Expanding Assessment of Analytical Skills among Biology Majors: From Introductory labs to Upper Division Electives

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Who we are

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URI 2012, B.S. Secondary Education and B.A. Biology

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Instructing BIO 102 in Spring 2013

Very sorry to miss the conference!

A Team photo from the National Academies Summer Institute, June 2010.
Faculty, Instructors, and Administrators from Boston College, Yale, Ohio State, U Wisconsin-Madison
General Goals

I. To identify common learning objectives for BIO 101 (Introductory Biology, semester 1)

II. To establish an approach for assessing data analysis skills at both introductory and upper-levels.
   - BIO 101 laboratory sections
   - BIO 262 (Ecology)
I. Overview of Activities

Fall 2011

For Common BIO 101 Learning Objectives:

Meeting(S) with four BIO 101 Instructors

Introduced idea of a formal, common assessment
Collected recent final exams from each instructor (or midterms from new instructors)

Analyzed prior final exams to identify common learning goals:
- Categorized each exam question in terms of a learning objective
- Compared each question to an extensive list of possible objectives from a colleague in the Undergraduate Education in Biology Scientific Teaching Summer Institute
- Tallied questions in each category
- Identified areas of overlap among the 4 instructors

Found 6 common objectives! (in next slide)
Learning Objectives in BIO 101 Assessment (Fall 2011)

1) Distinguish between a living and non-living organism
2) Predict direction of water movement in diffusion across a membrane, given solute concentrations on either side
3) Identify similarities and differences of prokaryotic and eukaryotic cells (either classifying examples or identifying in terms of cell properties)
4) Identify the macromolecules that make up cells and the relative abundance of those components in a cell
5) Recognize the steps involved in an electron transport chain
6) Distinguish between the outcomes of mitosis and meiosis

How were these used?

1. List was shared with instructors, feedback solicited
2. For Fall 2011 finals: Example questions for each of the 6 learning objectives were written and offered for instructors (most instructors wrote their own questions)

**Enabled a post-assessment of student performance in each section of BIO 101. (Built into the Final Exam).**
Student performance shown by objective (Instructor 1)
Student performance shown by objective (Instructor 2)
Student performance shown by objective (Instructor 3)
Student performance shown by objective (Instructor 4, Test A)
Student performance shown by objective (Instructor 4, Test A)
Total number of student responses

- Instructor 1: 73
- Instructor 2: 115
- Instructor 3: 71
- Instructor 4 (Test 1): 54
- Instructor 4 (Test 2): 55
What these data suggest:

• Students generally weakest with objectives 1*, 3*, and 5
  (*Scores < 50% except for 1 of the 4 instructors)

• Students strongest with objective 6
  (Scores close to, > 70%)

• High variability between instructors

1) Distinguish between a living and non-living organism
2) Predict direction of water movement in diffusion across a membrane, given solute concentrations on either side
3) Identify similarities and differences of prokaryotic and eukaryotic cells (either classifying examples or identifying in terms of cell properties)
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5) Recognize the steps involved in an electron transport chain
6) Distinguish between the outcomes of mitosis and meiosis
Other observations, suggestions

1. Instructors described minimal communication about the course and scheduling a common meeting time (for 4 instructors) was impossible.
   - Is a meeting possible before school starts?

2. All instructors independently suggested that the amount of content in BIO 101 was too large (some specified this in comparison to BIO 102)
   - Priorities are needed for content, coordinate with 102 instructors. (Work in progress)
Bloom's Levels of Understanding:
Exams target levels 1 and 2

6. Evaluation: think critically about and defend a position
   *Judge, Justify, Defend, Criticize, Evaluate*

5. Synthesis: transform, combine ideas to create something new
   *Develop, Create, Propose, Design, Invent*

4. Analysis: break down concepts into parts
   *Compare, Contrast, Distinguish*

3. Application: apply comprehension to unfamiliar situations
   *Apply, Use, Compute, Solve, Predict*

2. Comprehension: demonstrate understanding of ideas, concepts
   *Explain, Summarize, Interpret, Describe, Diagram*

1. Factual Knowledge: remember and recall factual information
   *Define, List, State, Name, Cite*

-Ok for introductory course? (But are students bored? prepared? Challenged?)

Ideas:
- Freeman text indicates Blooms levels for each question.

-Pre-lecture quizzes online (Mastering Biology) can address low Bloom’s level content well, enabling lecture time to focus on applications and higher levels of understanding.

(This does take a lot of planning, thought, and time.)

II. Overview of Activities

Spring 2012

Introductory Level

Discussed goals with Course Coordinator for BIO 101 labs

“Students should be able to build a graph”
“Want students to be able to interpret data on a graph”

Intermediate Level

Discussed goals with Instructors (and TA) for Bio 262

-Used experiences from Fall semester to design a pre-assessment for Spring

New Formative Assessment: Students plot their grade in class vs. time

New Pre-Assessment: Students answer questions about graphs, interpret experimental results

New Post Assessment in preparation.
Example of plotting ones grades assignment

• Opportunity for self-reflection
• Extra credit opportunity:
  (formative assessment= Instructors and TAs get feedback before there is a penalty to student grades)
Pre-Assessment 262
(Objective: Students can interpret data)

Format
6 questions: Multiple Choice and Short Response

Five types of data selected (based on instructor’s emphasis in the course):
(1) Population Growth
(2) Keeling Curve
(3) Rarefaction Curve (species richness)
(4) Competition/Predation Graphs
(5) Bar graphs from manipulative experiment

Sources for questions:
- Assigned SimU text (online program)
- Teaching Issues and Experiments in Ecology (TIEE)
- Customized from literature
Figure 5: The lines in this figure (called “isoclines”) show population sizes at which the growth rate of a population is zero. The population size of species 1 in these graphs (a pathogen) is on the x-axis, and that species 1 has an orange isocline. The population size of species 2 (a probiotic) is on the y-axis, and species 2 has a blue isocline. Above each isocline, the population decreases, and below the isoclines, it increases.

5. Which of the figures above illustrates a scenario in which the pathogen can compete most strongly against the probiotic bacteria?
(A) Figure A
(B) Figure B
(C) Both figures show cases in which the pathogen is equally competitive against the probiotic
(D) Neither figure shows any competitive effect of the pathogen on the probiotic bacteria.

6. In general, how would you rate your level of anxiety and frustration when you are presented with graph data to analyze or interpret?
A. No anxiety or frustration
B. Mild
C. Moderate
D. High anxiety or frustration
E. Extreme anxiety and frustration
Pre-assessment BIO 262

- 74 students total
- Student performance was stronger than expected.
- Generally, students performed poorly on a competition graph (required Ecology specific-knowledge).
- Post Assessment (by end of this semester) will measure improvement.

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Next Steps...

1. Revise Common learning objectives (priorities) based on all faculty and instructor input.
   - An all-faculty survey is being used to identify priorities for higher level courses.
2. Build a common on-line pre-assessment for Fall 2012
3. Compile a set of similar final exam questions across sections for post assessment.
Next Steps...

BIO 101 lab
- Continue graphing assessment, revise based on effectiveness.

BIO 262
- Examine results of post assessment, compare to pre-assessment
- Continue pre-and post-tests in future semesters (with instructor modification).
- Present format to faculty as a possible model for other upper level elective courses.

Sustaining Assessment Activities
Assemble a team of 3 faculty in Summer 2014 to apply for the Undergraduate Education in Biology Conference on Scientific Teaching.