

Course Development: Building an Advanced Cell/Molecular Lab as Undergraduate Research

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Acknowledgements & Funding: CETL Summer SoTL Grant and the Biology Department

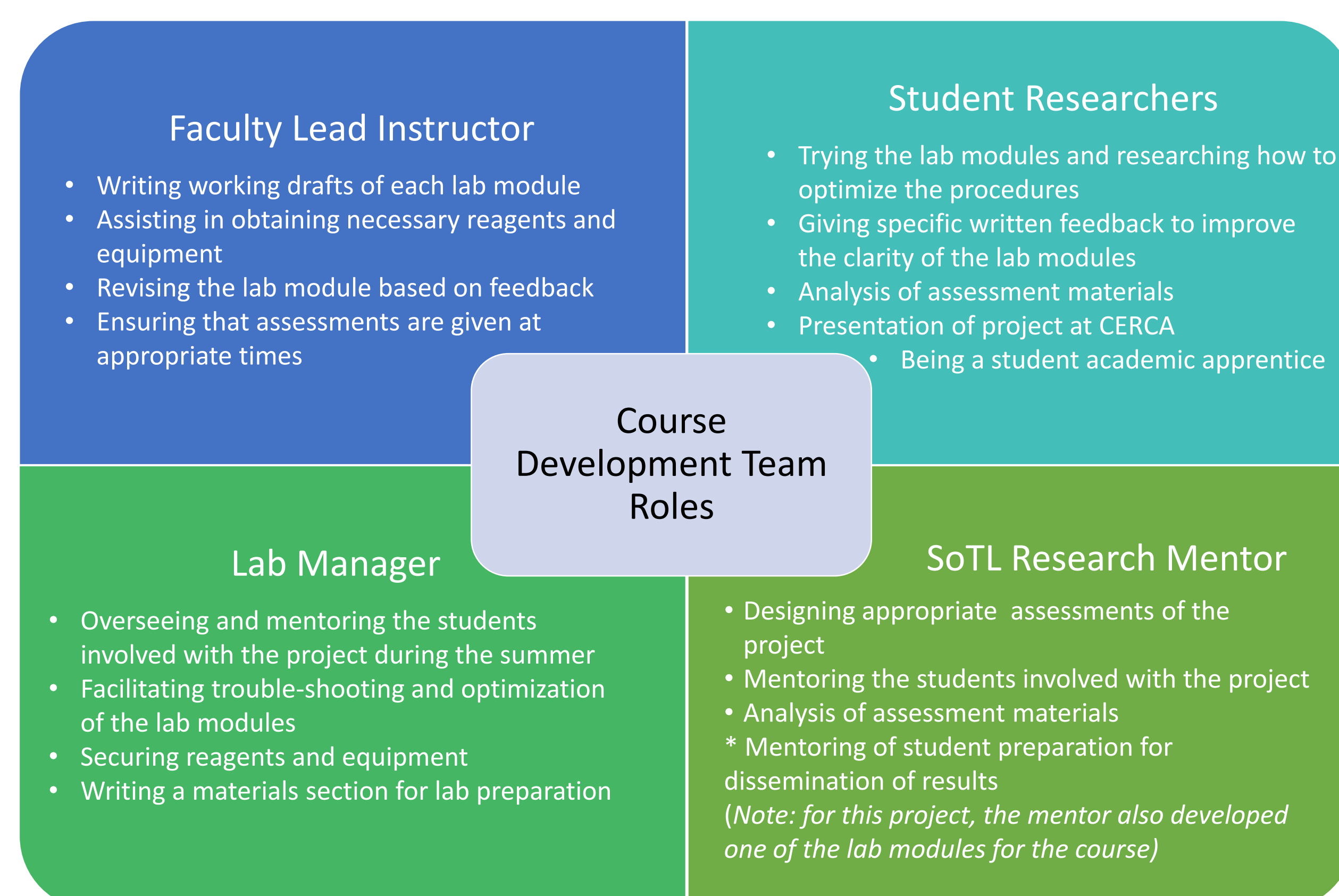
Introduction

The biology department seeks to provide authentic experiences for students both within and outside of the classroom. Teaching labs are a venue for development of technical and critical thinking skills, and upper level labs foster research skill development initiated in the introductory science labs. BIOL405 is a new laboratory-based course designed to immerse students in current molecular biology techniques. Bringing a new course to life requires optimization of the protocols, careful establishment of timing and reagent requirements, as well as development and administration of robust assessment that will inform future course development.

