Part 1. Transforming teaching

Faculty
Postdocs
Grad students

Professional development

Desired outcomes sustained
Transforming teaching

Faculty
Postdocs
Grad students

Professional development

Desired outcomes sustained

How do we assess the programs?
What does the evidence show?
FIRST IV – Postdocs at Field Stations
Collaborators

**FIRST IV Regional Team Leaders**
- Stephanie Aamodt
- Janet Batzli
- Peggy Brickman
- Elizabeth Derryberry
- Clarissa Dirks
- Chris Finelli
- Jan Hodder
- Jamie Keck
- Jenny Knight
- Debra Linton
- Tammy Long
- Marcy Osgood
- Emily Rauschert
- Courtney Richmond
- Alison Roark
- Cindy Sisson
- Christopher Tubbs
- Kathy Williams
- Michelle Withers

**FIRST IV Postdocs (n = 201)**

**FIRST IV Research Team**
- Terry Derting
- Tim Henkel
- Jessica Middlemis Maher
- Bryan Arnold
- Heather Passmore
- Jenni Momsen
- Alec Francisco Aiello
- Cody Bekkering
- Rachael Nye Jaeger
- Sarah Jardeleza
- Dan Totzkay

**DUE 0817224**
Sample population: FIRST IV postdocs

Postdoctoral scholars
\[ n = 201 \]

Year 1
Course Design, Assessment

Year 2
Reflect & Revise Course

Teach
x 2

Project Goal: Participants implement learner-centered pedagogy in their teaching of a transformed course
What did we do in the workshops?

- Conceptual change approach to teaching
- Build an entirely transformed course framework
- Assessment
- Evidence-based pedagogy
Research question – FIRST IV

To what extent do postdoctoral fellows (i.e., future biology faculty) believe in and implement evidence-based pedagogies after completion of a two-year professional development program?
Data Sources

- **Approaches to Teaching Inventory (ATI)**
  (Trigwell and Prosser 2004, Trigwell et al. 2005)

- **Teaching Goals Inventory (TGI)**
  (Angelo and Cross, 1993)

- **Experience of Teaching Questionnaire (ETQ)**
  (Trigwell and Prosser 1997, 2008)

- **FIRST IV background and annual surveys (FIRST IV)**
  (e.g., professional development activities, challenges, departmental support)
## Reformed Teaching Observation Protocol (RTOP)

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<tbody>
<tr>
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<td>0-30</td>
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<td>II</td>
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Teacher-centered

- Category I (0-30) - Straight lecture
- Category II (31-45)
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Reformed Teaching Observation Protocol (RTOP)

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Teacher-centered

Learner-centered
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Teacher-centered

Learner-centered

- Active student involvement in open-ended inquiry, resulting in alternative hypotheses, several explanations, and critical reflection.
Do FIRST postdocs practice learner-centered teaching in their final year of participation?

Quasi-experimental design - Paired Study

21 pairs of faculty
21 different institutions
Quasi-experimental design

21 pairs of faculty
21 different institutions

How did we determine equivalence of comparison groups?
Characteristics of matched pairs of faculty from FIRST IV with a non-FIRST faculty colleague (n=21)

<table>
<thead>
<tr>
<th>Group</th>
<th>Participants</th>
<th>Teaching Experience</th>
<th>Active-learning Knowledge</th>
<th>Active-learning Experience</th>
<th>Department Support</th>
<th>Course Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST IV</td>
<td>56</td>
<td>2.1 ± 2.3</td>
<td>35.2 ± 2.3</td>
<td>34.8 ± 1.8</td>
<td>21.3 ± 4.8</td>
<td>18</td>
</tr>
<tr>
<td>Paired Faculty</td>
<td>50</td>
<td>4.1 ± 4.3</td>
<td>35.3 ± 2.7</td>
<td>34.7 ± 2.5</td>
<td>23.2 ± 3.2</td>
<td>18</td>
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</table>
Observations of Teaching

What do we know about postdocs’ teaching?

