GE SLO K1-Introductory

Bio1000

Semester: FALL 2013

Background

In July 2012, the Director of General Studies approached the Biology Program to develop and oversee an assessment activity for measuring GE K1: Applying the scientific method to comprehend natural concepts and processes. The targeted course, BIO 1000 Principles of Biology, is a four credit science course for non-biology majors and is designated as a General Education Distribution Course. A sample worksheet of questions on the scientific method and quantitative reasoning was initially shared with the expectation that it would be modified by Biology faculty to meet this demand. A graduate assistant was then hired to work with the faculty and administer the assessment survey to 23 course sections of 20 students per section.

Bio1000 Assessment: Technical Review

In fall 2013, application of the scientific method in Bio 1000 is assessed based on student test scores on a departmental General Biology Assessment Exam: Assessment Activity (see below) using the Scientific Method Rubric which had been created as a group work of the Kean University Department of Biological Sciences and the Office of Accreditation and Assessment (see below: this was a follow-up to the original discussion of assessment in 2012). The first part of the assessment exam requires students to match a number of sentences that describe one of the 6 essential steps of scientific methods. Additionally, in the second part students were asked to organize, analyze and interpret data and graphs.

Number of students: 479
Number of sections: 22

Distribution of Scores

Mean scores overall:

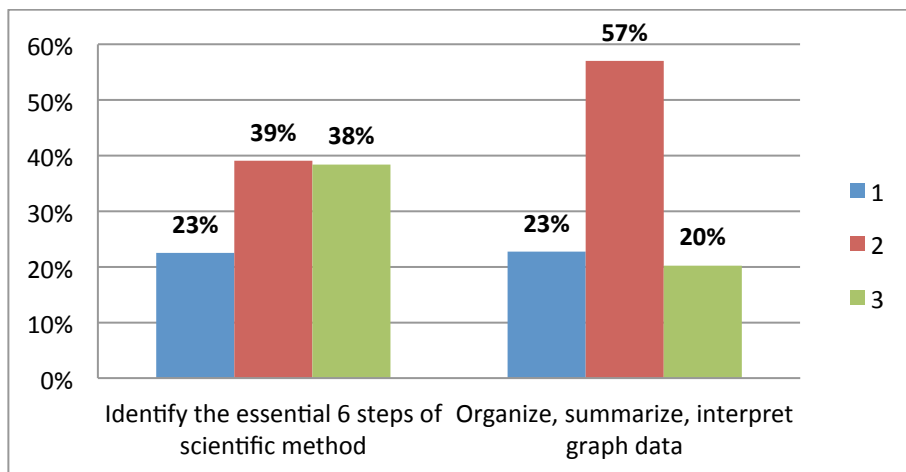| Identify the essential 6 steps of scientific method	2.2
Organize, summarize, interpret graph data	2.0

Distribution of Scores:

	Identify the essential 6 steps of scientific method	Organize, summarize, interpret graph data
1 below expectations	108	109
2 meets expectations	187	273
3 exceeds expectations	184	97
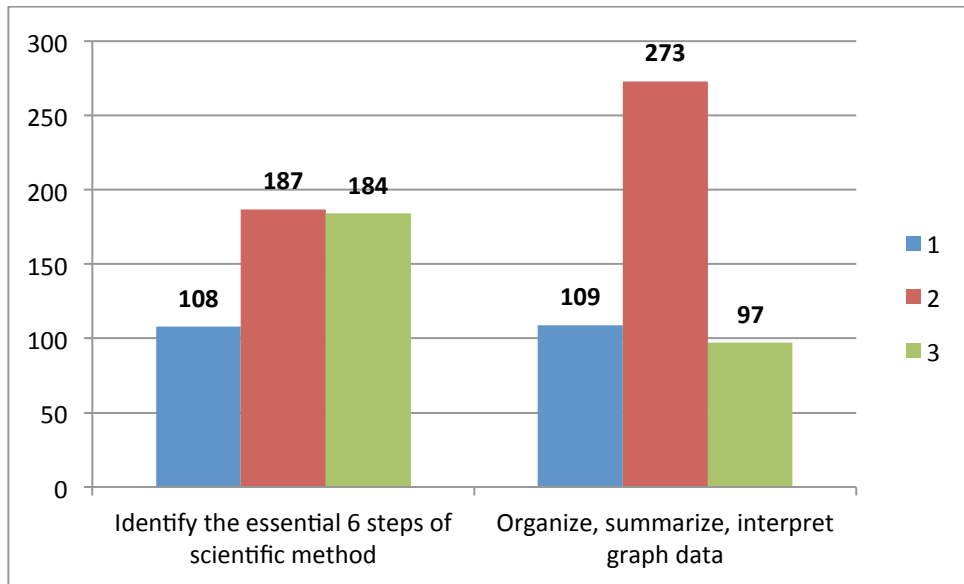
Distribution of Percentage

