Assessment of Student Preparedness for Independent Research in a Research-Based Teaching Lab

Cameron Pormir and Suzanne S. Bohlson

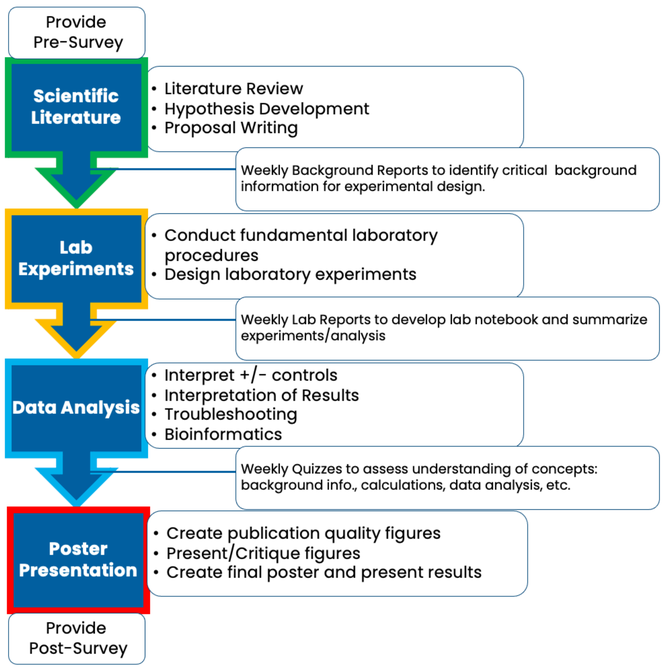
Abstract

Authentic engagement in research provides students with skills in scientific inquiry and experimental design that are not easily obtained through traditional pre-developed laboratories. The goal of this work is to transform a twenty-week traditional laboratory experience for first year MS students in a biotechnology program into a more authentic research experience. The laboratory curriculum focuses on developing students' ability to critically evaluate scientific literature as well as to plan, execute, and troubleshoot experiments. This was done by first introducing the students to relevant scientific articles related to a signal transduction cascade involved in leukemia stem cell self-renewal and identifying both gaps in knowledge and limitations in the literature. Students then design experiments to address those gaps in the form of an NIH-style research proposal, and ultimately conduct wet lab experimentation to address their proposed research questions. Additionally, students present their lab results weekly and develop a poster presentation to showcase their final work. Prior to beginning the course, students were surveyed using validated tools to measure their levels of experience in several skills such as scientific communication and collaboration as well as scientific literature review and comprehension. Further, students were assessed in their ability to plan and design-controlled experiments, solve multiple equations (e.g. generating working stocks, dilutions, etc.), conduct fundamental laboratory techniques and procedures, interpret results and data, and troubleshoot. Students were presented with the same survey upon completion of the teaching lab as well as with a perceived benefits survey to determine whether the lab is effective in developing students' preparedness for independent research. Here we will discuss the development of the pre- and post-survey and the preliminary results from the first iteration of laboratory assessment.

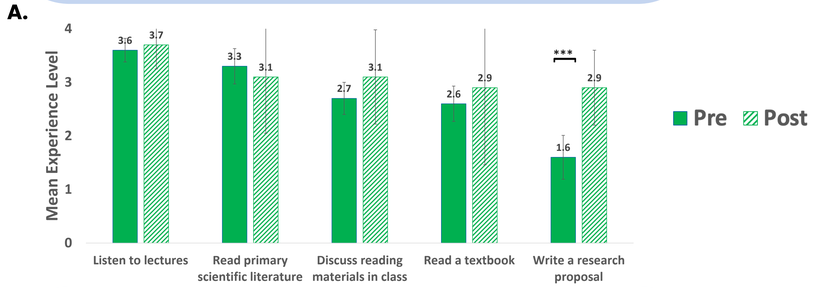
Student Learning Objectives (SLO)

By the end of this course, students will be able to:	
SLO1	Identify the critical background information necessary for experimental design.
SLO2	Apply scientific theory and methodology to safe laboratory practice.
SLO3	Design appropriately controlled experiments.
SLO4	Successfully conduct fundamental laboratory procedures.
SLO5	Analyze, evaluate, and troubleshoot experimental results.
SLO6	Develop a research proposal.
SLO7	Demonstrate scientific literacy by reviewing scientific literature and critiquing gaps in knowledge.
SLO8	Generate figures of publication quality for professional presentation.
SLO9	Generate and present a scientific poster.

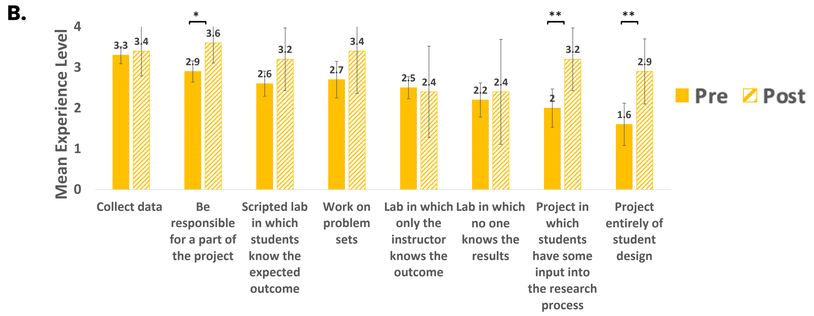
Course Outline



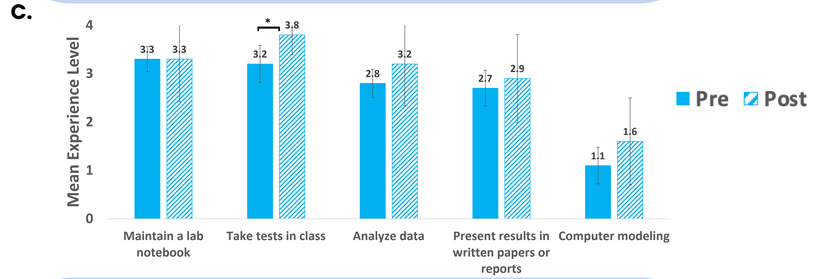
Students gained experience writing research proposals