- More learned-centered courses than comparison groups
- Transforming entire course – matters.
- Perceptions – differed between groups: conceptual change vs. information transfer
- Design, Practice, Feedback,…Modify design, Practice, Feedback (Mentoring)
- Assessments - add more peer and expert mentoring
Undergraduate Degree

Graduate Degree

Postdoctoral Work

Faculty Position

Tenured Faculty

6 years later
Academic pathway

Undergraduate Degree

Graduate Degree

Postdoctoral Work

Faculty Position

6 years later

Tenured Faculty
Research Questions

1. Is professional development in teaching maintained in pre-tenure faculty teaching practices?

2. How do faculty perceptions about and approaches to teaching impact their teaching practice?

3. How is the maintenance of behavior (teaching practice) shaped by institutional reward systems and alignment with faculty values?

4. What is the role of department climate and leadership in shaping early-career faculty teaching practice?

5. How does faculty self efficacy affect implementation of learner-centered teaching?

6. How do faculty teaching practices impact students’ conceptual understanding of biology?
Study Population:
- 75 faculty: primarily early-career faculty in biology departments.
- 36 pairs and 3 single participants (FIRST IV alumni)

### School Type

<table>
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<tr>
<th>School Type</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>Doctoral Universities</td>
<td>19</td>
</tr>
<tr>
<td>Master's Colleges &amp; Universities</td>
<td>12</td>
</tr>
<tr>
<td>Baccalaureate Colleges</td>
<td>2</td>
</tr>
<tr>
<td>Baccalaureate/Associate's Colleges</td>
<td>1</td>
</tr>
<tr>
<td>Associate's Colleges</td>
<td>2</td>
</tr>
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</table>

Map of states with participating schools (dark gray)
Research Model

Independent Variable: Past Experiences
- Professional Development
- Knowledge/Experience

Independent Variable: Current perceptions of teaching
- Approaches to teaching (ATI)
- Self-Efficacy

Response Variable: Teaching Practices

Independent Variable: External pressures
- Institutional characteristics
- Departmental culture/climate
- Departmental requirements
- Tenure portfolios

Teaching Videos (RTOP)
Learning Assessments (3D-LAP)
Student perceptions (ETLQ & MBEX)
Part 2. Improving Learning
Q #1

How important is it to use multiple kinds of assessments to determine students’ learning?

A = very important
B = important
C = somewhat important
D = not very important
E = not important at all
Q #2

In your experience, what percent of students’ final grade in introductory STEM courses is based on exams and quizzes?

A = 0 – 20%
B = 21 – 40%
C = 41 – 60%
D = 61 – 80%
E = 81 – 100%
Q #3

The proportion of assessments used in an introductory STEM course that demonstrate students’ problem solving and higher cognitive-level thinking abilities should be....

A = 0 – 20%
B = 21 – 40%
C = 41 – 60%
D = 61 – 80%
E = 81 – 100%
Claim 1:

Student knowledge is often fragmented and incoherent.
Claim 2:
Traditional Introductory Biology Curriculum

Mile Wide  ←  Inch Deep
Claim 3: Assessment is important

“to educate and improve student performance, not merely to audit it”


“If you don’t assess what’s important, what’s assessed becomes important”

Lauren Resnick (pers comm)
Reforming Introductory Biology at MSU: Does It Make a Difference?

- **Design**
  - Evidence-based, best practices
  - Responsive to local and national-level learning goals

- **Implement**
  - Multiple classrooms, instructors

- **Evaluate**
  - Transferability of curricular model
  - Student achievement of goals

NSF DUE 0736928; Long, PI (2008)
Collaborators

- Tammy Long (PI), MSU
- Diane Ebert-May, MSU
- Jennifer Doherty, University of Washington
- Sara Wyse, Bethel University
- Jennifer Momsen, North Dakota State University
- Elena Bray Speth, Saint Louis University
- Joe Dauer, U Nebraska
- Kristen Kostelnik, MSU

Funding
- National Science Foundation (DUE-0736928; Long, PI)

Undergrad Researchers
- Patrycja Zdziarska
- Anthony Machniak
- Sasha Makohon-Moore
- Justin LaCrosse
- Andy George
- Alvin Makohon-Moore
Backward Design

Goals

What should students know, be able to do?