	Identify the essential 6 steps of scientific method	Organize, summarize, interpret graph data
1 below expectations	23%	23%
2 meets expectations	39%	57%
3 exceeds expectations	38%	20%

Distribution of Percentage

Students Below Expectation on 6 Essential Steps of Scientific Methods						
	Observation	Hypothesis	Experiment	Data	Conclusion	Theory
Test Question (Q)	Q2+5	Q3+9	Q6	Q1+8	Q4+10	Q7
Percentage making mistakes	27%	49%	42%	21%	89%	58%
Percentage did not make mistakes	73%	51%	58%	79%	11%	42%

N=108 below expectations students

Biology 1000 Below Expectation Students Performance on 6 Essential Steps of Sientific Methods (N=108)
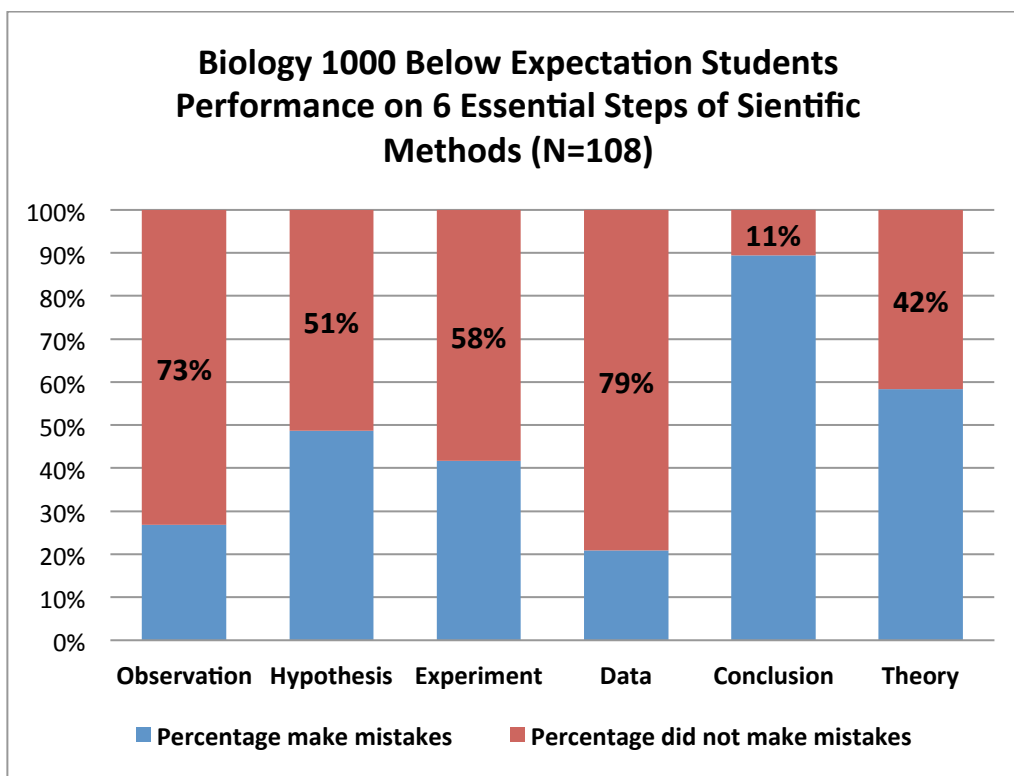
Discussion/Action/Closing the Loop:

The Department of Biological Science used the Scientific Method Rubric to measure students' performance in the test "Assessment Activity." All non-biology major students (N=479) from 22 Bio1000 sections took the test.

Based on the scoring rubric, students were divided into three groups as 3 (exceeds expectations), 2 (meets expectations) or 1 (below expectations) for two class student learning outcomes (CSLOs).

Assessment Activity Test Questions 1-10 were used to measure the first CSLO: Identify the essential 6 steps of scientific method. 77% of the 479 students met the expectations or exceed the expectations.