CURRICULUM DESIGN PROJECT OBJECTIVES

- * To optimize both the protocols and the instructions for the laboratory modules for BIOL405 so that the course can be more effectively taught within the time and workload constraints of a typical semester
- * To assess student mastery of learning objectives and identify course areas that either align poorly or could be redesigned to more effectively promote learning
- * To provide student researchers with an opportunity to further develop their research and analytical skills while participating in curriculum development

DEVELOPMENT, REFINEMENT AND ASSESSMENT OF LABORATORY MODULES REQUIRED TEAMWORK AND COMMUNICATION



All protocols were tested, optimized and scaled to ensure feasibility

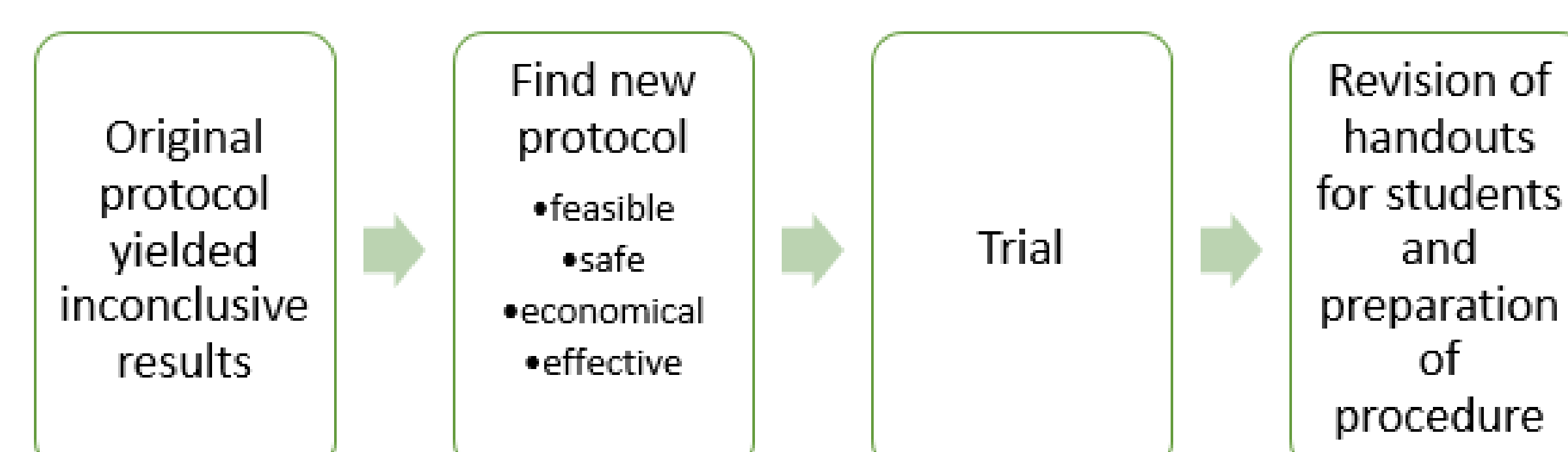


Figure 1. The sequence of events that were executed when lab modules needed to be revised to better fit the needs of the students and faculty.

