Welcome to the National Academies Summer Institute @ Washington State University

Goal: “To transform science and math education by improving classroom teaching and attracting/retaining diverse students in the sciences”
Acknowledgments

- National Academies Summer Institutes
  Co-founders: Jo Handelsman (Yale) & Bill Wood (UC, Boulder)
    - Funding: HHMI & NSF

- Scientific Teaching – Jo Handelsman, Sarah Miller and Chris Pfund (UW-Madison)
The funny version of why we’re here

• Five-minute University
The less funny version of why we’re here

• A Private Universe
A general wishes to capture a fortress in the center of a country. There are many roads radiating outward from the fortress. All roads have been mined so that while small groups of men can pass over the roads safely, a large force will detonate the mines. A full-scale direct attack is therefore impossible. The general’s solution is to divide his army into small groups, send each to the head of a different road, and have the groups converge simultaneously on the fortress.

You are a doctor faced with a patient who has a malignant tumor in the stomach. It is impossible to operate on the patient, but unless the tumor is destroyed, the patient will die. There is a kind of ray that may be used to destroy the tumor. If the rays reach the tumor all at once and with sufficient high intensity, the tumor will be destroyed, but surrounding tissue may be damaged as well. At lower intensities, the rays are harmless to healthy tissue, but they will not affect the tumor either. What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue?

Few college students could solve the second problem on their own. When told to use information from first, >90% were able to solve it.
Origins

• National Research Council “Bio2010”

• National Academies Summer Institute on Undergraduate Biology Education
  – http://www.academiessummerinstitute.org/
Evolution

- 2004-2011 - Central National Academies Summer Institute on Undergraduate Biology Education – U. Wisconsin
- 2009 – 1st regional SI @ WVU
- 2011 -2015 regionals expand across the country
- 2014 – 1st mobile SIs
  - Pomona College
  - Washington State University
Format of NASI@WSU

• Morning Sessions:
  – You will be involved in workshops focusing on the three main themes of scientific teaching: active learning, assessment and diversity

• Afternoon Group Work:
  – You will work in groups to produce teaching materials incorporating the teaching strategies that you learned during the morning sessions.
Our trusty leaders:

- **Randy Phillis**
  - Assoc Prof, Biology, U. Mass., Amherst
  - Speaker & facilitator at NASI@UWisc and WVU

- **Jim Belanger**
  - Assoc. Prof., West Virginia University
  - Participant @ NASI@UWisc and WVU

- **Richard Cardullo**
  - Prof., UC Riverside
  - Participant, facilitator @ NASI@UWisc, NASI West Coast
Themes of Scientific Teaching

• **Active learning**
  • Students engaged in the process of learning, constructing their own knowledge

• **Assessment**
  • Provide regular feedback for both the teacher and student about the student’s learning

• **Diversity**
  • Students bring a variety of learning styles and background experiences based on culture, race, and socioeconomic status to the classroom.
Great Expectations

• What are your biggest teaching challenges?

• What do you hope to get out of this week?
How People
Acknowledgments

• Mary Pat Wenderoth – U. Washington
• Jose Mestre – UIUC
• Jay Labov – National Research Council, NAS
Learning Outcome

• Be able to explain the cognitive underpinnings of constructivism and scientific teaching
What does the literature say?

How People Learn
National Research Council 1999

Three major implications for improving student learning:

1. Address misconceptions
2. Build conceptual framework
3. Monitor learning—metacognition
Scientific Teaching is based on Constructivism

Students are not empty vessels
Constructivism

PRIOR KNOWLEDGE

\[ \Downarrow \]

DISSONANCE

\[ \Downarrow \]

CONSTRUCTION OF NEW KNOWLEDGE
Dissonance moment

• If the seasons are caused by Earth’s distance from the sun at different times of the year, why is it summer in the northern hemisphere when it is winter in the southern hemisphere?
How important are conceptual frameworks?

The procedure is actually quite simple. First, you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities, that is the next step. Otherwise, you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first, the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then once can never tell. After the procedure is complete, one arranges the materials into different groups again. Then they can be put into their appropriate places.

Can you answer the following?

• What is the task that is described?

• Where could you go if you lack the facilities?

• How could mistakes be expensive?
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The value of conceptual frameworks

The chessboard challenge
Can you correctly place the 25 chess pieces?
Chess masters – Class A players – Beginners

![Graph showing the number of correctly recalled chess pieces over trial number for Master, Class A, and Beginner players.](chart)
Why is it different?

Board #2

[Chessboard image]

[Graph showing # pieces correctly recalled by Master, Class A, and Beginner across trials]
The shapes below equal which numbers?

How many did you correctly match?
Is it easier if you understand the pattern?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
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<tr>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>
Can you get them all now?
Which of the following do you think makes gives the best content retention?

