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Redesigning an 'Introductory Biochemistry Laboratory' curriculum for chemistry majors with a guided focus on transferable skills

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- 2008-2009 Biology Scholars Program Research Residency Scholar
- 2013-2014 Biology Scholars Program Assessment Residency Scholar
- 2017-2019 Boston University Blended Learning Challenge Fellow

BIOCHEMISTRY I
BI/CH/MET421/621

- First semester of a two semester Introductory Biochemistry Course with a laboratory component
- Students from Biology, Chemistry, BMB, and any other student who wants or needs a biochemistry laboratory experience in their transcript. (~140-150 students)
- Two lecture sections (one taught by BI professor and one by CH professor), two pre-lab discussion sections (taught by the lab coordinator) and 8-9 laboratory sections for all students.

Why do we have teaching laboratories in our college curriculum?

Provide students with the opportunity to:

- **Test and verify theories and solidify course concepts through hands-on experience.**
- **Go through research and design process; investigate, analyze, and reflect.**
- **Explore methods used by scientists in their discipline.**
- **Acquaint themselves with essential equipment.**

Let's start with a time travel

Go back in time to when you were a college student.
Pick a laboratory course you were enrolled in.
Picture yourself in one specific lab you performed.

Now take a minute to focus on remembering your entire lab experience.
Make a mental note of:

- **How the laboratory LOOKED.**
- **How the laboratory FELT.**
- **What everyone was doing? (including yourself, your lab mates, the laboratory assistant)**

Now write down one 'skill' you learned that day that you have used multiple times later in your life.

Let’s hear a few examples

Transferable skills are abilities and expertise you acquire in one setting and then can be used in a variety of other settings, roles, or occupations.

REFORMING UPPER LEVEL INTRODUCTORY BIOCHEMISTRY LABORATORY CURRICULUM

DESIGN ELEMENTS

- **Content:** Lecture material vs exploration and discovery
- **Structure:** Instructor vs student designed/driven; Collaborative vs individual
- **Equipment:** Simple vs advanced. Time vs cost efficient
- **Time Allocation:** Data collection vs analysis and interpretation
- **Outcome:** Content vs inquiry skills
- **Products and Assessment:** Data quality vs analysis and interpretation; Reports vs papers; Exams vs reflective work; Team vs individual

Transferable Skills in Upper Level Biochemistry Labs

1. Biochemistry specific technical skills
2. Experimental design, optimization, and troubleshooting
3. Data analysis and interpretation
4. Independent and 'on demand' learning
5. Planning and time management
6. Teamwork and collaboration with an emphasis of complementarity
7. Individual accountability in a group setting
8. Group management, leadership and delegation
9. Scientific communication (written and oral, concise or detailed as needed)
10. Self-monitoring and reflective self-assessment (metacognition)

Our Traditional Biochemistry Lab Structure

CONTENT AND STRUCTURE: 12 Weeks of **instructor designed** lab work described and prescribed in specific chapters of hardcopy laboratory manual carried out as **student pairs**.

Table of Contents

Our Traditional Biochemistry Lab Structure

Time Allocation, Outcome, Products, and Assessment:

- Weekly 50 min. prelab lectures focusing on the upcoming experimental protocol details including any optimizations or corrections based on TF test run. Weekly quizzes are given to assess student preparedness.
- Weekly 4 hr labs for data collection (in pairs) based on the lab manual procedure copied into lab notebook (students depart as soon as data is collected)
- In lab performance and behavior
- Six lab write-ups based on instructions and questions included in the laboratory manual.
- Office hours to obtain guidance for completing lab report

Our Traditional Biochemistry Lab Structure

HOW STUDENTS VIEWED THE EXPERIENCE:

- There is **a set of fixed biochemistry laboratory techniques** that are covered: For some students it is perceived as a resume builder for others waste of time if they have already encountered the technique elsewhere.
- A **successful lab** is where the collected **data resembles closely the predicted outcome** and can easily be analyzed and interpreted: The more experienced or ambitious partner plays a bigger role in data collection.
- **Laboratory reports are the main assessment** of laboratory work: Students spend many hours outside lab time focusing on writing the report rather than thinking about data processing and interpretation.
- **Learning environment is very competitive** with the goal of being better than others.