Assessment Activity Test Questions 11-14 were selected to measure the second CSLO: Organize, summarize, and interpret graph data. Each question was assigned with different points to reflect its difficulty levels. 77% of students met or exceeded the expectations.

The overall student performance for both CSLOs exceeded the class goal (70% to meet or exceed expectations). However 23% of the students failed to meet expectations in each CSLOs. It should also be noted that significantly more students exceed the expectations for CSLO1 (38%) than CSLO2 (20%).

Research on improving graphical literacy and the ability to understand and apply the scientific method suggests making graph reading metacognitive so that students learn to interpret the graph's visual features and evaluate the data it provides rather than merely retrieving facts (Shah and Hoeffner, 2002). In addition, integrating collaborative questions into laboratory activities can help students build on their conceptual understanding of the scientific method by integrating it into actual laboratory experiences (Quitadamo and Kurtz, 2007).

So as 23% of the students scored below expectations on questions that measure students' ability to create and interpret the graph, the Department is revising the Bio 1000 lab manual, and has scheduled the new version for pilot-testing during the Spring 2013 semester with full implementation by the Fall 2014 semester. The manual already includes multiple graphing activities and exercises using the scientific method. The revision will include questions asking students to explain the graphs they create.

Q1-10 in the Assessment Activity test are all real-world related questions asking students to identify essential 6 steps of scientific methods in the real world: Observation, Hypothesis, Experiment, Data, Conclusion and Theory. 108 (23%) students failed to meet expectations (only correctly answered 6 or less questions out of 10). Out of the six steps, students who failed to meet expectations are most likely to make mistakes on Conclusion (89%), followed by Theory (58%), Hypothesis (49%), and Experiment (42%). Students made fewer mistakes on Observation (27%) and Data (21%). This is unsurprising when one considers Bloom's Taxonomy.

In order to improve the overall performance, it is important to address the issues of those 23% of the students who failed to meet expectations for these questions. To this end, Biological Sciences will now introduce collaborative questions, with special attention to **Conclusion, Theory, Hypothesis and Experiment**. These questions will be added to ask students to apply the scientific method as they evaluate and interpret their own work and findings from relevant, real-world and published research appropriate to a non-majors biology class.

Different yet similar test items will be created to be used on the course sections in the coming semester. The results will be compared with the current set to find how accurately the test items measure the skills they are intended to test.

Finally, faculty will be asked to stimulate class discussion about data interpretation and the scientific method by sharing real-world examples of research throughout the course. Teachers will observe and evaluate the process to find the reasons behind students' weakness.

References

Quitadamo, I, Kurtz, M. 2007. Learning to improve: using writing to increase critical thinking performance in general education biology. *CBE Life Science Education* 6(2): 140-154.

Shah, P, Hoeffner, J. 2002. Review of graph comprehension research: implications for instruction. *Educational Psychology Review* 14(1): 47-69.

GE K1 Rubric

Applying the scientific methods to understand natural concepts and processes

GE K1 Rubric_ Scientific Method Rubric			
	Exceed Expectations (3)	**Meet Expectations (2)**	**Below Expectations (1)**
Identify the essential 6 steps of scientific methods (Observation, Hypothesis, Experiment, data, Conclusion and Theory)	Identify almost all 6 steps of scientific methods for given scenarios.	Identify most of the 6 steps of scientific method.	Identify few of the 6 steps scientific method correctly.
Organize, summarize and interpret graphic data	Accurately organize, summarize and interpret almost all of the graphic data with detailed steps and explanations.	Organize, summarize and interpret most of the graphic data correctly, but may lack of detailed steps or misinterpreted a few questions.	attempted to organize, summarize and interpret the graphic data but failed to do it accurately for most of the questions.

GE K1 Rubric_ Scientific Method Scoring Criteria			
	Exceed Expectations (3)	**Meet Expectations (2)**	**Below Expectations (1)**
Identify the essential 6 steps of scientific methods (Observation, Hypothesis, Experiment, data, Conclusion and Theory)	9-10 points	7-8 points	1-6 points
Organize, summarize and interpret graphic data	26-30 points (Students has to answer almost all Q11 correctly)	18-25 points (students have to answer at least part of the Q11 correctly)	1-17 points

Identify the essential 6 steps of scientific methods: Assessment Activity Test Question 1-10, 1 point each

Organize, summarize and interpret graphic data: Assessment Activity Test Question 11-14 (Question 11: 15 points, Q12: 5 points, Q13: 4 points, Q14: 6 points)

Appendix Assessment Activity Test

NAME:_____   BIO 1000, Section_____

GENERAL EDUCATION ASSESSMENT FOR BIO 1000

For each example given below, determine which part of the scientific method each represents. (5 points each)
Use the key to fill in the appropriate bubble.

