Development of an Introductory Biology Preparation Assessment Tool

Cynthia Giffen[1] and Laura Olsen[2]

cgiffen@umich.edu, ljo@umich.edu

[1]Comprehensive Studies Program & Dept. of Ecology & Evolutionary Biology

[2]Department of Molecular, Cellular, and Developmental Biology & Program in Biology

CRLT Center for Research on Learning and Teaching

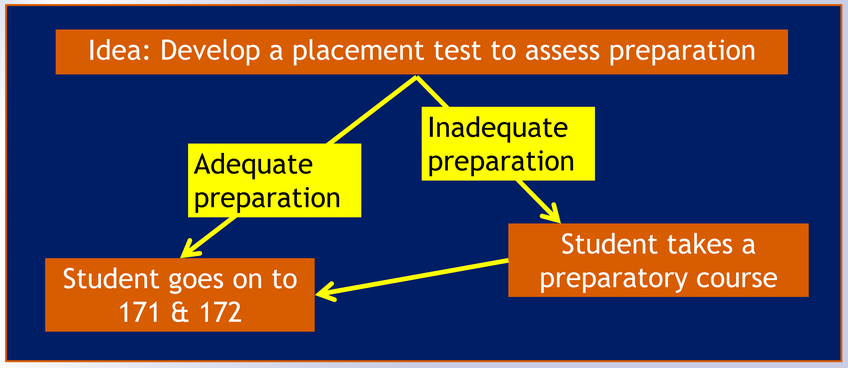
The 2015-16 Investigating Student Learning (ISL) Program was funded by the University of Michigan Office of the Provost and the Center for Research on Learning and Teaching.

LSA Comprehensive Studies Program, University of Michigan

LSA Biology, University of Michigan

LSA Ecology and Evolutionary Biology, University of Michigan

LSA Molecular, Cellular, and Developmental Biology, University of Michigan



Introduction

Introductory Biology is a two-semester course:
•171 (ecology, evolution, genetics, and diversity of life)
•172/174 (cell and molecular biology, animal and plant physiology), and
•173 (project-based laboratory with modules that cover content from both 171 and 172/174).
Enrollment in each of these courses is 500+ students per semester.

Students in Introductory Biology have diverse biology backgrounds and prior coursework experience. Differing levels of preparation stem from the diversity with which high school biology is taught and the co-curricular experiences (summer science camps, entrance exam prep courses) students have available to them.

Starting in Fall 2013, CSP (Comprehensive Studies Program) students interested in taking Introductory Biology were enrolled in smaller stand-alone sections taught by dedicated Lecturers (Giffen and Laury Wood). CSP sections meet an additional 2.5 hours per week to allow for greater instructor-student contact and more time to focus on mastering the course material. This change was made to help these at-risk students succeed in Introductory Biology so that we might retain more students in the STEM disciplines.

While this additional in-class time has helped many CSP students succeed, there remains a group of students whose high school science preparation is grossly insufficient. Approximately 50% of students in CSP sections earn final course grades of C or lower (Figure 1). We need to find ways to correct this preparation deficit and increase success of these students in Introductory Biology if we hope to retain more students in STEM fields.

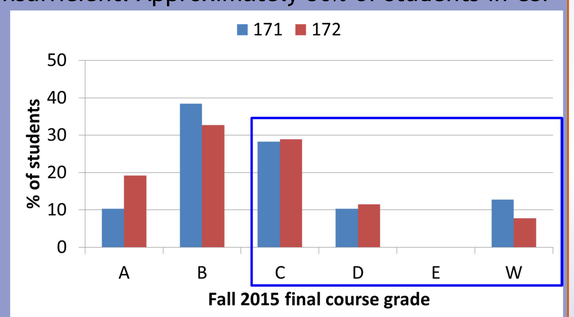


Fig 1. Bio 171 & 172 Fall 2015 course grade distributions for CSP sections.

Research Questions

1. What prior knowledge is necessary for successful performance in Introductory Biology?
2. Can we properly identify under-prepared students with a Preparation Assessment designed specifically for Introductory Biology at UM?
3. Once identified, what can we do to help students bolster their biology preparation to increase success in Introductory Biology?

Approach

- Summer 2015: drafted pre-assessment using Next-Generation Science Standards, published concept inventories, other biology placement tests
- Fall 2015: administered pre-assessment in CSP sections of 171 & 172 (n = 92); revised questions as needed and removed questions and non-distractor choices
- Winter 2016: administered pre-assessment in CSP sections of 171 & 172 (n = 88); coded and analyzed data using multiple linear regression

Pre-assessment construction

- MC questions in 7 blocks: chemistry, cell bio/physiology, evolution, genetics, ecology, graph reading, quantitative skills
- 56 questions in Fall; 50 questions in Winter
- "I don't know" option for every question
- Administered in first Discussion section of each semester
- At end of assessment, basic demographic questions, including semester in college, HS and college science courses, first-generation status, why the student is taking Intro Bio, etc.