Our Traditional Biochemistry Lab Structure

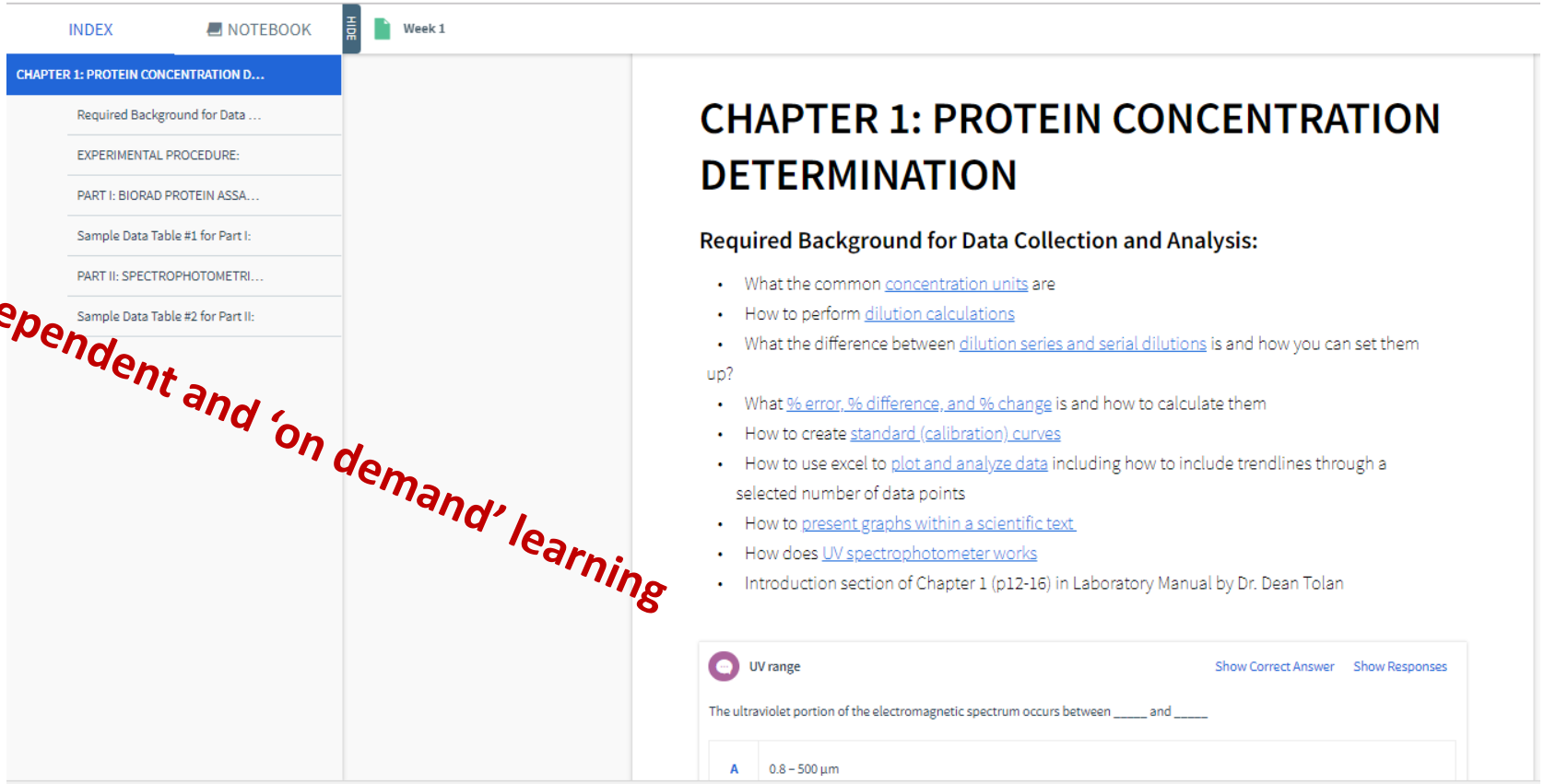
SHORTCOMINGS:

