Active Learning is Lecture

A. Malcolm Campbell

10 October, 2017
Hunter College
Key Points for Today

• teaching vs. learning
• what would a scientist do?
• three extracts to sample readings
• change labs to model real science
• assess your teaching to know what works
Malcolm Campbell  
Biology and Genomics (24 years)  
- Introductory Biology  
- Genomics  
- Lab Method in Genomics
Guess what, I taught my dog to whistle!
Teaching vs Learning

Really?!
Teaching vs Learning

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

??????????????

[Image of two people and a dog, with a speech bubble containing gibberish.]
Teaching vs Learning

I thought you said you taught your dog to whistle.
I did, but I didn’t say that he *learned* to whistle.
Backwards Design of Curriculum

1. What will your students be able to do after this lesson/activity/course? (learning objectives)

2. How will you know if they can do this?

3. What will your students do to gain this ability?
Bloom’s Taxonomy of Learning

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation
Think of one class to focus on today.

Look at Bloom’s taxonomy & pick the level to target.

Write one learning objective using Bloom’s verbs.
How People Learn Best

- construct our own knowledge
- connect to previous knowledge
- guided enquiry effective
- lecturing is coverage, not learning
How People Learn Best

• construct our own knowledge
• connect to previous knowledge
• guided enquiry effective
• lecturing is coverage, not learning
Biology Has Become A Religion
Biology Has Become A Religion

- no data
- accept on faith
- repeat what told
- too much detail
- not science
I want my students to think like scientists, but not necessarily stay in science.

WWSD?

The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive.

I am being proven right about massive vaccinations—the doctors lied. Save our children & their future.
WWSD?

I want my students to think like scientists, but not necessarily stay in science.
Students need to practice:
interpreting data
constructing knowledge
making connections.

Chapter 13.2 Emergent Property at Molecular Level
formative assessment and class activity
hemoglobin handout

synthesize the data and information
to complete the tables on the new handout
Students need to connect new knowledge to existing:
- draw on life experience
- remember past interactions
- provide practical advice

ELSI 4.1 Are evolution and religion compatible?
think-pair-share

What do you do when a student tells you they *believe* the Bible literally?
Interactive: BioMath Exploration

Students need to practice:
- interpreting mathematical model
- connect model to real world experience
- apply math to gain biological insights

BME 13.1 How can you quantify cooperativity?
Interactive: BioMath Exploration

Graph: Hemoglobin’s Affinity

- High affinity
- Low affinity

O₂ binding

Slope = __

- Fully saturated
- Fully depleted

Increasing O₂
Interactive: BioMath Exploration

graph hemoglobin’s affinity

fully saturated

fully depleted

slope = 2.8

increasing \( \text{O}_2 \)
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>
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* p<0.05, ** p<0.01, *** p<0.001, ^ p= 0.06
Do *ICB* students see biology differently?

<table>
<thead>
<tr>
<th>1-5 scale 5 = extremely accurate</th>
<th>Average at Start Fall</th>
<th>( \Delta ) in Average End of Fall</th>
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<tr>
<td>Total</td>
<td>ICB</td>
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<td>3.15</td>
<td>3.02</td>
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<table>
<thead>
<tr>
<th>1-5 scale 5 = extremely important</th>
<th>Memorization</th>
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<tr>
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<td>3.96</td>
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<tr>
<td>Traditional</td>
<td>3.64</td>
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## 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>
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<td>ICB</td>
<td>Traditional</td>
<td>ICB</td>
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<td>-0.58***</td>
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<td>big questions of biology already answered</td>
<td>1.71</td>
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<td>-1.08***</td>
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<td>memorization</td>
<td>3.96</td>
<td>3.64</td>
<td>-1.48***</td>
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</table>

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

Map out active learning module for your course.

https://www.ibiology.org/scientific-teaching/active-learning.html
End of Semester Course Evaluations

traditional textbook + traditional lab

“Lecture and lab are not integrated.”
End of Semester Course Evaluations

traditional textbook + traditional lab
   “Lecture and lab are not integrated.”

ICB textbook + traditional labs
   “I love how lecture and lab are so integrated!”
## What’s lacking in Lab?

<table>
<thead>
<tr>
<th>Trait</th>
<th>Inquiry Lab</th>
<th>CURE</th>
<th>SURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>scientific practice</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>discovery</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>relevance</td>
<td>rarely</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>collaboration</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>iteration</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
What’s lacking in Lab?

