WHAT DO ANIMAL PHYSIOLOGY STUDENTS LEARN FROM A CURE INVESTIGATING THE EFFECTS OF SEPTICEMIA ON CARDIAC FUNCTION: FROG AND LARVAL *DROSOPHILA* MODELS

KATHERINE A. SHARP[1], REBECCA M. KRALL[1], ROBIN L. COOPER[2,3], MELODY DANLEY[2], JATE BARNARD[4]

[1]Dept. of STEM Education, Univ. of KY, [2]Dept. of Biology, Univ. of KY.; Univ. of KY;

[3]Center for Muscle Biology, Univ. of KY. [4]College of Medicine, Univ. of KY

Introduction

Authentic undergraduate scientific research experiences can build skills and experience in applying scientific practices while engaging students in a scientific community of discovery and collaboration (Auschencloss et al., 2014; Lopatto, 2007; National Research Council [NRC], 2003; Shapiro et al., 2015). These experiences can foster excitement about science as students conduct scientific research and increase motivation to pursue careers in scientific research through feelings of recognition of being a scientist (Starr, 2020). Such experiences also develop critical reasoning skills and science practices, such as experiences collaborating with peers, arguing from evidence, and perseverance in problem-solving (i.e., Auchincloss et al., 2014; Ditty et al., 2013; Miller et al., 2013). Unfortunately, many undergraduate science courses they complete are offered in large, lecture style formats while laboratories often present standardized laboratory exercises that offer little opportunities for setting up equipment, constructing deeper understanding of the topic, arguing from evidence, and collaborating in sense-making activities to interpret the data (NRC, 2003; AAAS, 2010; Holt, 1969).

Course-based undergraduate research experiences (CURE) derived from ongoing faculty research articulates the calls for change within undergraduate biology education. Specifically, the AAAS (2010) *Vision and Change in Undergraduate Biology Education Initiative* recommended use of student-centered pedagogies in instruction and a trajectory of scientific research experiences for students beginning in the early in their undergraduate academic careers. Likewise, the NRC (2003) has recommended the use of project-based laboratories in undergraduate biology instruction to foster science practices and enculturate students in scientific research.

A challenge for college laboratory instructors is garnering sufficient time and materials to support such experiences. Examples of challenges laboratory instructors report include the increased amount of time to develop and implement a CURE, the need for increased funds to purchase necessary materials, anticipating what supplies will be required, arranging additional laboratory time that allow for project completion, the expanded role of an instructor that includes mentorship, and determining research projects that can be successfully completed a course laboratory setting (Shortlidge et al., 2016). Additionally, the development of authentic experiences requires revision and re-implementation upon student feedback. Consequently, curriculum development is a time-consuming process (Marbach-Ad & Rietschel, 2016).

In this study, we sought to describe the initial stage of a transformative process in which a physiology laboratory classroom moves from a standardized lab to an authentic experience. This presentation describes the results of a pilot study on the first iteration of a short-term CURE and future efforts to continue the course's transformation into an authentic research experience. This study is part of a larger study that explored student outcomes from a bench science investigation on the effects of bacterial endotoxin on cardiac tissue. The purpose of this paper is to report on the successes and challenges of implementing an authentic laboratory investigation in an animal physiology course. The research conducted in the laboratory was an extended the work on the effects of lipopolysacharide (LPS) on cardiac tissue researched by Dr. Robin Cooper and colleagues (2019).

Research Questions

The driving question for the research study was: How does student participation in the frog cardiology laboratory activities affect students' understandings of the anatomy and physiology of the heart under the effects of a bacterial endotoxin? Three sub-driving questions guided the exploration of students' views resulting from their participation in the laboratory:

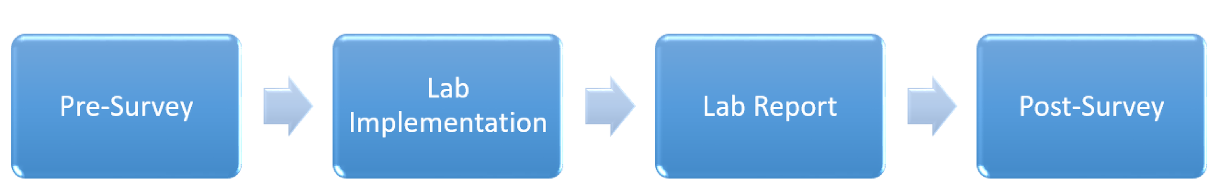
- How do the frog cardiology laboratory experiences affect students' understandings of the anatomy and physiology of the frog heart? The *Drosophila* heart tube?
- How does the frog cardiology laboratory experiences affect students' knowledge about bacterial endotoxin and its effect on animal models?
- What were students' perceptions of the frog cardiology laboratory?

Participants

Study participants included 42 undergraduate students enrolled in the undergraduate animal physiology lecture and laboratory courses taught by Dr. Robin Cooper in the spring semester of 2020. Sixty-eight students volunteered to participate in the study, but only 42 completed the pre- and post-test.