1. Reading your chapter once
2. Reading your chapter twice
3. Reading your chapter three times
4. Reading your chapter five times
<table>
<thead>
<tr>
<th>Times</th>
<th>Multiple Choice</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>84%</td>
<td>79%</td>
</tr>
<tr>
<td>2</td>
<td>83%</td>
<td>80%</td>
</tr>
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</table>
Context, meaning, connections – improve learning

36 facts about Canadian provinces and territories

Example TEST Q: Which province had the worst tornado?

Read & Understand
48%

Read & answered “Why?”
73%

Pressley et al. (1988)
Engaging students to promote metacognition
Science of Learning

- Audio-visual
- Demonstration
- Discussion
- Lecture
- Practice
- Reading
- Teaching
Science of Learning

- Audio-visual
- Demonstration
- Discussion
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- Practice
- Reading
- Teaching
“Deliberate Practice”
The one doing is the one learning.
Who’s learning here?
How effective is this practice?

• In terms of monitoring and responding appropriately to progress, how effective is this?
Students in AL classes have higher normalized learning gains than students in traditional courses (Knight and Wood, 2005).
Cognitive Science of Learning

12 word pairs Swahili-English

<table>
<thead>
<tr>
<th>Group 1</th>
<th>S S S S S</th>
<th><strong>Test</strong></th>
<th>1st week</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>S S S T T</td>
<td>Test</td>
<td>1st week</td>
<td>Test</td>
</tr>
<tr>
<td>Group 3</td>
<td>S S T T T</td>
<td>Test</td>
<td>1st week</td>
<td>Test</td>
</tr>
<tr>
<td>Group 4</td>
<td>S T T T T</td>
<td>Test</td>
<td>1st week</td>
<td>Test</td>
</tr>
</tbody>
</table>

“Testing Effect” - Retrieval
Ask, don’t tell

Re-study or re-reading creates
“Illusions of knowing”

Retrieval of information enhances learning
“Testing Effect”
Break
Scientific Teaching

Goal: “To transform science education by improving classroom teaching and attracting/retaining diverse students in the sciences”
Intended Learning Outcomes

• By the end of this session you will:
  – Know your group mates a little better.
  – Be able to explain the relationship between scientific teaching and student-centered learning
  – Be able to use backward design
Getting to know you…

First Name

City of origin

Teaching or research specialty area

What you wanted to be as a kid

Something unique about you
If the camera crew from “A Private Universe” were to question your students at the end of your course or graduation, what would you be most embarrassed to find out that they didn’t know?
Scientific Teaching & Student-Centered Learning

In your groups, discuss aspects you think makes teaching:

A. Scientific  B. Student-centered

How do these compare to traditional, teacher-centered classrooms?
How active are you?

How student-centered are you?

• Put your mark on the charts.
Can teaching be active without being student-centered?

• What would that look like?

• How could you make something more student-centered?
Peer evaluation of teaching

• Video analysis using the Rubric page 29 of booklet
What are the first 3 things you do when designing a course.
Standard course planning

Choose textbook
↓
Create syllabus
↓
Write/revise lectures, notes
↓
Prepare PowerPoint presentations
↓
Write exams

Instructor-centered

Backward Design

Formulate broad learning goals
↓
Set specific learning objectives/outcomes
↓
Design assessments (summative)
↓
Prepare learning activities (formative assessments)

Student-centered
Scientific teaching uses backward design to orient teaching toward specific, desired learning outcomes.
Backward Design
(Wiggins and McTighe, 1998)

What should students know or be able to do by the end of the class?

What evidence will convince you that they got there?

How will you help them get there?
Which is easier to assess?

**Learning Goals**

A. Understand gene expression

B. Develop science process skills

C. Understand evolution by natural selection

**Learning Outcomes**

A. Students will be able to predict changes in amino acid sequences caused by mutations

B. Students will be able to interpret a graph.

C. Students will be able to explain how adaptations seen in nature occurred.
<table>
<thead>
<tr>
<th>Learning Goal</th>
<th>Learning outcome</th>
<th>Assessment</th>
<th>Learning Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will understand evolution by natural selection</td>
<td>Students will be able to explain how adaptations seen in nature occurred.</td>
<td>Students will be able to explain how running speed in cheetahs increased following introduction of gazelles into their habitat.</td>
<td>Work in groups to apply understanding of natural selection to explain how adaptations occurred in specific scenarios.</td>
</tr>
</tbody>
</table>
If the camera crew from “A Private Universe” were to question your students at the end of your course or graduation, what would you be most embarrassed to find out that they didn’t know?

• Write learning outcomes for 1-2 of your “private universe” goals.
Tomorrow: Agenda
(copy in your booklet)

• Start at 8:00 am tomorrow morning in this room (Assessment & Active Learning)

• Reading assignments in your booklet pg 7