Fixing Intro Bio: Integrating Concepts in Biology

A. Malcolm Campbell
Biology Department and GCAT

Franklin & Marshall University
August 11, 2014
Outline of Presentation

What did Vision & Change Propose?

What is the AP Biology Redesign?

How does *ICB* fit with these curricula (+ GRE and MCAT)?

Students meet learning objectives (content and attitude).

How do we run our classrooms? Write tests?

Let’s tour the book.
Teaching vs Learning

Guess what, I taught my dog to whistle!
Really?!
Teaching vs Learning

Whistle! C'mon boy, whistle!
Teaching vs Learning

???????????????
Teaching vs Learning

I thought you said you taught your dog to whistle.
Teaching \textit{vs} Learning

I did, but I didn’t say that he learned to whistle.
Our Current Challenge: Introductory Biology

Integrating Concepts in Biology

by

A. Malcolm Campbell, Laurie J. Heyer and Christopher J. Paradise
What’s Wrong with Biology Education Now?

- Vocabulary is emphasized (800-1000 vs 1400)
- Experimental approaches are minimized
- Math is absent
- Memorization is rewarded
- Critical thinking is discouraged
- Information is irrelevant to students
If we currently cover all the important stuff....

...how can we add more content?
Too much content for the containers
Too much content for the containers
“Never mistake activity for achievement.”

John Wooden
Concepts

Vision & Change
Evolution
Structure and Function
Information
Energy and Matter
Systems Biology

AP Biology
Evolution
Information
Homeostasis
Emergent Properties
V&C Competencies

• Apply the process of science
• Use quantitative reasoning
• Use modeling and simulations
• Integrate different disciplines
• Communicate & collaborate
• Connect science & society
AP Competencies

• use models to communicate and solve problems
• apply mathematics appropriately
• scientific thinking to extend thinking and guide experiments
• plan and implement data collection strategies
• data analysis and evaluation of evidence
• work with scientific explanations and theories
• connect information across scales, concepts and domains
Start with the literature...
Present information and data…
... in the context of the big picture.
Artificial Divide within Biology

Small Biology

Big Biology
Five Levels of Organization

- Molecular
- Cellular
- Organismal
- Population
- Ecological System
Five Big Ideas of Biology

- Information
- Homeostasis
- Emergent Properties
- Cells
- Evolution
BioMath Explorations
BioMath Exploration 6.3

How can you fit exponential curves to data?
Ethical, Legal and Social Implications

Are religion and evolution compatible?

Is science possible if you are uncertain about what is true?

Does basic biology have any impact on the real world?

Who owns your DNA?
Did my students learn less content?
Student Content Assessment

83% response rate (new)
63% response rate (traditional)

$p = 0.06$

percent correct

Fall 2010

$p = 0.97$
Student Content Assessment

- 83% response rate (new)
- 63% response rate (traditional)

*p = 0.06

Fall 2010: 60% percent correct (new) vs. 60% percent correct (traditional), p = 0.97

Spring 2011: 65% percent correct (new) vs. 55% percent correct (traditional), p = 0.06

+-/ SEM
Can my students analyze data better?
Student Skills Assessment

% Correct

Traditional  New

$p = 0.043$
Are *ICB* students overconfident?

<table>
<thead>
<tr>
<th>* p&lt;0.05, ** p&lt;0.01, *** p&lt;0.001</th>
<th>Average at Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 5 scale, 1 = weak</td>
<td>ICB</td>
</tr>
<tr>
<td>understand central concepts of biology</td>
<td>4.11</td>
</tr>
<tr>
<td>apply concepts to new situations</td>
<td>3.89***</td>
</tr>
<tr>
<td>analyze new data</td>
<td>3.68**</td>
</tr>
</tbody>
</table>