“Troubleshooting experiments, confirming that the experiments do work, and understanding the timeline. By using undergraduate students, it allowed the professor to understand a realistic timeline that the students of the class can do and understand the learning capacity of the students.” – faculty lead instructor

Equipment accounts for the majority of the expenses associated with the lab

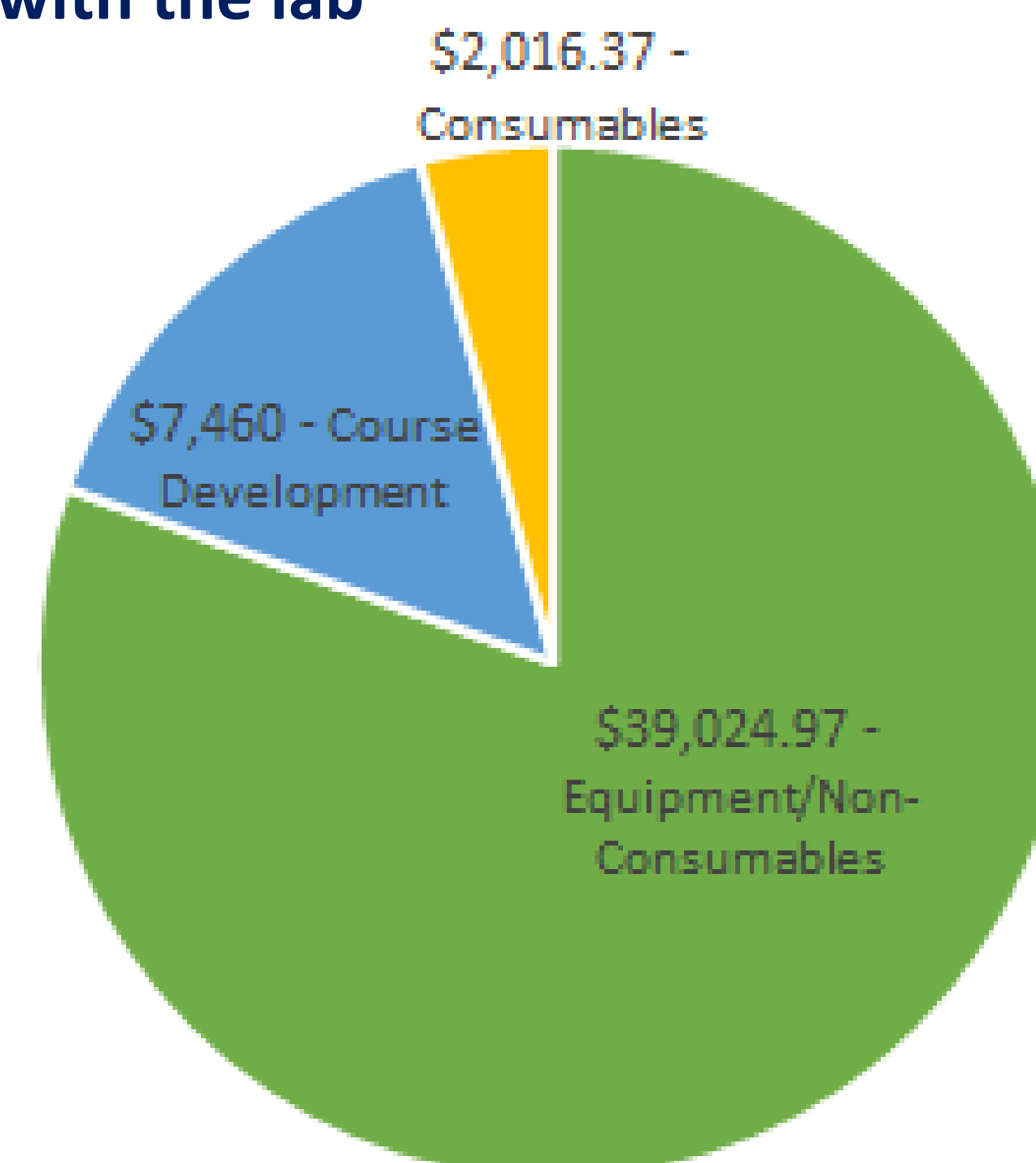


Figure 2. Expenses for development and the first offering of BIOL405. The consumables are an estimate for a class of 20 conducting 5 sets of each experiment. The CETL grant includes the money to hire two student researchers and one mentor for eight weeks as well as research supplies. While the initial start up cost is \$48,501.34, 96% of that amount is a one time cost for equipment. Note: cost does not include refrigerator, -80°C Freezer, or liquid nitrogen.

