find their mates?

2) Does mating decrease or increase a beetle's lifespan?

3) Does the presence of females reduce or increase the attempts of male-to-male mating attempts?

4) Does the presence of extra male beetles increase or decrease the time it takes to successfully mate with a female beetle?

It is claimed that adult bean beetles do not need to eat or drink.

5) Would beetle life span increase in the presence of food?

6) Do beetles survive longer in the presence of light or in the presence of dark?

Females show preference to laying eggs on their natal bean (the bean they hatch from).

7) Are female beetles picky about the size of natal bean?

8) Are female beetles picky whether and egg has already been laid on a natal bean?

9) Is seed coat necessary to lay eggs?

10) What makes the natal bean attractive to the female its color or shape?

Assessment tool:

Grade on Pre- and post- Scientific method test

The Scientific Method test: 30 multiple choice questions

Question Category	No. of questions
Use of Scientific method	3
Theory/ Hypothesis	6
Experimental design & sample size	5
Independent variable	5
Dependent variable	4
Controlled variable	3
Control	4

Data Analysis:

1) Compare each students performance on pre and post test.

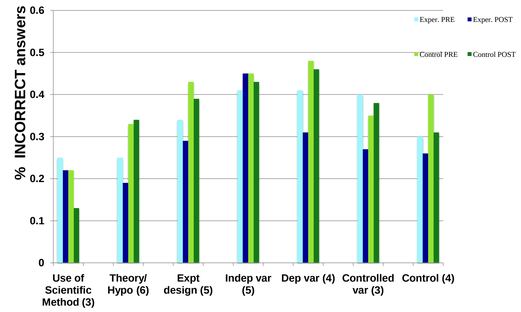
2) Determine the question categories that showed poor student performance.

Results of Statistical analysis:

The Experimental group demonstrated better understanding of the scientific method after Inquiry- based labs. *t value = 3.784, p value = 0.0013*

The Control group did NOT demonstrate better understanding of the scientific method after completing standard labs. *t value = 0.8148, p value = 0.4258*

Student performance by Question category:



WHAT WE HAVE LEARNED?

Students inability to indentify the independent variable

A rice farmer has determined that his rice yield has declined since last year. He feels that the sparrows are eating the ripe rice grains. To test his hunch, he stakes a fine net above half the rice field, while keeping the other half of the field open. Answer questions (3-7).

4) What is the independent variable in the farmer's experiment?

a) The sparrows

b) The net

c) The rice field covered with net

d) The rice field not covered with net

Red arrow indicates student answer. Highlighted correct answer.

Future directions:

More emphasis and examples in class on parts of the scientific method.

Acknowledgement:

Christopher Beck and Lawrence Blumer's Bean beetle Curriculum development workshop for their support