Mixing Up the Recipe

Inquiry-based learning in first-year undergraduate labs

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Context

Existing literature clearly demonstrates that active learning is by far the best method for students to obtain a deep understanding of materials (e.g., Freeman et al 2014) and the laboratory provides ample opportunity for active learning. In order to successfully implement active learning, 'cookbook' labs require modification that allow students to delve into a topic (e.g., Brownell et al 2012). Augustana has recently redesigned the first year biology courses including labs. Thus, we have begun to alter our existing labs into structured investigations as a first step to our change.

Purpose: Demonstrate an inquiry-based approach to a "cookbook" lab activity

What did I do?

I started with a lab that used classical methods to determining how auxins (natural IAA and synthetic 2,4-D) affect coleoptile growth in monocots and root growth in dicots (Augustana University College 1994). My goal was to get students working with the scientific process through experimental design, peer review, oral presentation, and written communication.

- Before: The activity occurred in one lab session and included a detailed method for investigating roots or coleoptiles – students were to test the effect of auxin concentration on roots or coleoptiles. Although investigative, it was not designed to have students explicitly working with the scientific process.
- Altered: The activity occurred over 4 lab session as a 6 stage process (below) with the purpose of providing conceptual context and time for students to design their experiments, as well as to obtain feedback and assistance.

Prior to Lab Session 1
Stage 1: Student preparation through readings

Lab Session 1 (45 mins)
Stage 2: Discussion of auxins in plant growth followed by question selection (Table 1)

Due Lab Session 2 (15 min discussion)
Stage 3: Student groups complete an "Experimental Design Sheet" – Instructor feedback relating to validity of experimental design

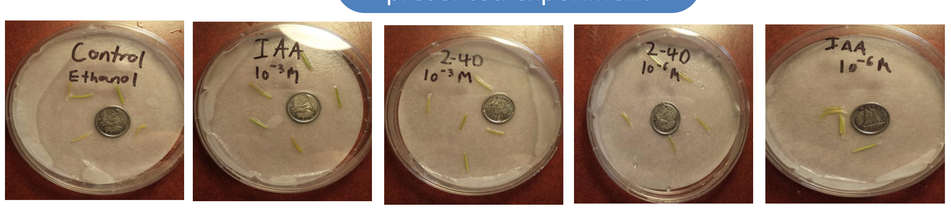
Lab Session 3a (1.5 hours)
Stage 4: Peer review of experimental design through feedback of presented experiment

Lab Session 3b (1.5 hours)
Stage 5: Revise (if necessary) and set up experiment (Figure 1). Students take home experiment for measurement 72 hours later

Due Lab Session 4
Step 6: Graphical presentation and written communication of results. Students were to explore the implications of their experiment.

Table 1 Subset of prepared questions and choices

Question	Choices
Question 1: Does **concentration of auxin** alter the growth response of coleoptile/root growth?	Coleoptile or roots Oat or cucumber IAA or 2, 4-D
Question 2: Does **2, 4-D** have the same response as **IAA** when same conditions?	Coleoptile or roots Oat or cucumber Concentration
Question 3: Does IAA applied to **coleoptiles** have the same response of that applied to **roots**?	Oat or cucumber Concentration
Question 4: Are **dicots** (cucumber) and **monocots** (oat) affected to the same degree by auxin?	Coleoptile or roots Concentration IAA or 2, 4-D



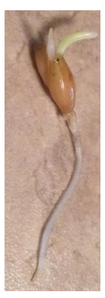


Figure 1. Sample Experimental Set-up

How did it go?

"…Plant Growth…[was] my favourite lab. A lot more work compared to other labs, but was more investigative and research like, which was enjoyable." – AUBIO 111 Student F2015

Successes:

- Provided an intellectually safe environment and low stakes assignment for their first university oral presentation
- Gave students confidence to ask questions and articulate rationale for their experiments
- Students were exposed to peer review

Challenges:

- Some students did not put effort into making the experiment better
- Little experience with literature search, therefore had difficulty formulating hypotheses
- Some student resistance to outside lab work
- More guidance needed for graphing
- Instructors need to be willing to allow students to have freedom in experimental design

What's next?

Potential alterations in activity and instruction:

- Provide a scenario and have each group investigate one question that will address the bigger picture
- Take out peer-review of experimental design but have instructor consultation prior to set up
- A lab period focussing on representing data graphically and interpreting data
- Peer-review of figures during the analysis lab period
- I have found from other labs that students are more invested in the final product when they have results to show – change to a low stakes presentation at the end of the experiment
- Have discussions with instructors about providing guidance and flexibility in students' experimental design

Take Home Message: Students like investigating their own question when given enough guidance and context – I have used the experience of this lab alteration to help redesign other labs

References

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Acknowledgements

Thanks to Neil Haave for consultation during the process of changing the lab activity and Doris Audet for discussion, comments, and suggestions for this presentation topic. Thanks also to the biology lab technicians, Marian Forre and Dawn Lawson, for the support during testing and implementing the change. And finally to the AUBIO 111 Fall 2015 students for their invaluable feedback on the lab activity.