Project assessment included interviews of team members and pre- and post-assessment of enrolled students

INTERVIEWS OF TEAM MEMBERS DEMONSTRATED PERCEIVED VALUE OF THIS METHOD OF COURSE DEVELOPMENT



Figure 3. Summary of interviews of team members involved in course development. Font size reflects significance of the words.

ASSESSMENT SHOWS LAB MODULES INCREASED STUDENT KNOWLEDGE AND CONFIDENCE IN RELATED TECHNIQUES

Pre- and post-surveys were administered to students in the course. The survey contained a self-assessment and knowledge based questions. All identifying information was removed, and each survey was assigned a random number so that pre- and post-surveys could be matched. The student researchers used a rubric created by Dr. Lyman Gingerich to score the surveys. Paired t-tests were run on a statistical software called *R* to make comparisons (n=18).

“Practicing skills/lab techniques learned about in previous courses. Beneficial interactions with professors and other faculty members.” – student researcher

BOTH STUDENT CONFIDENCE IN AND KNOWLEDGE OF RELATED TECHNIQUES IMPROVED AFTER THE MODULES WERE TAUGHT

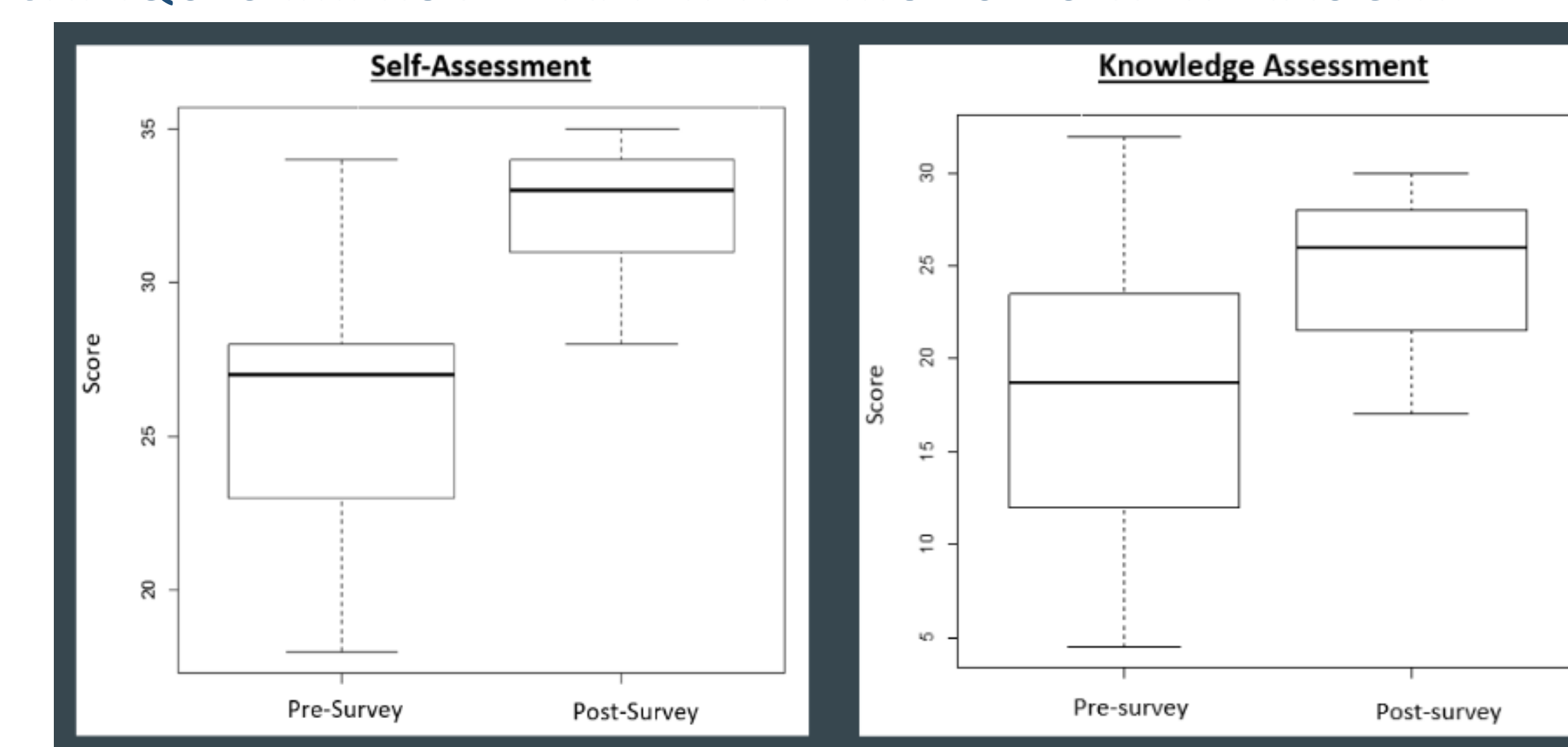


Figure 4. Both student confidence (self-assessment questions) and knowledge showed significant improvement after the modules were taught (p-value= 3.262 e⁻⁵ and 3.075 e⁻⁴, respectively).

SELF-ASSESSMENT AND KNOWLEDGE QUESTIONS SURVEYED SIMILAR CONTENT TO ALLOW COMPARISONS TO BE MADE

Question text	Average pre-survey score	Average post-survey score	p-value
I could look at the results of an RT-PCR experiment and tell whether a gene is expressed or not.	3.50/5	4.89/5	2.70 e ⁻⁵
What are two techniques for measuring the activity of a gene? Describe them to the best of your ability.	3.17/6	4.77/6	0.023
What is cDNA? How is it different from genomic DNA? Is cDNA single- or double-stranded? Explain.	0.77/6	1.69/10	4.41 e ⁻⁴
I know what the differences are between Southern, Northern, and Western Blotting.	3.39/5	4.94/5	6.33 e ⁻⁴
