TRANSFORMING CURRICULUM TO IMPLEMENT COURSE-BASED RESEARCH EXPERIENCES ACROSS THE SCIENCES

Patricia Marten DiBartolo & Kevin Shea
Overview

- Why? The promise of CBREs
- How? Models of CBREs
- No but really how? Implementation challenges and obstacles
- Now what? Generating change
Why? The Promise of CBREs

- Long-history for advanced students
- Growing pressures
- Need to blur lines between classes and research labs
- Innovation through piloting
What is your why? What do you hope to get out of this session?
How? Models of CBREs

- There is no one effective model!
- CBRE principles
  - Importance and impact
  - Discovery and engagement
  - Road bumps and failure
  - Communication
- Better science and meaningful outcomes
Case Study: Organic II Lab

- Fall 2014
- 1 lab section (16 students) of 7 total labs
- Work in pairs
- 13 weeks, 3 hours per week
- Students representative of broader class
- Not coordinated with lecture
Scientific Goals

- Promising treatment for lymphatic filariasis
- Synthesize previously unknown analogs for subsequent biological testing

![Neurolenin A](image1.png)  ![Neurolenin B](image2.png)
Research Plan

- Isolate neurolenin A and B
- Propose reaction based on Organic I knowledge
- Find literature procedure
- Run reaction to make new molecule
- Purify and analyze reaction
- Present results – poster and paper
No But Really How? Challenges and obstacles

What challenges and obstacles do you face in your course, department, or institution?
No But Really *How*? Challenges and obstacles

Case study from Organic Chemistry II lab

- Student expectations/evaluations
- Student learning
- Instructor benefits
I know this is mostly because the lab section is experimental, but I would love if the expectations of what we are to do in preparation for and in follow up to lab were more clear. We are given the huge topic of synthesizing molecules, and I am not sure if the expectation is for us to spend one hour outside of class preparing, or ten hours.
I’m a little bit disappointed that we didn’t make the product, but I’m still really glad that we did the individual projects. I feel like I’ve gained more confidence in lab. I think that the experimental lab was a really good idea.
Well, December sure was a whirlwind! This was a very scary, but very impactful course. Definitely worth the worry! The poster session was so fun, it was great to get to feel knowledgeable and hear other people’s feedback. I only wish we had more time.
I think the experiment-based lab section is good for us in the kinda hellish, mostly intangible, and probably wishful way that eating spinach and waking up early is good for us - in the long run, I believe it will make us better (scientists, people, whatever).
Formal Student Evaluations

- Instructor created effective learning environment: 3.77 out of 4 (other 6 sections averaged 3.47)
- Course contributed significantly to my education: 3.85 out of 4 (other 6 sections averaged 3.39)
## Grades

<table>
<thead>
<tr>
<th>Students</th>
<th>Average Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental lab exam performance (n = 14)</td>
<td>434.4 out of 600 (72.4%)</td>
</tr>
<tr>
<td>All other students exam performance (n = 75)</td>
<td>414.2 out of 600 (69.0%)</td>
</tr>
<tr>
<td>Experimental lab overall course grade (n = 14)</td>
<td>3.11</td>
</tr>
<tr>
<td>All other students overall course grade (n = 75)</td>
<td>3.02</td>
</tr>
</tbody>
</table>
Post-Test: Overall Course Evaluation

- Good way of learning about the subject matter: Mean = 4.3, N=10
- Good way of learning about the process of scientific research: Mean = 4.8, N=42
- Positive effect on my interest in science: Mean = 4.5, N=10
- Ask questions and get helpful responses: Mean = 4.7, N=42

Mean: 1 = Strongly Disagree - 5 = Strongly Agree
Draw, build, and visualize molecules
Predict reaction outcomes
Use arrow-pushing mechanisms
Identify orbital interactions
Propose multistep syntheses
Identify structures spectroscopically
Identify nucleophiles and electrophiles

Post-Test: Chemistry Questions
"I have the ability to..."