Assessment

What evidence will we accept?

Instruction

How can we best prepare students?

Adapted from Wiggins and McTighe (1998)
Goals:

Students need to:
- know how science works
- solve ‘real-world’ problems
- see how biological concepts connect
- evaluate information from media

Emphasis on skills - particularly those that reflect *practices* of the discipline
Science learning should reflect science practice

- Science Process
- Quantitative Reasoning
- Modeling
- Interdisciplinarity
- Science & society

**Introductory Biology**

- **Models & modeling**
  - Build, use, revise

- **Argumentation**
  - Claims, evidence, reasoning

- **Data**
  - Collect, represent, interpret

Vision & Change (AAAS 2011)
K12 Framework for Science Education (NRC 2012)
Next Generation Science Standards (2013)

... MAD Biology!
Core Concepts for Biological Literacy

1. **EVOLUTION**: The diversity of life evolved over time by processes of mutation, selection, and genetic change.

2. **STRUCTURE AND FUNCTION**: Basic units of structure define the function of all living things.

3. **INFORMATION FLOW, EXCHANGE, AND STORAGE**: The growth and behavior of organisms are activated through the expression of genetic information in context.

4. **PATHWAYS AND TRANSFORMATIONS OF ENERGY AND MATTER**: Biological systems grow and change by processes based upon chemical transformation pathways and are governed by the laws of thermodynamics.

5. **SYSTEMS**: Living systems are interconnected and interacting.
## Instructional Model

<table>
<thead>
<tr>
<th>Category</th>
<th>Reformed</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode</strong></td>
<td>Active, learn primarily by doing (Lord 1997; Kitchen et al. 2003; Prince 2004; Knight &amp; Wood 2005; Michael 2006, Freeman et al 2014))</td>
<td>Passive, learn primarily by receiving info</td>
</tr>
<tr>
<td><strong>Theory</strong></td>
<td>Constructivism (in Fosnot 1996)</td>
<td>Behaviorist</td>
</tr>
<tr>
<td><strong>Teaching approach</strong></td>
<td>Driven by objectives (NRC 2000; Weimer 2002)</td>
<td>Variable: instructor’s discretion</td>
</tr>
<tr>
<td><strong>Student interactions</strong></td>
<td>Collaboration (Johnson et al. 1991; Chickering and Gamson 1999)</td>
<td>Competition</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>Frequent, iterative, diverse types with feedback (Klionsky 2001; Casem 2006; Freeman et al. 2007)</td>
<td>Infrequent, multiple choice, variable feedback</td>
</tr>
</tbody>
</table>
Final Grades: Spring 2009
(mean +/- SD)

- **Sec 1**: Grade 3.25, n=155
- **Sec 2**: Grade 3.58, n=193
- **Sec 3**: Grade 3.09, n=181
The wolves of Isle Royale
Isle Royale is an island in Lake Superior located off the northern shore of Michigan’s Upper Peninsula. Very rarely, freezing creates ice bridges connecting islands to the main land. In 1950, several wolves crossed an ice bridge from Canada to Isle Royale, Michigan. Their arrival changed the lives of the resident moose forever (no wolves lived on Isle Royale before 1950).

We briefly detailed:
1. The wolves – and the vertebrae deformity
2. The moose
3. The project

We then asked questions on the genetics, ecology & evolution of the moose and wolf community.
Final Exam Performance by Bloom (mean +/- SE)

Mean: 84.9% ± 9.4%
N = 512 students, 3 sections

Performance

Know  Comprehend  Apply  Analyze  Evaluate/Synthesize

Bloom Level
Conclusions – Short-Term

- Curricular model is transferable
  - Variable class features, instructor experience

- Students can achieve on desired competencies
Conclusions – Long-term

- Whether reform “makes a difference” may depend on how we ask the question.
- Reduction in “content coverage” in favor of practices did NOT impact subsequent achievement.
- Lack of alignment across courses is challenging
  - Difficult to evaluate long-term impacts on skills/practices
  - 3D LAP may save us?
Three-Dimensional Learning Assessment Protocol: 3D – LAP