- Students come into this upper level laboratory course with a wide range of prior experience. This model **does not allow for any customization** or provide the same **growth opportunities** for all students.
- There is **very little room** or opportunity for students **to explore and take risks**, learn or develop skills in experimental design, optimization, and trouble shooting.
- There is **very little opportunity to develop analytical skills** through discussion and appreciate the "hands-on" and "collaborative" learning aspect of laboratory work.
- The degree of agreement of the one-time product to the expected outcome determines the success of the experience rather than the development of any transferable skill.
- Does **not leverage the expertise of the TFs, the lab coordinator, or the peers** or the available digital platforms.

Under-Reform Biochemistry Lab Structure

1st Iteration

CONTENT AND STRUCTURE: **10 Weeks of instructor designed** lab work described in a **customizable "online" manual** (through TopHat platform) carried out as **student pairs** followed by **2 weeks of student designed** lab work carried out in **groups of 2-4.**



Independent and 'on demand' learning

Under-Reform Biochemistry Lab Structure

1st Iteration

Enabling Student Input in Lab Protocols

PART B-1: OBTAINING ABSORPTION SPECTRA OF NAD⁺ AND NADH

1. Prepare 3.0 mls of a 50 µM NAD^+ solution by diluting the 1.0 mM NAD^+ stock solution with dH_2O.

How many microliters of the 1.0 mM NAD^+ solution would you need to use, to make 3.0 mls of a 50 µM NAD^+ solution? 150

2. Prepare 3.0 mls of a 50 µM NADH solution by diluting the 1.0 mM NADH stock solution with dH_2O.
3. Take the absorbance spectrum for each of these solutions from 400 nm to 250 nm using the Cary 60 spectrophotometer.

What should you use to blank your UV-Vis spectrophotometer before recording your spectra?

a. Your UV transparent plastic cuvette
b. 50 mM K_2PO_4 buffer
c. Water
d. 1mg/ml BSA solution

4. Save your raw data and sketch an annotated spectra for each of your scans in your notebook (make sure to clearly indicate the wavelength of maximum absorbance (λ_{max}) and the corresponding absorbance value)
5. Keep the diluted NADH solution for Part B-2.

Experimental design
Planning
Individual accountability

Under-Reform Biochemistry Lab Structure

1st Iteration

Time Allocation, Products, and Assessment:

- Weekly 50 min. prelab lectures first 10 weeks **focusing on the design considerations** of the predesigned labs. Online manual embedded questions replace in-class quizzes for these 10 weeks. One week used for **planning student projects**.
- Weekly 4 hr labs **with in-lab preliminary data assessment and analysis questions** to be completed before lab departure (**An individual copy of this group work is graded**)
- In lab performance and behavior (graded)
- Four short and three long reports
- Office hours for **guidance in BOTH upcoming and past lab work**
- **Weekly reflective entries indicating what each student already knew, what was new, what was still confusing and a digital project diary.**

Under-Reform Biochemistry Lab Structure

1st Iteration

STUDENT PROJECTS: Major addition to the curriculum

Projects driven fully by student inquiry require time, careful planning, and close, interactive support. Students need guidance to make sense of their results, optimize and plan future steps, and trouble shoot.

The payoff for such effort is the increased level of student engagement and the development of analytical and problem-solving skills.

Requirements:

1. Experiments that leverage the expertise of the TFs and the lab coordinator.
2. Access to major equipment

Under-Reform Biochemistry Lab Structure

1st Iteration

STUDENT PROJECTS: Collaborative Planning
Shared Google Docs (in- and out- of class time)

Under-Reform Biochemistry Lab Structure

1st Iteration

STUDENT PROJECTS: Individual Reflections- Project Diary

PROJECT DIARY

Name: **Date:** **Week #: 1**

Planned Reading/ Online Research for the Week	Accomplished Reading/Online Research for the Week
Planned Lab Work for the Week	Accomplished Lab Work for the Week
Planned Post-lab Work for the Week	Accomplished Post-Lab Work for the Week

Weekly Reflection note:

What are the most important things you learned from this experience this week?

a. Scientifically (i.e. new technique, new scientific concept or information, etc)

b. Personally (i.e. being and thinking like a scientist, being fully in charge of your own experiment, etc.)