Comparison between 171 & 172 CSP students

No significant differences ($p>0.05$) between 171 & 172 CSP students in:
- Biology class exam average (73% in Fall & 69% in Winter)
- Biology course grade (Fall 2015 only) (~79.5%)
- Current GPA (~3.1 in Fall & Winter)

Bio 172 CSP students are on average 0.5 semester farther along in their college careers.

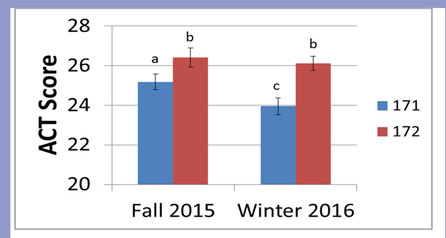


Fig 2. Comparison between 171 & 172 students' average ACT scores. Error bars are ±1SE. $p_{Fall} = 0.06$; $p_{Winter} = 0.0001$

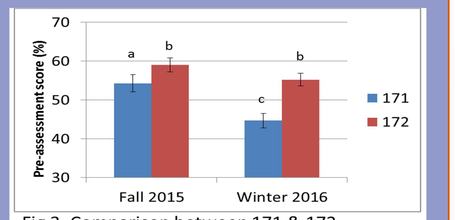


Fig 3. Comparison between 171 & 172 students' average pre-assessment scores. Error bars are ±1SE. $p_{Fall} = 0.1$ & $p_{Winter} < 0.0001$

Bio 172 CSP students appear to be better prepared, but the 172 CSP students' outcomes are the same as 171 students (exam average, course grade).

Results

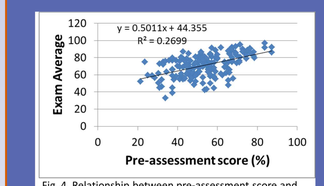


Fig. 4. Relationship between pre-assessment score and exam average for all 171 & 172 CSP students, Fall & Winter 2015-16. n = 179; p < 0.0001.

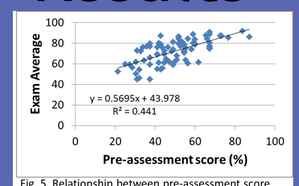


Fig. 5. Relationship between pre-assessment score and exam average for all 171 CSP students, Fall & Winter 2015-16. n = 80; p < 0.0001.

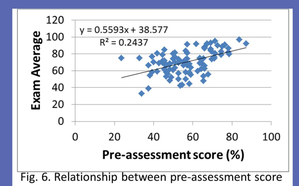


Fig. 6. Relationship between pre-assessment score and exam average for all 172 CSP students, Fall & Winter 2015-16. n = 98; p < 0.0001.

- Pre-assessment % alone is not sufficient to predict success (Figs. 4, 5, 6)
- Use multiple linear regression (MLR) to incorporate additional variables we believe may have predictive value: 171 vs. 172, semester in college, first-generation status, number of previous college science courses, ACT score, AP biology course & exam score.
- Only variables that have statistically significant predictive value are pre-assessment score & ACT score

Exam Average = (1.225 * ACT score) + (0.345 * pre-assessment %) + 21.5
$R^2 = 0.322$ (32% of variation is explained by ACT and pre-assessment score)
$p = 0.003$

Next Steps:

- Better align pre-assessment with 172
- Works well for many students, but some greatly outpace model predictions
- Further analysis on outliers may help us understand what factors are allowing underprepared students to succeed
- What other data can we collect to explain variation in achievement?

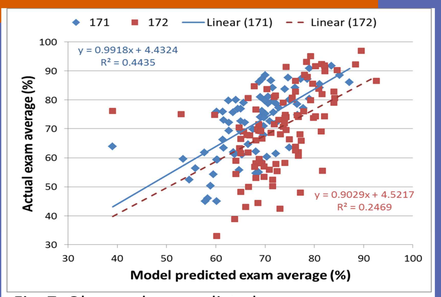


Fig. 7. Observed vs. predicted exam average, based on best MLR model.

Acknowledgements: We would like to thank Western Oregon University, Dartmouth University, Susan Elrod (Genetics Concept Inventory), Michelle Smith & Jennifer Knight (Genetics Concept Assessment), Cara Gormally, Peggy Brickman, and Mary Lutz (Test of Scientific Literacy Skills) for proving validated questions, and Laura Eidietis, Jo Kurdziel, and Meghan Duffy for feedback on the assessment. Laury Wood's contributions were invaluable ranging from piloting the assessment, aiding in data collection, and giving feedback on the assessment. Mary Wright from CRLT aided in the design of the research and staff at CSCAR assisted with data analysis. Sarah Crawford in the Office of the Registrar provided student records data under IRB protocol HUM00018003. We appreciate the participation of Bio 171 & 172 CSP students who took the assessment.