Integration of the Biology and Organic Chemistry Laboratories Through a Huntington's Disease Research Practicum

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Abstract

Many universities have recognized the need to advance introductory science teaching for undergraduates. Introductory laboratory courses have employed interdisciplinary project-based labs that address real-world problems, and grant students the independence to influence experimental methodologies. Some non-majors courses approach science from a liberal arts perspective; however, few initiatives intended for science majors have combined these approaches into one course. A multidisciplinary research practicum was developed for Brandeis University's introductory Biology and Organic Chemistry laboratories. Students were granted considerable independence in the design and implementation of an experiment to target polyglutamine protein aggregates in Huntington's Disease. Students also engaged with the material from a sociological perspective through literary analysis of a graphic novel and screening of a documentary. Responses to feedback surveys indicated that having ownership of their work in a collaborative, multidisciplinary environment resulted in a heightened appreciation of and interest in experimental processes, awareness of the connections between disciplines, recognition of the sociological context of scientific content, and increased focus, camaraderie, and engagement in the course. Future course design initiatives are intended to use this practicum as a model to integrate other introductory science courses.

Introduction

- A loss of over half of intended STEM majors occurs within two years of taking their first college science class[2]
- Students find introductory courses to be uninspiring.[2]
- Universities have recognized the need for alternatives to historically common segmented, stepwise lab manipulations[3-5]
- Project labs are often only intended for upper level courses[6-8]
- We recognize that science is interdisciplinary, but students often do not make that connection.[9]

Attrition rates for students pursuing a Bachelor's Degree	
STEM majors	48%
Education	62%
Health Sciences	58%
Humanities	56%

Table 1: Attrition rates from STEM majors are lower than that of other fields, but the focus is not on curbing attrition. Rather, if students decide to leave the sciences, it is important that they make an informed decision[1]

Addressing Inspiration

- Participating in inquiry-based labs
- Crossing disciplinary boundaries
- Engaging in research early
- Being a part of small learning communities

Purpose

- Through collaboration between the introductory organic chemistry and biology laboratories at Brandeis University, we designed a small-enrollment, research-based, multidisciplinary, Experiential Learning (EL) practicum that affords students the opportunity to explore the connections between biology and organic chemistry while participating in a project lab series focused on Huntington's Disease.

EL 94A Learning Goals

- Experiencing the scientific process
- Interdisciplinary research linking Biology and Organic Chemistry
- Collaborative experience
- Assessment of scientific data
- Sociological context
- Real-world applications
- Presentation of research findings in a public forum
- Use of scientific literature

The Experiment

- A total of 37 students opted to participate in EL 94A and agreed to concurrently enroll in Biology Lab, Organic Chemistry Lab, and EL 94A.

Week	Lab Schedule	EL 94A Schedule
1		Course Introduction Organic Chemistry Component Introduction
2		Collaborative Design of Synthetic Inhibitor
3	Inhibitor Synthesis I in **Organic Chemistry Lab**	How to Give Presentations, Inhibitor Chemistry Part I
4	Inhibitor Purification in **Organic Chemistry Lab**	Inhibitor Chemistry Part II Biological Method/Analysis Introduction
5	Inhibitor Analysis in **Organic Chemistry Lab** Observe PolyQ *Drosophila* in **Biology Lab**	^{1}H-NMR Polymer Analysis
Break		
6	*Drosophila* Cross Setup in **Biology Lab**	Graphic Novel Introduction Collaborative Design of Method of Analysis
7	*Drosophila* Cross Transfer I in **Biology Lab**	Right Angle Light Scatter Analysis 3D Visualization using 3D Projector
8	*Drosophila* Cross Transfer II in **Biology Lab**	Peer Review Presentation I, Statistics Part I
9	*Drosophila* Cross Scoring in **Biology Lab**	Data Analysis, Statistics Part II
10		Graphic Novel Final Project Introduction Results Discussion, Statistics
11		Documentary Screening
Break		
12		Final Presentations Part I
13		Final Presentations Part II, Feedback Survey

Figure 4: EL 94A Semester Schematic Students followed an adapted lab schedule in addition to weekly one-hour EL 94A meetings. All other components of both Biology and Organic Chemistry lab remained unchanged. Scheduling and assignments took into account Biology and Organic Chemistry lecture and lab exam weeks, noted in purple.

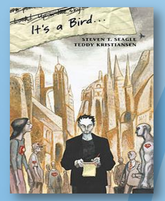

Figure 3: Course Highlights Students were in lab sections of 8-10 students, and they all met together for the practicum (Left). In addition to a rigorous research experience, students also engaged with the sociological context of Huntington's Disease through literary analysis of a graphic novel (Middle) and screening of a documentary (Right).

Student Results

- Students designed and synthesized 19 unique polymers

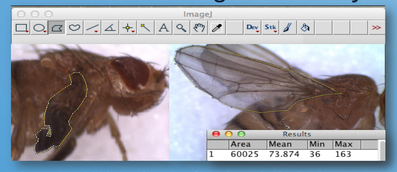

Figure 5a: 2013 Student-Designed Analysis Students used the image analysis software, ImageJ to measure wing size (Figure adapted from students Erick Yeung and Heather Lin)

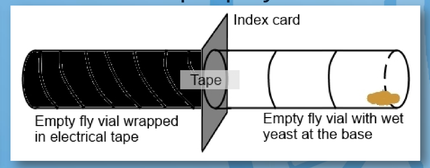

Figure 5b: 2014 Student-Designed Analysis Students took advantage of phototaxis and chemotaxis to quantify the motility of PolyQ48 *Drosophila*. Each group built their own apparatus.

Consistent Findings

- Administering a higher concentration of inhibitor treatment increased wing size and decreased motility in the PolyQ flies.

Course Feedback

Relevant Survey Question (1 = Strongly Disagree, 5 = Strongly Agree)	Average Rank	Standard Deviation	Median
Interdisciplinary Connections			
The practicum helped be establish connections between Biology and Organic Chemistry	4.8	0.4	5
This practicum has had a positive impact on my perspectives of Biology and Organic Chemistry	4.5	0.8	5
"Taking the practicum course really allowed me to see the deeper connections between organic chemistry and biology, which I would not have seen simply from taking introductory science courses"			
The Scientific Process			
Having the opportunity to design a unique experimental treatment and method of analysis had a positive impact on my experience in the labs	4.7	0.6	5
"I really enjoyed the opportunity to design experiments and collect new data. I also have a much greater understanding of the research process and feel I can more easily look critically at scientific literature to determine whether or not it was a well done study"			
Fluidity, Collaboration, and Community			
Being co-enrolled in the same group for both Biolab and Orgolab was beneficial to me	4.9	0.4	5
"I had a chance to really get to know the people who were in lab with me, and this made me feel more comfortable asking them for help. It also led to more working together which aided our understanding"			
Sociological Context			
The *It's a Bird…* assignments were beneficial to me	4.3	1.2	5
Screening the documentary *Do You Really Want to Know?* was beneficial to me	4.5	0.8	5
"This helps put understanding of the sciences in context and helps you see why it is important in real life"			
Overall Course Experience			
Participating in the practicum was a positive experience	4.7	1.2	5
"This semester was exponentially more enjoyable. Labs did not seem like a tedious test, but rather it felt like we were accomplishing something new each week"			

Figure 6: Evaluating Course Success with Student Feedback Learning outcomes are demonstrated by responses to both Likert-type and written responses from students in both an in-class feedback survey and a University-initiated course evaluation.

Future Directions

- Scale components of the practicum for large enrollment courses
- Expand the interdisciplinary scope by incorporating concepts in Physics and collaborating with advanced project labs

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