What is probed in a Southern Blotting experiment?	1.33/5	1.53/5	0.30
I am comfortable performing basic molecular biology techniques such as micro pipetting, gel electrophoresis, and nucleic acid purification.	3.67/5	4.72/5	1.75 e ⁻⁴
How might a scientist determine the concentration of nucleic acid in a test tube?	0.22/2	0.67/2	0.0071

Figure 5. Changes in student knowledge and confidence were not always consistent upon examining paired survey questions. The discrepancy seen between confidence and knowledge for question pairs could be the result of strong previous knowledge or issues with the specificity of the rubric, or could indicate areas needing improvement in the course.

This model of course design benefited all participants in the process

We used a new approach to develop an advanced cell/molecular biology laboratory course. We found:

- The optimized experiments worked well in the hands of undergraduate students
- Revising the course timeline to reflect the learning stages and capacities of the students required input from students themselves
- A significant increase in knowledge about the topics and confidence in performing lab techniques occurred for students in the course
- Although the initial start-up cost for the course is quite high, \$48,501.34, 96% of that is a one time cost. This means that approximately \$100 per student is spent on consumables per semester
- Modification of the assessment rubrics and questions may better reflect students' actual knowledge

As student researchers, we:

- Improved our molecular biology skills
- Incorporated knowledge and skills from our previous coursework in biology, chemistry, math and English
- Improved our ability to think critically to overcome challenges

While this research was carried out specifically for Molecular Biology, we think this approach can be used for course development in a broad range of disciplines.

“It will help propel the department forward by incorporating cutting-edge experimentation/techniques.” – lab manager