- synthetic biology (week 1)
- taste evolution
- antibiotic resistance (week 15)

No Relevance
What’s lacking in Lab?

week 1

synthetic biology

No Iteration

week 15

taste evolution

antibiotic resistance
WWSD?
What Would a Scientist Do?
Provide Iteration, Sustain Relevance

Week 1

synthetic biology I

Taste evolution

Week 15

Synthetic biology II

Antibiotic resistance
pClone Red

J119137
pClone Red

all colonies green

GFP  RBS  RBS  RFP

Bsa I  Bsa I
Golden Gate Assembly Method

Bsa I + ligase

Bsa I  Bsa I

GFP  RBS  RBS  RFP

Diagram shows the Golden Gate Assembly Method with restriction enzymes Bsa I at specific sites and the addition of ligase to join the fragments.
GGA Cloning Always Works

GFP → RBS → RBS → RFP

Bsa I

Diagram showing genetic elements and restriction sites.
First Year Students in 3 Hour Lab

no gel purifications!

GFP → RBS → RFP
Student Sample, November 2012

-35 ATAA (deleted) -10

5’ CGACGAGC TTGACA----ATCATCGGCTCGTATAATGTGTGGA 3’
3’ CTCGACAACTGT----TAGTAGCCGAGCATATTACACCTCGCC 5’
Adding Parts to the Registry

The Registry’s Repository contains thousands of documented parts with available DNA samples. Last year, iGEM teams submitted samples for over 1900 parts.

Be sure to add your parts and send samples to the Registry so that they can be made available to the community!

add a part sample submission

2016 DNA Distribution

The iGEM 2016 DNA Distribution is shipping to registered teams and labs. We’ve added some new material this year, so be sure to read through the 2016 Distribution Handbook before using your kit.

Collections [updated!]

We’ve updated the Registry part collections. There are part collections for reporter proteins, plant chassis, cellulose-related parts, and more. Users can discover new parts and collections and build upon what previous iGEM teams and labs have achieved.

- Plant Chassis [UPDATED!]
- Bacillus subtilis [UPDATED!]
# First Year Promoters in Registry

<table>
<thead>
<tr>
<th>BBa_100282</th>
<th>Reporter</th>
<th>rClone Red Version 2 with RBS: Device for GGA Cloning and Testing RBS elements and Riboswitches</th>
<th>Rachel Neal</th>
<th>738</th>
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<tbody>
<tr>
<td>BBa_100283</td>
<td>Reporter</td>
<td>rClone Red with RBS: Device for GGA Cloning and Testing RBS elements and Riboswitches</td>
<td>Rachel Neal</td>
<td>738</td>
</tr>
<tr>
<td>BBa_100284</td>
<td>Plasmid</td>
<td>JC184d5 with Mutagenesis Cassette Removed</td>
<td>Zachary Shaver</td>
<td>3760</td>
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<tr>
<td>BBa_100285</td>
<td>Plasmid</td>
<td>SPT7specific with Riboswitch C</td>
<td>Dylan Maghini</td>
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<tr>
<td>BBa_100286</td>
<td>Composite</td>
<td>tetA+sacB with RBS</td>
<td>Hartlee Johnston</td>
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<tr>
<td>BBa_100287</td>
<td>Plasmid</td>
<td>J100265 (pJC173b) with GFP replacing LuxAB</td>
<td>Owen Koucky</td>
<td>4981</td>
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<tr>
<td>BBa_100288</td>
<td>Plasmid</td>
<td>pJC173b with gllI neg</td>
<td>Hartlee Johnston</td>
<td>6178</td>
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<tr>
<td>BBa_100289</td>
<td>Measurement</td>
<td>Pnar7 Nitrate Biosensor</td>
<td>Shuk Hang Li</td>
<td>1503</td>
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<tr>
<td>BBa_100290</td>
<td>Measurement</td>
<td>O Biosensor + NarX</td>
<td>Shuk Hang Li</td>
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<tr>
<td>BBa_100291</td>
<td>Measurement</td>
<td>L Biosensor + NarX</td>
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<tr>
<td>BBa_100292</td>
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<td>R Biosensor + NarX</td>
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<tr>
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<td>B Biosensor + NarX</td>
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<tr>
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<td>BBa_100296</td>
<td>RBS</td>
<td>rClone Red Version 2 with RBS 2.0: Device for GGA Cloning and Testing RBS elements and Riboswitches</td>
<td>Shuk Hang Li</td>
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<td>BBa_100297</td>
<td>RBS</td>
<td>rClone Red Version 1.5 with RBS 2.0: Device for GGA Cloning and Testing RBS elements and Riboswitches</td>
<td>Shuk Hang Li</td>
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<tr>
<td>BBa_100298</td>
<td>Regulatory</td>
<td>decP2-&gt; cAMP --&gt; E. coli</td>
<td>Shannon Blee</td>
<td>54</td>
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<tr>
<td>BBa_100299</td>
<td>Regulatory</td>
<td>lysine regulated promoter</td>
<td>Lydia Soifer</td>
<td>47</td>
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<tr>
<td>BBa_100300</td>
<td>Regulatory</td>
<td>PrprB</td>
<td>Jose David Hernandez</td>
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<tr>
<td>BBa_100301</td>
<td>Regulatory</td>
<td>ompW Promoter</td>
<td>Hannah Sinks</td>
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<tr>
<td>BBa_100302</td>
<td>Regulatory</td>
<td>asr promoter (trimmed version of K123100)</td>
<td>Jackson Miller</td>
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<td>BBa_100303</td>
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<td>PrmanP</td>
<td>Emilie Uffman</td>
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<td>BBa_100304</td>
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<td>NPT-II</td>
<td>India Little</td>
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<td>BBa_100305</td>
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<td>upp Promoter</td>
<td>Sabrina Shepherd</td>
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<td>BBa_100306</td>
<td>Other</td>
<td>repClone Red (J100205) with wt TetR promoter (R0040)</td>
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<td>2339</td>
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<td>BBa_100307</td>
<td>Composite</td>
<td>Variant of repClone Red (J100205)</td>
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<td>BBa_100308</td>
<td>Other</td>
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<tr>
<td>BBa_100309</td>
<td>Reporter</td>
<td>actClone Red with wt full OmpR promoter</td>
<td>Monica Prudencio</td>
<td>1683</td>
</tr>
</tbody>
</table>
One Lab Group’s Promoter, **upp**

