Helping Introductory Biology Students Learn Scientific Reasoning Skills

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INTRODUCTION

In Fall 2010, Iowa State University initiated a program to transform introductory science courses with the goal of increased student success in scientific disciplines. Historically, introductory biology courses have emphasized the memorization of material, and this has left little time to devote developing scientific reasoning skills. The large number of students taking these courses as well as the diversity of student backgrounds creates unique challenges; it also presents important opportunities to inspire student interest, improve scientific literacy, teach important concepts, and develop reasoning skills. The ISU biology faculty have initiated a multi-step strategy to improve student learning in these courses.

STUDY LOCATION

Iowa State University is a land-grant university that supports world-class research and enrolls over 25,000 students. Approximately 2000 students take the introductory biology sequence each year. Pedagogical innovations and achievements in these courses can have tremendously positive impacts—but at large public universities like ISU, there are also inherent challenges to inspiring students' interest and assessing student learning.

PROJECT GOALS

- Faculty agreement on overarching course goals and learning objectives regarding scientific literacy.
- Create student-centered learning activities to explicitly teach students scientific reasoning skills in the context of course content.
  - → Post-doctoral science fellow works collaboratively with faculty to develop such activities.
- Assess students' scientific reasoning skills.
- Develop a process and materials that will enable sustainable changes after the completion of the grant.

CHALLENGES

- Each course in the two-semester introductory biology sequence is taught in 5 – 6 sections of around 250 students.
- Transformation of introductory biology is a collaborative effort, requiring coordination of >12 faculty instructors.
- 20% increases in enrollment from Fall 2010 to Fall 2011.
- Little to no teaching assistant support for lectures.
- Over 40 different majors take the introductory biology sequence.
- Formative and summative assessments must recognize budgetary constraints.
- Limited tools available to assess scientific reasoning skills.

APPROACH

(1) Create a *Faculty Learning Community* composed of more than 15 faculty members teaching introductory biology
- Work together to define learning objectives and identify foundational reasoning skills for students.
- Democratic rather than oligarchical approach; ie. change from the ground up.

FOUNDATIONAL SCIENTIFIC SKILLS

Data Interpretation	Research Design
Interpret graphs.	Interpret predictive models.
Describe patterns in graphs.	Predict results.
Describe patterns in data.	Observe patterns in data.
Create graphs.	Generate hypotheses.
Interpret data.	Identify controls.
Identify discrepancies in data.	Recognize that science is iterative.
	Design experiments.

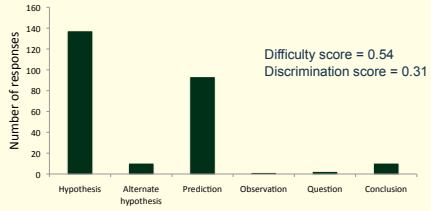
(2) Collaboratively construct POGIL (Process Oriented Guided Inquiry Learning) activities to explicitly teach scientific reasoning skills in the context of biological problems.

(3) Assess student progress toward scientific reasoning skills objectives using modified Lawson's tests.
→Refine Lawson's tests to provide information to our faculty on our learning objectives. Initial analysis of students' scores on Lawson's test include discrimination scores and difficulty indexes. The pilot data are from 759 students who took introductory biology courses in Spring 2011 and 12 student interviews.

EXAMPLE ASSESSMENT QUESTION

While walking around a lake one day, you find two dead fish lying about 10 feet apart on the shore. One of the fish is a bluegill, the other a bass. The bluegill is lying within one foot of the lake water on a moist, muddy area. The bass is resting on a dry, sandy area 6 feet from the water. Upon returning to the area two weeks later, you find the bluegill tissue is almost completely decomposed whereas the bass is just beginning to decompose.

"The difference in decomposition may be due to the amount of available moisture" is a _____.



IMPLEMENTATION

Fall 2010 and Spring 2011:
- Formation of the Biology Faculty Learning Community, including over 15 faculty from multiple departments that contribute to the core Biology curriculum.
- Pilot assessment administered to introductory biology students. These data help us to evaluate student learning, and it provides important information about the utility of assessment questions.

Summer 2011 and Fall 2011
- Work collaboratively to develop POGIL activities for use in large enrollment introductory biology courses. POGIL activities will be student-centered and explicitly focus on scientific reasoning skills in the context of biological problems.
- In Fall 2011, we will introduce these active learning exercises to some sections of Biology 211 courses (the first of the the two semester introductory series). Other instructors of the same course will choose to explicitly teach scientific reasoning skills through lecture format rather than POGIL activities (control 1) or may choose not to modify their lectures to explicitly teach scientific reasoning skills (control 2).
- Gains in student learning of scientific reasoning skills using modified Lawson's tests and other assessment tools.

Difficulty index = fraction of students who select the correct answer. The most useful question are have a score of 0.4 – 0.8.

Discrimination score = the fraction from the top 25% in performance on the assessment who choose the correct response minus the fraction from the bottom 25% who choose the correct response.

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