Yes?
Are *ICB* students overconfident? *less so*

<table>
<thead>
<tr>
<th></th>
<th>Average at Start</th>
<th>( \Delta ) in Average at End</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>p</em>&lt;0.05, *<em>p</em>&lt;0.01, **<em>p</em>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 5 scale, 1 = weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>understand central concepts of biology</td>
<td>4.11</td>
<td>+0.12*</td>
</tr>
<tr>
<td>apply concepts to new situations</td>
<td>3.89***</td>
<td>-0.04**</td>
</tr>
<tr>
<td>analyze new data</td>
<td>3.68**</td>
<td>-0.28**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ICB</th>
<th>Traditional</th>
<th>ICB</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.76</td>
<td>3.02</td>
<td>+0.53</td>
<td>+0.67</td>
</tr>
</tbody>
</table>
Do *ICB* students see biology differently?

<table>
<thead>
<tr>
<th>1-5 scale 5 = extremely accurate</th>
<th>Average at Start Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>biology is definitions &amp; processes</td>
<td>ICB: 2.86, Traditional: 2.61</td>
</tr>
<tr>
<td>big questions of biology already answered</td>
<td>ICB: 1.71, Traditional: 1.50</td>
</tr>
<tr>
<td>big/small division of biology describes nature</td>
<td>ICB: 3.15, Traditional: 3.02</td>
</tr>
</tbody>
</table>

* p<0.05, ** p<0.01, *** p<0.001,  ^ p= 0.06

**no**
## Do ICB students see biology differently?

<table>
<thead>
<tr>
<th>1-5 scale 5 = extremely accurate</th>
<th>Average at Start Fall</th>
<th>Δ in Average End of Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology is definitions &amp; processes</td>
<td>ICB 2.86 Traditional 2.61</td>
<td>ICB -0.58*** Traditional +0.50</td>
</tr>
<tr>
<td>Big questions of biology already answered</td>
<td>ICB 1.71 Traditional 1.50</td>
<td>ICB -0.32* Traditional +0.22</td>
</tr>
<tr>
<td>Big/small division of biology describes nature</td>
<td>ICB 3.15 Traditional 3.02</td>
<td>ICB -1.08*** Traditional -0.06</td>
</tr>
<tr>
<td>1-5 scale 5 = extremely important</td>
<td>Memorization</td>
<td>ICB -1.48*** Traditional -0.08</td>
</tr>
</tbody>
</table>

* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06

**yes!**

**yes!**

**yes!**

**yes!**
Do *ICB* students see biology differently?

<table>
<thead>
<tr>
<th>1-5 scale</th>
<th>Average at Start Fall</th>
<th>Δ in Average End of Fall</th>
<th>Δ in Average End of Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 = extremely accurate</td>
<td>ICB</td>
<td>Traditional</td>
<td>ICB</td>
</tr>
<tr>
<td>biology is definitions &amp; processes</td>
<td>2.86</td>
<td>2.61</td>
<td>-0.58***</td>
</tr>
<tr>
<td>big questions of biology already answered</td>
<td>1.71</td>
<td>1.50</td>
<td>-0.32*</td>
</tr>
<tr>
<td>big/small division of biology describes nature</td>
<td>3.15</td>
<td>3.02</td>
<td>-1.08***</td>
</tr>
</tbody>
</table>

* 1-5 scale, 5 = extremely important

* *p* < 0.05, ** *p* < 0.01, *** *p* < 0.001, ^ *p* = 0.06

*yes!*
How do I run my class?

• Assume they have read before class.
• Go through reading like a journal club.
• Cold call on students to answer questions.
• It is ok to be wrong.
• Students ask more than just clarifying questions.
• Try to answer Integrating Questions on their own.
• I do not collect IQ answers, but will review some in office.
• I cover key points but do not present the information to them.
• Remember learning is not the same thing as teaching.
• Value added by coming to class.
How do I assess student learning?

• 10% of questions come from lab
• questions are based on Integrating Questions (not identical)
• questions are based on Review Questions (not identical)
• support their answers with data!!!
• focus on learning objectives and Bloom’s terms
• they draw some answers
• design experiments with controls
• could be multiple choice format
Touring ICB

- eBook website
- PPT for teachers
- Excel from BME 3.1
- sample test