Registry of Standard Biological Parts

**Part: BBa_J100305**

Designed by: Sabrina Shepherd  Group: Campbell_M_Lab  (2016-09-08)

**upp Promoter**

This promoter is UTP sensitive and begins the transcription process of the upp gene in E. coli. We are going to test with a 600 µM solution of UTP.

Sequence and Features

<table>
<thead>
<tr>
<th>Subparts</th>
<th>Ruler</th>
<th>SS</th>
<th>DS</th>
<th>Length: 56 bp</th>
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<td></td>
<td>1</td>
<td>11</td>
<td>21</td>
<td>31</td>
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<td>41</td>
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<tr>
<td></td>
<td>81</td>
<td>91</td>
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Assembly Compatibility:  
10 12 21 23 25 1000
Negative Control \textit{vs} Colony #1

GFP $\xrightarrow{\text{Bsa I}}$ RBS $\xrightarrow{\text{Bsa I}}$ RBS $\xrightarrow{}$ RFP

![Graph showing fluorescence intensity vs experimental groups](image)
Negative Control vs Colony #1

- GFP
- RBS
- RFP

**Experimental Groups:**
- neg. con. + UTP
- neg. con. + UTP
- col. #1 + UTP
- col. #1 + UTP

**Results:**
- Positive
- Positive with UTP

**Comparison:**
- Bsa I
  - neg. con.
  - col. #1
- neg. con.
  - col. #1
Positive Control vs Colony #2
Positive Control vs Colony #2
Students Discovered Strong Promoter

Registy of Standard Biological Parts

Part.BBa_J100305
Designed by: Sabrina Shepherd Group: Campbell_M_Lab (2016-09-08)

uPP Promoter
This promoter is UTP sensitive and begins the transcription process of the upp gene in E. coli. We are going to test with a 600 µM solution of UTP.

Sequence and Features

<table>
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<tr>
<th>Parameters</th>
<th>Categories</th>
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<tbody>
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GFP - RBS - RFP

RFP Relative Fluorescence Intensity

- Negative
- Negative with UTP
- Positive
- Positive with UTP
- UPP Colony 1
- UPP Colony 1 with UTP
- UPP Colony 2
- UPP Colony 2 with UTP
rClone Red (ribosome research)

J119384
rClone Red (ribosome research)

J119384

12 - 60 bp

RBS

Bsa I

RFP
rClone Red (student-designed RBS)
tClone Red (terminator research)

J119361

Diagram:
- GFP
- RBS
- RBS
- RFP
- Bsa I

Additional elements:
- Blue circle with green dots
tClone Red (terminator research)

