Evaluating Student Learning in Large Introductory Biology Courses: Predictors of Student Success and Lessons for Course Redesign

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University of Calgary
### Organizing the Core Biology Curriculum at U of C

<table>
<thead>
<tr>
<th>Course Name</th>
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<tbody>
<tr>
<td>Introduction to Cellular Biology (Biol 231)</td>
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<tr>
<td>Organismal Biology of Plants and Animals (Biol 233)</td>
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<tr>
<td>Principles of Genetics</td>
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<tr>
<td>Introduction to Ecology and Evolution</td>
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<tr>
<td>Introduction to Cellular and Molecular Biology</td>
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<tr>
<td>Introduction to Biochemistry</td>
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<tr>
<td><strong>Student and Faculty Perspectives of Core Courses</strong></td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td><strong>Students</strong></td>
</tr>
<tr>
<td>Repetition from high school and between core courses</td>
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<tr>
<td>Focus on memorization of a LOT of detail</td>
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<tr>
<td>Links between courses weak</td>
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<tr>
<td>Few opportunities for feedback on lecture content</td>
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<td>Lab experience could be improved</td>
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Traditional Organization of the Biology Curriculum

Core courses introduce “disciplines”, not biology

Integrated Understanding of Core Concepts
Using Core Concepts to Organize the Biology Curriculum
Organizing the First-Year Biology Curriculum

Energy Flow in Biological Systems

DNA, Inheritance and Evolution
Investigating the Impact of Course Redesign

<table>
<thead>
<tr>
<th>Research Questions:</th>
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<td>(1) What are the <strong>major predictors of student success</strong> in our first-year biology classes (e.g. study strategies, ways of thinking, prior knowledge)?</td>
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<td>(2) How do changes to lecture approach and teaching style influence student understandings (and misconceptions) of energy, evolution, and information?</td>
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<td>(3) How do redesigned laboratories impact the acquisition and retention of student skills around the scientific process (e.g. graphical analysis, experimental design)?</td>
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<tr>
<td>(4) How are <strong>measures of student and faculty satisfaction</strong> influenced by the redesigned curriculum?</td>
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# Research Design: Pre-Course

**ASSIST Survey** *(Online)*  
Approaches and Study Skills Inventory for Students  
- Conceptions of Learning  
- Approaches to Studying

**Learning Assessment** *(In-Lab)*  
Scientific Process Skills Assessment  
  (graphing, experimental design)

**Energy, Evolution and Information Concept Test** *(Biol 231 only)*  
- 9 multiple-choice questions on each topic (27 total)  
- 1 application-style written response question on each topic  
- In-depth interviews with ~7 students

Information on ASSIST and ETL surveys can be found at [http://www.etl.tla.ed.ac.uk](http://www.etl.tla.ed.ac.uk)
Research Design: Post-Course

**ETL Survey** (Online)
Experiences of Teaching and Learning Questionnaire

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<tr>
<th>Approaches to Studying</th>
<th>Learning Experience</th>
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**Final Lecture and Lab Examinations**

Lab exam: Similar questions to the Scientific Process Skills Assessment

Lecture exam: All items on concept test included (Biology 231 only)

**In-depth interviews** with ~7 students (Biology 231 only)

Information on ASSIST and ETL surveys can be found at http://www.etl.tla.ed.ac.uk
Research Design Overview

Courses run both Fall and Winter Semesters

* 1732 students from both courses completed the ASSIST and ETL surveys (and the course)
* 942 students completed both pre- and post-course concept tests
Motivations for Learning

Responses from 1732 students in first-year biology.

No differences between courses, terms or lecture section were found (All p values <0.0001).
Students come into first year biology with weak conceptual understandings of energy, evolution and information.

Students achieved higher scores for evolution in Winter semester likely because they took Biology 233 in Fall semester.
## Predictors of Student Success

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<tr>
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<th>r value</th>
<th>p value</th>
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<tbody>
<tr>
<td>Pre-Test Score</td>
<td>0.525</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Deep Learning Approach</td>
<td>0.159</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Surface Learning Approach</td>
<td>-0.162</td>
<td>&lt;0.0001</td>
</tr>
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</table>

Responses from 942 students in Biology 231

* Students who come into first-year biology with minimal knowledge of pre-requisite information are not able to make up the knowledge gap

* Promoting a deep approach to learning new information could help students learn more
How much are students learning?

* Normalized change values indicate only low to moderate learning of concepts in our current first year courses

### How will these results impact our course redesign?

- **Students achieving higher scores on pre-test achieve higher course grades**
  - Students with lower skills on fundamental course concepts are unable to make up the learning over the semester.
  - Prerequisite knowledge strongly tied with the learning outcomes articulated in the high school curriculum.
  - Students will complete a pre-learning assessment to help them identify areas where they need to review.
  - On-line activities will be provided to help students learn fundamental concepts.
How will these results impact our course redesign?

* Students who take a deep approach to learning learn more

* Taking a student-centred approach to teaching

  * Courses developed using a backwards design model.

  * Active learning strategies intentionally embedded
    * In-class activities, small lecture assignments and clicker questions designed to help foster the development of deep learning of course material.

  * Study tips will be presented throughout the semester using course instructor blog

How will these results impact our course redesign?

* Students learning of foundational course content is limited

* Taking a student-centred approach to teaching

  * Core concepts taught in an integrated way - from biomolecules to the biosphere

Energy Flow in Biological Systems

**Theme 1:** Fundamentals of thermodynamics

**Theme 2:** Cells and energy

**Theme 3:** Energy budgets and flow in organisms

**Theme 4:** Energy flow in ecosystems
Acknowledgements

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