AAU Team

- Melanie Cooper
- Joe Krajcik
- Diane Ebert-May
- Danny Caballero
- Lynmarie Posey
- Sonia M Underwood
- Becky Matz
- Cori Fata Hartley
- Sarah Jardeleza
- J.T. Laverty
3D–LAP – assessment items with 3 dimensions

- scientific practices
- core ideas
- cross-cutting concepts

1. Characterize assessment questions
2. Develop/modify assessments
1. The total amount of energy that plants assimilate by photosynthesis is

a. gross primary production
b. net primary production
c. biomass
d. a pyramid of energy
e. succession
What are we asking students to do for this assessment?

2. Create a model that explains the origin of the biomass of the radish seedlings.

The three dimensions

**Scientific practices**
1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Crosscutting concepts**
1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter:
6. Structure and function
7. Stability and change

**Core ideas**
The core ideas are identified by groups of faculty in the disciplinary discussions

---

Develop and Use Models

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

2. Question gives a representation or asks student to construct a representation.

3. Question asks student to explain or predict the outcome of the event, observation, or phenomenon using the representation.

4. Question asks student to provide the causal reasoning that links the representation to their explanation or prediction.
Let’s Analyze an Assessment Item

Read the excerpt from the paper by Croll et al. 2005...

Aleutian Is. Case: Introduced predators transform subarctic islands from grassland tundra. From Croll et al. 2005
Here is the assessment

Make two different models that illustrate the trophic relationships in this subarctic ecosystem, (1) for islands with no foxes, and (2) for islands with foxes.

Based on the information in reading and models you created above, make two graphs that predict the following – remember to label the axes.

(i) biomass of the plants on the fox free islands vs. fox-infested islands
(ii) nitrogen composition of dominant plants on fox-free islands vs. fox-infested islands.
Models

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

- Islands with foxes, islands without foxes etc.
Models

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

2. Question gives a representation or asks student to construct a representation.

- Construct two different models that illustrate the trophic relationships in this subarctic ecosystem.
Models

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

2. Question gives a representation or asks student to construct a representation.

3. Question asks student to explain or predict the outcome of the event, observation, or phenomenon using the representation.

Predict biomass of plants on fox-free islands vs. fox-infested islands.
Models

1. Question gives an event, observation, or phenomenon for the student to explain or make a prediction about.

2. Question gives a representation or asks student to construct a representation.

3. Question asks student to explain or predict the outcome of the event, observation, or phenomenon using the representation.

4. Question asks student to provide the causal reasoning that links the representation to their explanation or prediction.
Revise Assessment

Make two different models that illustrate the trophic relationships in this subarctic ecosystem, (1) for islands with no foxes, and (2) for islands with foxes. Here is one fact not explicit in the reading that you need to incorporate into these models – seabirds eat fish. Also, “guano” is “poop” that is nutrient-rich [nitrogen, in this case]. Be certain to include the appropriate behaviors (processes – verbs) on the arrows that link one trophic level to another.

Based on the information in reading and models you created above, make two graphs that predict the following – remember to label the axes.
(i) biomass of the plants on the fox free islands vs. fox-infested islands
(ii) nitrogen composition of dominant plants on fox-free islands vs. fox-infested islands.

Provide the reasoning for your prediction for both graph 1 and graph 2 = WHY?
Final Claims

• Three-Dimensional Learning is a productive basis for transforming undergraduate courses.

• The 3D-LAP can help us create and modify assessments.

• The 3D-LAP can help us characterize assessments for “what” is assessed.
Tips for transformation

1. Get over coverage.

2. Ask not what YOU are going to do... Ask what your STUDENTS are going to do....

3. Set the bar high.

4. Assess – what do you want students to “do” with the core ideas? [e.g. models, arguments, explanations/narratives, data]

5. Guide students to meaningful learning by using science practices in an active, collaborative, supportive community.