Does Method Matter?:
A Collaborative and Comparative Study of Teaching Methodology and Content Learning in Introductory Biology

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Background

- High School & Military career
- Undergraduate courses
- First field research experience
- Graduate school
- Research in Conservation Ecology and Behavior
- Disciplinary-Based Education Research (D-BER)
Biology Education

• “Not only have we done a poor job in communicating our science to the public, we are becoming increasingly aware of the poor job we are doing in communicating the nature of biological science to our own students.” (Howard 2014)

• The national conversation for Biology Education
  – Conceptual framework upon which to build disciplinary knowledge
  – Science as a process

• Learn biology by doing biology

• Research in the field focused on pedagogical methods and theoretical framework of biology education
  – improve engagement, retention, persistence, and learning of content.

Froyd 2007 (Project Kaleidoscope); Davis 1997 (National Research Council - NRC); Nielsen 2011 (NRC); NRC 2000, 2003, 2004; National Science Foundation 1996; The Boyer Commission 1998; Bonwell and Eisen 1991 (The Educational Resources Information Center); Cerbin 2012 (The Carnegie Foundation for the Advancement of Teaching); AAAS (2009)
Biology Education

- Traditional undergraduate course:
  - Lecture section
  - May or may not have a laboratory section
  - Labs were historically “cookbook” activities
  - Little to no scientific thinking
  - Small proportion of students engage in research

Froyd 2007 (Project Kaleidoscope); Davis 1997 (National Research Council - NRC); Nielsen 2011 (NRC); NRC 2000, 2003, 2004; National Science Foundation 1996; The Boyer Commission 1998; Bonwell and Eisen 1991 (The Educational Resources Information Center); Cerbin 2012 (The Carnegie Foundation for the Advancement of Teaching); AAAS (2009)
Background

- Undergraduate STEM Education
- 2012 PCAST Report: 1 million new STEM graduates THIS decade
- Focus on pedagogical methodology and science as process
- Scientific Method as framework for all courses
  - Observation, comparison, & correlation
  - Experimental investigation
  - Scientific thinking
Pedagogy methods in the lab:

- Active Learning through:
  - Hands-on learning
  - Problem-based learning (PBL)
  - Course-based research (CBR)
Pedagogy methods in lecture:

• Active Learning through:
  – Active lecture
  – Cooperative Group Learning
  – The Flipped Classroom model
  – Primary Literature-Based instruction
  – Hybrid models
Cooperative Group Learning

• In- and out-of-class assignments
• Assigned groups
• Graded group and individual assessments

Excellent review by Davidson & Major 2014
The Flipped Classroom Model

- **Goal:** Increase student engagement and content learning in lecture settings
- **CLICed (Cinematic Lectures and Inverted Classes)**

From Marcey and Brint 2012
Primary Literature-Based Instruction

- Carefully selected literature
  - Content-specific
  - Accessible to novice learners
- The CREATE Strategy
  - Consider Read, Elucidate the hypotheses, Analyze and interpret the data, and Think of the next Experiment (Stevens & Hoskins 2014)
Methods

- **Introductory Biology I**
  - 11 sections, team-taught
  - 507 students; 434 completed study
  - Student demographic

- **Pre- and post-instruction content knowledge surveys**
  - Ecology, Genetics, Cell Bio, Evolution

- **Correct for variation in aptitude**
  - ACT score
Results

1. Did student post-instruction scores change compared to pre-instruction scores?
   - Paired T-test: $T = -28.30$, $df = 433$, $P < 0.001$

2. Is improvement related to sub-disciplinary content (cell, genetics, ecology, evolution)?
   - Two-samples paired t-test

<table>
<thead>
<tr>
<th>Discipline</th>
<th>T-statistic</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>-7.133</td>
<td>433</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Genetics</td>
<td>-23.019</td>
<td>433</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cell Biology</td>
<td>-11.360</td>
<td>433</td>
<td>&lt;0.001</td>
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<tr>
<td>Evolution</td>
<td>-20.200</td>
<td>433</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Results

• 3a. Was performance (Overall $\Delta_{\text{Score}}$) related to ACT?

Bivariate Fit Logistic Regression:

$F_{1,400} = 10.889, P = 0.011$
Results

• 3b. Was performance (Overall $\Delta_{\text{Score}}$) related to ACT for each sub-discipline?

• Subsequent analyses correct for ACT

- Cell Bio
  $F_{1,400}=18.6145, P<0.001$

- Genetics
  $F_{1,400}=7.9056, P=0.0052$

- Ecology
  $F_{1,400}=0.4953, P=0.4820$

- Evolution
  $F_{1,400}=0.9021, P=0.3428$
Results

4. Which predictor variable explains the difference?
   - 4a. Does overall $\Delta_{\text{Score}}$ relate to declared major?
     - Biology, Nursing, Exercise Science, Other, Undeclared
   - No difference between majors in performance improvement
Results

4. Which predictor variable explains the difference?
   - 4b. Does overall $\Delta_{\text{Score}}$ relate to enrollment in high school AP Biology?

   Two sample test comparing performance increase between those that did and did not take AP Biology in high school.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>T-ratio</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>-2.64</td>
<td>235.67</td>
<td>0.009</td>
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<tr>
<td>Genetics</td>
<td>-3.32</td>
<td>189.86</td>
<td>0.001</td>
</tr>
<tr>
<td>Cell Biology</td>
<td>0.275</td>
<td>218.56</td>
<td>0.392</td>
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<tr>
<td>Ecology</td>
<td>0.679</td>
<td>210.93</td>
<td>0.249</td>
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<tr>
<td>Evolution</td>
<td>-3.22</td>
<td>245.76</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Results

• 4. Which predictor variable explains the difference?
  – 4b. Does overall $\Delta_{\text{Score}}$ relate to pedagogy?
Results

4. Which predictor variable explains the difference?
   - 4b. Does overall $\Delta_{\text{Score}}$ relate to pedagogy?
   - 4c. ...in subject area?
Scheme for pedagogical decision making based on course structure (TMC. Hall)
Your Syllabus

• Which model fits best?
Many thanks!

Questions?