A Biology Placement Test for Introductory Majors Biology

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Background & Development

Biology 211, the gateway course for our major, covers cells, metabolism, and genetics. Prior to 2013, there were no pre-requisites for this course and we observed years of high F/drop rates despite incorporating active learning strategies in 2009.

Placement tests in writing, reading, and math are readily available, including commercial products (e.g. Accuplacer). While the American Chemical Society has developed a widely used placement test, Biology lacks such tools - even though many programs describe tests on-line (see adjacent summary).

Thus, we developed a Biology 211 content-targeted test based on the 2011 Oregon Dept. of Education Standards for Middle & High School Science. Six questions (of the 30 total) are organized thematically below.

Biology Placement Test Purpose & Review

Google-searching "Biology Placement Test" AND college or university yielded ~3000 hits. The following represents a summary of our review of these hits.

1. Determining preparedness for allied health A&P, Microbiology
Many Community Colleges - e.g. Montgomery, DeAnza Foothill, Glendale, Denver

2. Allowing students to test out of introductory biology
Many University/Colleges - e.g. St. Cloud, Chicago, Brown, College of Southern Maryland

3. Determining preparedness for majors introductory biology
Fewest Examples (<10 University/Colleges) - e.g. Mills, Wayne State, SUNY – Staten Island
Mills' exam consists of 20 on-line questions; Wayne State's is 50 questions.

EBSCO-searching "Biology Placement Test" yielded only 1 publication about test validation: the 1976 paper by White et al. that examined what would become the AP Biology Exam.

Middle School: Describe the atomic model and explain how the types and arrangements of atoms determine the physical and chemical properties of elements and compounds.

High School: Compare and contrast the four types of organic macromolecules.

Which is found in the nucleus of an atom?
a. protons only
b. electrons only
c. protons and electrons
d. protons and neutrons

Which is the most hydrophobic?
a. proteins
b. lipids
c. carbohydrates
d. nucleic acids

Middle School: Explain the processes by which plants and animals obtain energy and materials for growth and metabolism.

High School: Explain how cellular processes are regulated in response to the environment.

Photosynthesis produces
a. carbon dioxide
b. water
c. oxygen
d. light

A red blood cell in a high salt solution will
a. explode
b. appear shriveled
c. appear normal
d. appear swollen but not explode

High School: Explain and apply laws of heredity and their relationship to DNA.

High School: Describe the structure of DNA and its relationship to chromosomes. Explain the role of DNA in protein synthesis.

Crossing two heterozygous individuals yields
a. all dominant offspring
b. all recessive offspring
d. 1:1 dominant : recessive offspring
d. 3:1 dominant : recessive offspring

Reading RNA information into protein
a. is called replication
b. is called translation
c. is called transcription
d. mutation

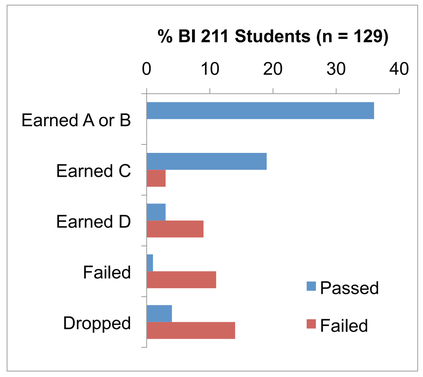
2012 Placement Test & Benchmark Pilot

For our trial run, we defined failing as earning less than 20/30 (67%). We demonstrated that 88% of students who scored below 67% failed or dropped the class.

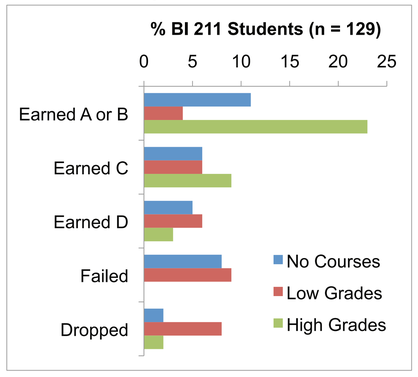
Given that 70% students reporting completing non-majors Biology or Chemistry, we evaluated transcripts, sorting by high grades (A/B), low grades (C or lower), or no such courses. A/B grades were most represented among successful BI 211 students.

Note: 156 students signed up for Biology 211 by September 2012. Of these, 27 dropped before the term began or during week one (these were excluded from analyses).

Placement Test vs. Course Outcome



Pre-Course Experience vs. Course Outcome



For the analysis of placement test vs. course outcome, the course outcome for students who passed the placement test was significantly different from the course outcome for students who failed the placement test (Chi-square, $p < 0.001$). For the analysis of pre-course experience vs. course outcome, there was a significant difference in course outcome due to pre-course experience. Students in the "high grade" category had a significantly different course outcome distribution compared to students in the other two categories (Chi-square, $p < 0.001$).