- Draw, build, and visualize molecules
- Predict reaction outcomes
- Use arrow-pushing mechanisms
- Identify orbital interactions
- Propose multistep syntheses
- Identify structures spectroscopically
- Identify nucleophiles and electrophiles

Mean of 1-"Not at All" to 5-"A Great Deal"
Iterative Model

Christine Trotta (Biology) 2013-14
Katie McGeough (Chemistry) 2015-16

Faculty-Student Engagement and Project Development

Outcomes
- Dreyfus Grant
- Summer Research Fellowship
- 2 Presentations at National Scientific Meeting

Course-Based Research

Cycle #1
Cycle #2

Thesis Research

Organic II 2014 (1 lab)
Organic II 2016 (2 labs)

Ongoing Funding
- Dreyfus Foundation

Faculty-Student Engagement and Project Development

Seed Funding
- Science Center
- Provost’s Office
- Chemistry Dept
Now What? Generating Institutional Change

- Experiment with your obstacles in mind
  - Start small
  - Find your allies
- Develop evidence and arguments
- Create eco-systems for change
What one or two things can you bring back with you to create change in your course/s, department, or institution?

Now What? Generating change
Questions?

- Patty DiBartolo, Science Center Director and Professor of Psychology – pdibarto@smith.edu
- Kevin Shea, Professor of Chemistry – kshea@smith.edu
Organic Chemistry II Case Study
Course Schedule

- Weeks 1-4 – isolate neurolenins (literature prep)
- Week 5 – present proposal for novel neurolenin reaction
- Weeks 6-12 – run, purify, and analyze reactions
- Week 13 – present results in public poster session
Grading

- Project proposal
- Final paper
- Poster
- Journal
- Preparation and technique
- Notebook
Synthetic Goals

- CuBr$_2$ addition
- Etherification
- Ozonolysis
- Epoxidation
- Dehydration
- Reduction
- Esterification

Compounds:
- Neurologenin A
- Neurologenin B
Informal Evaluations - Pros

- Having the opportunity to do actual experimental research and learn chemistry in the context of real life applications
- No weekly lab reports
- It was really exciting to be doing reactions that weren't fully spelled out for us in a lab manual. We were able to explore reactions that were interesting to us, and I felt really invested in my group's project.
- This lab section was a lot more interesting than any other general lab section that I've been in. I really liked not having mindless busywork; it felt like we actually had a personal stake in what was happening.
Informal Evaluations - Cons

- Being almost completely oblivious to the work done in the regular lab sections, and this may have helped understand concepts in lecture.
- This lab definitely took more time than a normal class lab.
- This lab was a bit overwhelming/demoralizing at times, but not excessively so.
- Stressing over having no idea what the heck I'm doing.
- Less practice writing lab reports.
What will you take forward?

- Hoping it will help me stand out as a candidate for a lab internship over the summer.
- Failure is fun.
- It has taught me how to be resilient - as a researcher and as a student - and how to move forward when something doesn't go well initially.
- I can do research with less fear.
- I learned a lot about how to work with someone that I didn't necessarily jive with. I think that will be really helpful moving on in life in general.
This lab experience for me was something I found extremely rewarding. I was much more independent with my approach, problem solving strategies, critical thinking, etc. since we had to do all the research for our experiment on our own. I definitely took charge of this lab experience (with the help of my partner) rather than simply "going with the flow" as I have done in the past.

This lab helped me realize what it takes to be a chemist rather than mindlessly running reactions.

Lab was less stressful because it was self-guided.

Because we were responsible for designing the experiment ourselves, I felt like I understood much more about why we were doing each step, instead of just following instructions like in CHM 222.

I definitely felt more invested in and involved with what we were doing in lab. It didn't feel like just a class.

In normal lab, if you are having a hard time, there's no real motivation to understand the problem - a million people already did the same thing, so why am I struggling just to do it again?
Post-Test: Course Expectations

- Will get a high grade
- Intellectually challenged
- Exposed to novel ideas
- Personally enriching
- Apply in other contexts.

Mean: 1 = Strongly Disagree - 5 = Strongly Agree

Experimental Lab
N=10

Other Lab Sections
N=42
Post-Test: Chemistry Questions
"Presently, I understand..."

Mean of 1—"Not at All" to 5—"A Great Deal"

- Reactivity of alkenes
- Reactivity of alkyl halides
- Reactivity of C-C bond formation
- Reactivity of alcohols
- Reactivity of ethers
- Reactivity of carboxyls
- Reactivity of conjugated alkenes
- Reactivity of aromatic compounds
- Molecular structure
- Reaction mechanisms
- Organic synthesis
- Properties of organic compounds

Experimental Lab...  Other Lab Sections...
Post-Test: Benefits and Learning Gains

Mean: 1-"No Gain" to 5-"Very Large Gain"

- Experimental Lab...
- Other Lab Sections...
Conclusions and Next Steps

- Very successful
- Rewarding teaching experience
- Sustainable model
- Dreyfus Foundation funding for 4 total lab sections 2016-2018