Under-Reform Biochemistry Lab Structure

1st Iteration

STUDENT PROJECTS: Individual Reflections- Project Diary

PROJECT DIARY

Name: **Date: 12/5/2017** **Week #:1**

Planned Reading/ Online Research for the Week	Accomplished Reading/Online Research for the Week
Research methods for pouring gels	Found protocol for pouring and running a native protein gel.
Research methods for trypsin digestion, buffer conditions, reaction times, etc	Found methods for trypsin digestion, including buffer conditions and reaction times.
Think of what variables we want to study	Chose to study if there are differences between denatured and native LDH and BSA digestions with trypsin (i.e. are some amino acids more accessible to be cleaved than others).
Planned Lab Work for the Week	**Accomplished Lab Work for the Week**
Make protein gels	Made protein gels (made 4 - 2 each)
Make LDH and BSA trypsin digest samples, perform digestion	Made samples: I made the LDH samples (One nondigested LDH (PL), one non-denatured/native LDH digested with trypsin (NDL), and one denatured LDH digested with trypsin (DDL)), and Mei made the BSA samples (One nondigested BSA, one non-denatured/native BSA digested with trypsin, and one denatured BSA digested with trypsin)
Planned Post-lab Work for the Week	**Accomplished Post-Lab Work for the Week**
Stop the digestion samples	Mei put the samples in the freezer after about 5 hours of the digestion reaction.
Plan the order to run gel samples	We will most likely run the marker in the middle of the samples so it is easiest to compare the bands.

Weekly Reflection note:

What are the most important things you learned from this experience this week?

a. Scientifically (i.e. new technique, new scientific concept or information, etc)

I learned how to prepare and pour protein gels, and learned that to smooth the loading gel, you can pour isopropyl on top and then pour it off once the gel has polymerized, which was not in the protocol we found and was something totally new to me.

b. Personally (i.e. being and thinking like a scientist, being fully in charge of your own experiment, etc.)

I learned about being able to think through things in the midst of an experiment, and that sometimes you will end up changing your plans and having to recalculate reagents and reconsider the planned protocol. This helps to optimize the experiment and its efficiency. It was a cool experience to have planned the experiment by ourselves in such a short time and to do it in lab and have it work well (hopefully!). It was helpful to plan how we were going to split up the work, but both were able to do both parts of our project (making gels and digestion samples). It was also cool that everyone in lab was doing something different, so I am excited to learn about the different projects.

Under-Reform Biochemistry Lab Structure

1st Iteration

STUDENT PROJECTS: Group Presentation

Lab Meeting Format- Around a round table

How did the first implementation go?

AFTER FIRST ITERATION HOW STUDENTS VIEWED THE EXPERIENCE:

- Empowering, but at times overwhelming.
- More fun and adventurous, but more risky.
- Great enthusiasm and positive feedback for student projects great idea, but need more in-class planning time and stronger guidance and support.

PLANED CHANGES FOR SECOND ITERATION

Content and Structure: Minimal change to incorporate student feedback on improvements for the online-manual - editing

Time Allocation, Products, and Assessment:

- **Prelab lectures:** Minimal change to first ten weeks with an increase in time allocation for student directed discussion, rework last two weeks to allow for more group time and guidance in planning the student projects. Remove final exam for lab.
- Weekly 4 hr labs divided as 3 hrs for data collection (in pairs) and 1 hr in-lab preliminary data assessment and analysis (in discussion groups with a TF facilitator) (An individual copy of this group work is graded)
- In lab performance and behavior (graded)
- Three short reports and one paper style scientific communications (with an initial draft submission)
- Special meetings with lab coordinator for student designed projects.

Please join me today @3:05 pm in Debartolo Rm213 if you are interested in the integrated digital and online elements I used for the redesign of this laboratory to enhance the “transferable skills” focus.

THANK YOU!!!