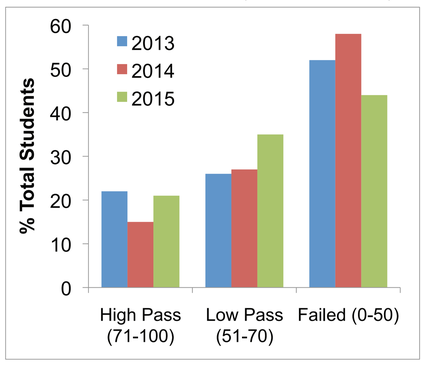
2013-2015 Placement Test Results

New BI 211 Benchmarks
Pilot data were used in meetings with the Academic Advising & Learning Center (AALC) and Associate Provost about defining new access benchmarks for BI 211. First implemented in 2013, these include earning 51% or higher on the placement test OR an A/B in non-majors Biology (cells/genetics) or Chemistry (atoms/bonds).

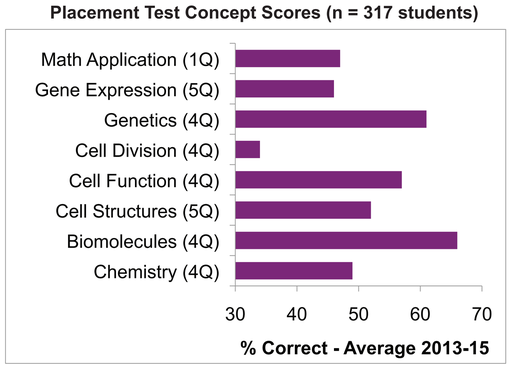
Placement Test Administration
We worked with University Computing Services (UCS) to program the test into our secure portal with a 45 minute time-limit. Students must be provided with access by one of a limited number of faculty and staff. Nearly all entering freshman take the test during Summer Orientation Advising Registration (SOAR) with Biology faculty present to provide feedback. Walk-in testing is also available at the the AALC.

Placement Test Results
Between 2013-2015, 317 students have taken the placement test. As shown in the graph to the right, only HALF of all students pass the test. Below are summaries of results according to performance on specific concepts or questions.

Placement Test Scores (n = 317 students)



Placement Test Concept Scores (n = 317 students)

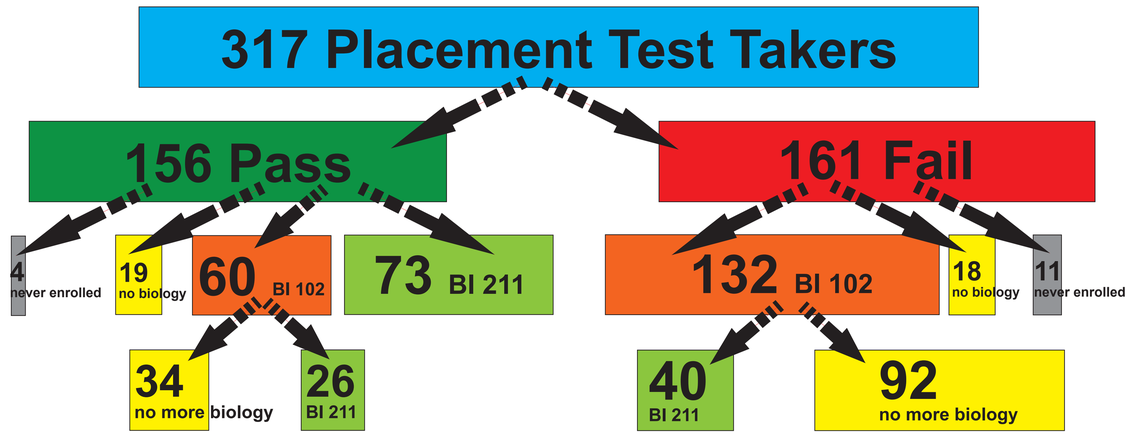


Lowest Scoring Concepts (<30%)
CELL DIVISION: MEIOSIS (21%)
CHEMISTRY: BONDS (25%)
GENETICS: SOLVING CROSSES - PERCENTS (27%)
CELL DIVISION: MEIOSIS CROSSING OVER (28%)
CELL STRUCTURES: MITOCHONDRIA (29%)
GENE EXPRESSION: CODONS (30%)

Highest Scoring Concepts (>70%)
GENETICS: CROSS LOGIC - DIMPLES (88%)
GENETICS: SOLVING PARENTS - BLOOD TYPING (87%)
BIOMOLECULES - PROTEINS/AMINO ACIDS (77%)
BIOMOLECULES - CARBOHYDRATE EXAMPLES (76%)
CELL FUNCTION: PHOTOSYNTHESIS PRODUCTS (71%)

Short-Term Placement Test Taker Fate

The following flow chart diagrams the course selection/fate of Biology Placement Test takers (n = 317 total) between 2013 and 2016. Sub-cohorts have been color-coded, and the sizes of each box represents the sub-cohort proportion in relation to the total.