Students gained experience experimental design



Students have limited bioinformatics experience



Students gained scientific presentation experience

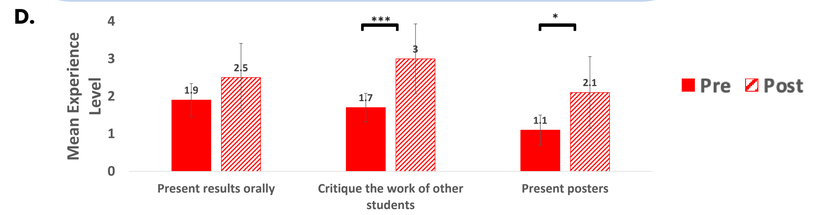


Figure 1 (A-D). Pre- & Post-Survey Results. Students (n=14) were provided with statements related to laboratory course work and asked to rank their experience level. Experience levels were assigned the following values for quantification: None (0), Little (1), Some (2), Much (3), and Extensive (4). Responses were averaged and grouped according to scientific literature (A), lab experiment (B), data analysis (C), and poster presentation (D). Data labels represent average experience, error bars represent standard error of mean. Statistical analysis was completed with Excel. A T-test was used to determine significance. * represents p values ≤ 0.05., ** p ≤ 0.005, *** p ≤ 0.0005.

Students report they largely benefited from taking research-based teaching lab

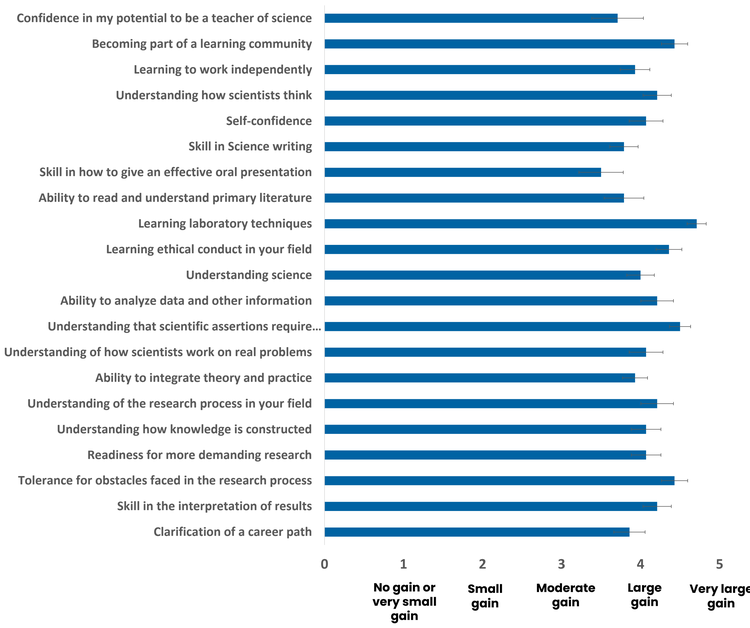


Figure 2. Post-Course Perceived Benefits Survey Results. Students (n=14) were provided with statements related to their preparedness for laboratory research and asked to rank their perceived benefits after taking the course. Gains were assigned the following values for quantification: No gain or very small gain (0), small gain (1), moderate gain (2), large gain (3), and very large gain (4). Responses were averaged. Error bars represent standard error of mean. Statistical analysis was completed with Excel.

Future Directions

- Administer Pre- & Post- Survey to future cohorts
- Develop instrument to assess faculty perception of readiness for research

References

- Jordan, Tuajuanda C., Sandra H. Burnett, Susan Carson, Steven M. Caruso, Kari Clase, Randall J. DeJong, John J. Dennehy, et al. 2014. "A Broadly Implementable Research Course in Phage Discovery and Genomics for First-Year Undergraduate Students." *mBio* 5 (1): e01051–13.
- Lopatto D., *Cell Biol. Educ.* ***3***, 270 (2004).
- Riether, Carsten, Ramin Radpour, Nils M. Kallen, Damian T. Bürgin, Chantal Bachmann, Christian M. Schürch, Ursina Lüthi, et al. 2021. "Metoclopramide Treatment Blocks CD93-Signaling-Mediated Self-Renewal of Chronic Myeloid Leukemia Stem Cells." *Cell Reports* 34 (4): 108663.

Acknowledgements

The authors are grateful for assistance from Drs. Brian Sato and Matthew Mahavongtrakul with the UCI Division of Teaching Excellence and Innovation (DTEI) in development of the survey instruments. In addition, we are grateful to the UCI MS Biotechnology and MS Biotechnology Management 2021-2023 cohorts for their work shown and described here.