KEY: a - Observation   b - Hypothesis   c - Experiment   d - Data   e - Conclusion   f - Theory

(a) (b) (c) (d) (e) (f)   1. Daily temperatures (°C) of a terrarium for April: 23.9, 24.5, 24.0, 24.0, 23.8, 24.1, 23.7, 23.9, 24.3, 24.1, 24.0, 24.2, 24.1, 23.7, 24.0, 23.9, 23.6, 23.9, 24.1, 24.1, 23.8, 24.2, 24.4, 24.0, 24.7, 24.2, 24.0, 24.0, 23.9, 24.3

(a) (b) (c) (d) (e) (f)   2. One day, John noticed that large numbers of spider crab shells were suddenly scattered along the beach. They had not been there last week.

(a) (b) (c) (d) (e) (f)   3. A scientist wonders if Fertilizer A will produce taller plants than Fertilizer B.

(a) (b) (c) (d) (e) (f)   4. The high experimental growth rates of an organism with Nutrient Solution D, compared to A, B, and C, indicate that these organisms thrive best in glucose solution. To provide optimal growth for these organisms, we will only use the glucose nutrient solution.

(a) (b) (c) (d) (e) (f)   5. The student in the lab noticed that a plate containing a bacterial culture was contaminated with a colony of mold. Curiously, there was no bacterial growth within 12mm of the mold.

(a) (b) (c) (d) (e) (f)   6. Dr. Norman placed 100 mice individually in cages. Each mouse was infected with the same disease. The next day, fifty of the mice were given a new medication while the other fifty received no medication. He examines the mice every 12 hours and categorize them as either alive or dead. At the end of one week, the doctor tests the surviving mice for the disease and labels them as sick or cured.

(a) (b) (c) (d) (e) (f)   7. For centuries, scientists have considered that diseases come from something and don't just happen on their own. Through the research of many people over a long time, as van Leeuwenhoek, Pasteur, and Koch, it has become accepted that microorganisms, like bacteria and fungi, are responsible for many diseases.

(a) (b) (c) (d) (e) (f)   8. The recorded daily rainfall for Union, NJ from 2000 to present.

(a) (b) (c) (d) (e) (f)   9. Since birds often eat insects, will the use of pesticides in an area affect the bird population?

(a) (b) (c) (d) (e) (f)   10. Research of two organisms in an ecosystem, suggests that Animal A is a consumer of Plant B. Further study is recommended.

- - Continue to other side - -

Which is the highest level of math you have completed? *Pick only one.*
❏ High School   ❏ Developmental, ie MATH0901   ❏ College Algebra, ie MATH1000   ❏ Beyond Algebra

11. Use the data chart below for the number of trees at varying distances from a river to create an appropriate line graph, including all labels, on the right. (15 points total)

Distance (m)	Number of Trees
0	2
10	8
20	19
30	22
40	33
50	48
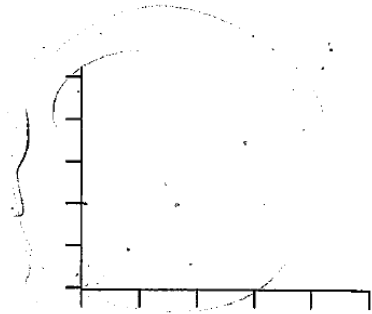
12. What is the relationship between the distance of the trees to the water and how many there are? (5 points)

13. Which two (2) tree types make up nearly $\frac{2}{3}$ of all the trees? (4 points)

Trees in a NJ Forest

_____ and _____

14. If you were to randomly pick a tree in the forest, you would have less than a 10% chance of picking which three (3) types? (6 points each)

_____   _____

_____

Show how you figure these out. Write out your set up and calculations.
An answer alone does not count. No calculators. (10 points each)

15. A fish tank with different types of tropical fish needs to be fed with two types of food. Each day it costs $0.75 for plankton and $1.25 for worms to feed this tank of fish. How many full days can you feed the fish with $40.00?

16. An experiment replicated four (4) times required water temperature to be measured. The first three (3) temperatures were 27°C, 25°C, and 26°C. The scientist forgot to record the fourth measured temperature, but fortunately calculated the average first. The average of the four (4) temperatures was 25°C. What was the temperature this person forgot to record?