Long-Term Placement Test Taker Fate - 2013 Cohort

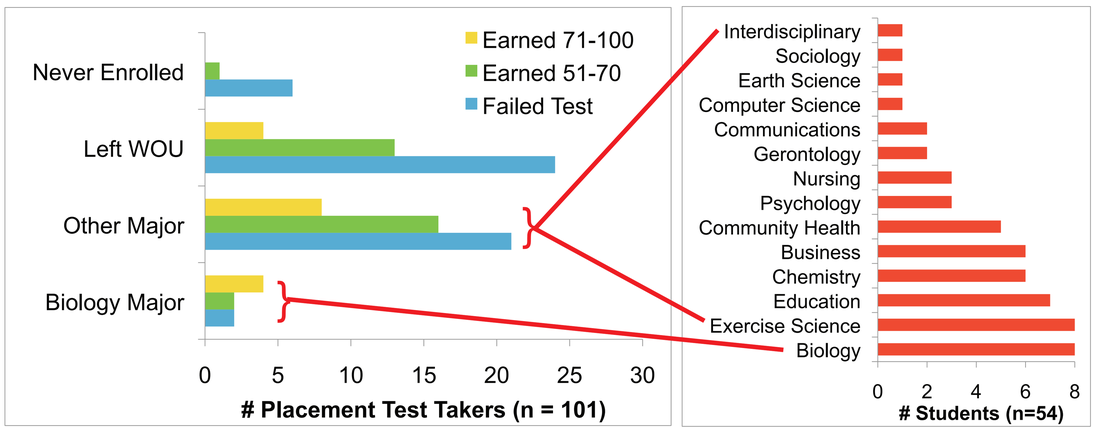
Although we aim to assess the long-term fate of all Biology Placement Test takers, we focused only on the 2013 cohort for this presentation because these data - given 3 years of passed time - are more reliable in terms of major/goal progress and drop-out observations.

2013 Students Who Failed (n = 53/101)
Most (29) took BI 102 but did not choose to enroll in BI 211 (about half received benchmark-passing grades). Of the 18 students who took BI 102 and then BI 211, only 2 remain Biology majors. **In total, nearly HALF this subcohort (24) left the university.**

2013 Students Who Passed, Earning 51-70 (n = 32/101)
About half (15) took just BI 211, with 2 pursuing Biology majors. Of the 21 students who took BI 102, 10 moved into BI 211 (2 are Biology majors). **In total, 40% of this subcohort (13) left the university.**

2013 Students Who Passed, Earning 71-100 (n = 16/101)
Nearly all took BI 211, earning Biology, Education, or Exercise Science majors. **In total, 25% of this subcohort (4) left the university.**

Some General Trends - Beyond the 2013 Cohort
With each passing year, the drop-out rate increases; 2014 shows fewer drop-outs than 2013 and 2015 shows the fewest drop-outs. Conversely, the number of Biology majors goes down; 2014 shows more majors than 2013 and 2015 shows the most because of the inverse relationship with dropping out.



Conclusions and Future Work

We observed some knowledge gaps between 2011 Oregon education science standards and student performance on our placement test, particularly in terms of cell division.

Many students (nearly 40%) chose to leave Biology after completing a non-majors course focused on cell biology and genetics - most (73%) after failing the placement test.

In terms of long-term analysis (2013 cohort only), half of all students who failed the placement test left the university, most within 2 years of initial enrollment.

In terms of long-term analysis (2013 cohort only), 27% are earning Natural Science degrees, 39% Health-focused degrees, and 13% Education degrees.

The next phase of this project involves looking at long-term dynamics of other placement test cohorts, as well as progress over time within the Biology degree.

Previous Presentations About This Work

S.M. Boomer, M.J. Baltzley, K.L. Latham, 2012. Active Learning and Advising Strategies in Freshman Introductory Biology - If You Build It, Some Will Come. ASM-CUE.

S.M. Boomer, M.J. Baltzley, K.L. Latham, 2013. Active Learning and Advising Strategies in Introductory Biology II - If You Click It, a Few More Will Come. ASM-CUE.