J119361

60 - 230 bp

Bsa I

RBS

RFP

(optional ligand)
tClone Red (student-designed terminators)
tClone Red (student-designed terminators)
repClone Red
J100205
repClone Red

J100205

Ptet

54 bp

Bsa I

TetR RBS

RBS RFP

Bsa I
repClone Red

J100306
repClone Red

J100306
repClone Red
J100306

Diagram showing aTc, Bsa I, RBS, and RFP.
Student Results repClone Red F2017

<table>
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<tr>
<th></th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>WT</th>
<th>- cont</th>
<th>RFP</th>
<th>0</th>
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<td>aTc</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td></td>
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<tr>
<td>aTc</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
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</tr>
<tr>
<td>J100205</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

fluctuation/absorbance
Student Results repClone Red F2017

J100205

percent difference +/- aTc

X1  X2  X3  WT  - cont

Conditions
actClone Red

J100204

GFP → RBS → TT → RBS → RFP

Bsa I Bsa I

3' PompR
actClone Red

J100309 = WT

all of *PompR*
Student Results actClone Red F2017

![Bar graph showing fluorescence/absorbance results for different samples. The x-axis labels are: 0, X1, X2, X3, WT, - cont, RFP. The y-axis represents fluorescence/absorbance values ranging from 0 to 50,000.]
Genuine Introductory Student Research

pClone Red

rClone Red

tClone Red

repClone Red

actClone Red
Critical Aspects in CURE Experiences

present work outside class
work collaboratively with peers
select or design all or part of data collection methods
analyze results
read & evaluate science literature

collect novel data

present work outside class
work collaboratively with peers
select or design all or part of data collection methods
analyze results
read & evaluate science literature

collect novel data

activities

CBE LSE Vol. 14, 1 - 13, Spring 2015
Critical Aspects in CURE Experiences

- Present work outside class
  - Increased communication skills
  - Increased collaboration skills

- Work collaboratively with peers
  - Increased collaboration skills
  - Sense of belonging to a larger community

- Select or design all or part of data collection methods
  - Collect novel data
  - Increased project ownership

- Analyze results
  - Increased analytical skills
  - Increased technical skills

- Read & evaluate science literature
  - Increased content knowledge

Activities
  - Short-term outcomes

CBE LSE Vol. 14, 1 - 13, Spring 2015
Critical Aspects in CURE Experiences

- Present work outside class
  - Increased communication skills

- Work collaboratively with peers
  - Increased collaboration skills
  - Sense of belonging to a larger community

- Select or design all or part of data collection methods
  - Collect novel data
  - Increased project ownership
  - Increased technical skills
  - Increased motivation in science
  - Increased tolerance for obstacles

- Analyze results
  - Increased analytical skills
  - Increased content knowledge
  - Increased self-efficacy

- Read & evaluate science literature
  - Increased content knowledge

Activities
- Short-term outcomes
- Mid-term outcomes

CBE LSE Vol. 14, 1 - 13, Spring 2015
Critical Aspects in CURE Experiences

- Present work outside class
  - Increased communication skills
- Work collaboratively with peers
  - Increased collaboration skills
  - Sense of belonging to a larger community
- Select or design all or part of data collection methods
- Collect novel data
- Increased project ownership
- Analyze results
- Increased analytical skills
- Increased technical skills
- Increased content knowledge
- Read & evaluate science literature
- Increased self-efficacy
- External validation from scientific community
- Increased tolerance for obstacles
- Enhanced science identity
- Career clarification
- Persistence in science
- Increased motivation in science
- Increased content knowledge
- Increased technical skills
- Increased self-efficacy
- Activities
  - Short-term outcomes
  - Mid-term outcomes
  - Long-term outcomes

3 hubs
degree ≥ 6
Critical Aspects in CURE Experiences

Present work outside class
- Increased communication skills
- Increased collaboration skills
- Sense of belonging to a larger community

Work collaboratively with peers
- Increased collaboration skills

Sense of belonging to a larger community
- External validation from scientific community

Select or design all or part of data collection methods
- Increased project ownership

Collect novel data
- Increased technical skills

Increase results
- Increased analytical skills

Analyze results
- Increased content knowledge

Read & evaluate science literature
- Increased self-efficacy

Activities
- Short-term outcomes
- Mid-term outcomes
- Long-term outcomes

Early phase

Middle phase

Late phase

Increased motivation in science
- Enhanced science identity

Increased tolerance for obstacles
- Career clarification

Increased technical skills
- Persistence in science
Teaching Should Be Fun!