Design and implementation of research-based laboratory courses

Southern California PKAL Regional Network Meeting
Fullerton CA | February 7, 2015

Stanley M. Lo
University of California, San Diego
National calls for research-based laboratory courses

Boyer Commission on Educating Undergraduate (1998)
• Restructure undergraduate learning experience
• Focus on inquiry- and research-based learning

President’s Council of Advisors for Science and Technology (2012)
• Increase STEM-educated workforce
• Engage students in authentic research in laboratory courses
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<th>Stand-alone laboratory course</th>
<th>Stand-alone laboratory courses</th>
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<td>Independent on-going research program</td>
<td>Connected to faculty research programs</td>
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<td>Shared experiments among all students</td>
<td>Different experiments among groups</td>
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<td>Single course in one quarter</td>
<td>Sequence of two courses</td>
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Authentic research experience: Students perform the same tasks as scientists would in the same setting (i.e. legitimate), even though students’ level of competence may not be as sophisticated (i.e. peripheral)
UC San Diego: Longitudinal survey on soil microbiomes

Soil properties
• How much moisture does the soil contain?
• How acidic is the soil?

Functional biodiversity
• What carbon sources are metabolized by the microbial community?

Genetic biodiversity
• What microorganisms are present?
Specific research question for each quarter

Native plant species

How do soil properties and microbiome biodiversity differ for native and invasive plant species?

Invasive plant species
Soil microbiome project
Research proposal

- Asking questions
- Making observations
- Generating hypotheses
- Designing and doing experiments
- Collecting and analyzing data
- Drawing conclusions
- Communicating results and ideas
Course structure: Three hours of laboratory per week

Per laboratory section:
- 32 students in 8 student groups
- 1 undergraduate TA and 1 graduate TA

For all laboratory sections:
- 1 faculty
- Weekly 80-min “lecture”
Northwestern: Focus on experimental design

Design an experiment based on a defined model

- Introduction to model via online lectures
- Create hypotheses and set up experiments
- Collect, analyze, and interpret data
- Repeat experiments if necessary
- Present results, conclusions, and future directions
Research project: Protein-folding diseases in model organism

Round worm *C. elegans*
- Visible under standard dissecting scopes
- Grow on agar plates with bacteria
- Store indefinitely in -80°C
Course logistics: Parallel but different experiments

38 candidates genes that may have effects on toxicity:
• Knockdown by RNAi

4 toxicity assays:
• Thrashing, movement, longevity, and egg laying
Course structure: Three hours of laboratory per week

24 students in 6 student groups per section
1 undergraduate TA and 1 graduate TA per section
1 faculty per 3 concurrent sections
What resources and support do you need?

- Lab supplies and budget
- Having TAs who are trained to teach these types courses
- Time for instructor to redesign the courses
- Ability to sequence DNA
- Staff for preparing the labs
- Open hours for lab
- How would this work if it is connected to a lecture course
- to change student
- A budget for supplies and TAs and faculty
- Someone to maintain instrument, make solutions, etc.
- Development time for activities, articulation agreements, fit with program
- Students also require more time, e.g. office hours
- Faculty buy-in: is this a legitimate way to spend a semester
- Lab space
- How does this work for chemistry? What about safety issues?
- More time
- More instruments or instrument time
What barriers and challenges do you anticipate?

- Fulfilling accreditation, e.g. ACS
- Coming up with a good research question to serve as a platform
- Time to think about all the things
- Student ability: authentic experience relies more on students doing more
- How to train TAs to deal with open ended questions
- Getting different departments to agree
- Figuring out how it fits into curriculum but not as an add-on
- Fit into program learning outcomes
- Undergraduate research supervision not compensated
- Research in faculty lab vs. course lab
- Human errors in lab experiments
- Students do not have adequate background
- You have to be really sure about your TAs: how do you train them?
- Continuous money
- No graduate students
What potential solutions can you think of?

- Get my own funding!
- Make the question or problem relatable to students to get student buy-in
- Having good models and presenting them to faculty
- Being able to show that it is actually successful
- Release time for faculty
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