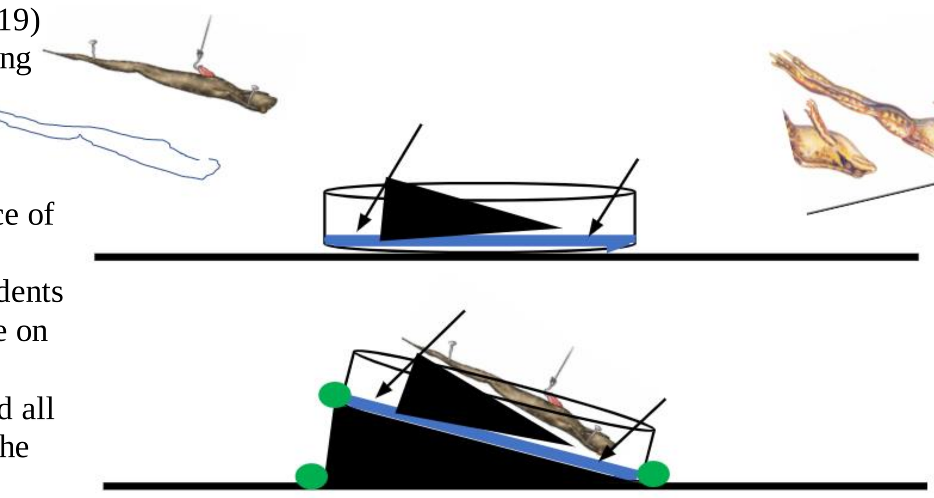
Methods

Students were majoring in biology or a related discipline and were taking the course as a requirement for their major. Prior to the laboratory exercise, students completed a pre-survey that assessed their content knowledge on LPS and heart anatomy. Students completed the laboratory exercise. Upon completion of the laboratory exercise, students completed a post-laboratory report. After laboratory reports were submitted, students completed a post-survey identical to the pre-survey. See QR code for pre- and post-survey.



Intervention

- CURE investigation was derived from Anyagaligbo et al. (2019)
- Students began the exercise by dissecting the frog and attaching the apex of the frog heart to a force transducer.
- Students were provided one of two solutions in a blind study: A) LPS dissolved in saline; or B) saline.
- Upon application of LPS or saline, students measured the force of contractions using the force transducer.
- Students also measured the effects of LPS in *Drosophila*. Students visually measured heart rate upon application of LPS or saline on larval *Drosophila* hearts.
- All data was compiled on the course LPS, which students used all data to determine statistically significant difference between the two solutions.



Findings

Table 1. *Comparison of Pre- and Post-test Results on Physiological Knowledge about Frog Heart and Larval Drosophila Heart Tubes.*

Question	Frequency of Correct Pre-Test Responses (n=42)	Percentage of Correct Pre-Test Responses by Students	Frequency of Correct Post-Test Responses (n=42)	Percentage of Correct Post-Test Responses by Students
Does the larval (maggot) stage of Drosophila (Fruit fly) have some form of a heart?	13	30.95%	28	66.67%*
How many chambers does a frog heart have?	17	40.47%	36	85.71%***
Which of the following best describes the larval *Drosophila* heart?	4	9.52%	15	35.71%*
Which of the following best describes the human heart?	15	35.71%	34	80.95%***
What is the neurotransmitter released from the tenth cranial nerve on the frog or human heart?	12	28.57%	25	59.52%*
In larval *Drosophila*, which of the following can increase the heart rate?	3	7.14%	4	9.52%

**indicates significant change at 0.05 confidence level.*
****indicates significant change less than 0.001 confidence level.*

Table 2 . *Pre- and Post-Test Scores Assessing Students' Self-Efficacy Regarding Frog Heart and Larval Drosophila Cardiac Anatomy and Physiology.*

Survey Item	Average Pre-Test Response	Average Post-Test Response	Effect Size
I can describe the anatomy of the frog heart	1.71	3.07	-.542***
I can describe how the anatomy of the frog heart differs from the human heart.	1.62	3.19	-.569***
I can describe the anatomy of the heart tube of a *Drosophila* larva.	1.38	2.62	-.560***
I can explain how the autonomic system controls heart function in a frog.	1.76	3.07	-.558***
I can explain how the autonomic system controls heart function in larval *Drosophila*.	1.55	2.79	-.532***
I can compare the cardiac physiology of insects and amphibians.	1.74	2.86	-.507***
I can calculate a change in heart rate.	2.52	3.52	-.526***

****indicates significant change less than 0.001 confidence level.*

Table 3. *Comparison of Pre- and Post-test Results on Lipopolysaccharide (LPS) and physiological effects of LPS.*

Question	Frequency of Correct Pre-Test Responses (n=42)	Percentage of Correct Pre-Test Responses by Students	Frequency of Correct Post-Test Responses (n=42)	Percentage of Correct Post-Test Responses by Students
Where does Lipopolysaccharide (LPS) come from?	22	52.39%	39	92.86%***
Does LPS have any direct effect on the physiology of organs?	19	45.24%	32	76.19%*

**indicates significant change at 0.05 confidence level.*
****indicates significant change less than 0.001 confidence level.*

Table 4. *Pre- and Post-test Scores Assessing Students' Self-efficacy Regarding Bacterial Endotoxin and its Effect on Animal Models.*

Survey Item	Average Pre-Test Response	Average Post-Test Response	Effect Size
I can explain how septicemia develops in humans	1.5	2.83	-.549***
I can define bacterial LPS	2.07	3.19	-.482***
I can explain what happens when LPS is introduced to frog cardiac tissue	1.42	3.05	-.589***
I can explain what happens when LPS is introduced to the Drosophila heart tube	1.33	2.88	-.589***
I can identify substances that are released from tissues in the body when LPS is in the blood of an animal	1.52	2.71	-.522***
I can explain the cascade of the events that occur in a human example from the introduction of LPS in the blood to sepsis	1.48	2.95	-.584***

****indicates significant change less than 0.001 confidence level.*

Conclusions

- Students demonstrated little change in their understanding with their ability to identify the neurotransmitters that can increase heart rate. This is not surprising as the results of the CURE investigation were inconclusive.
- Significant positive changes were demonstrated in students' knowledge of the anatomy and physiology of frog heart and *Drosophila* heart tube, in addition to innervation of frog and human hearts.
- Students a demonstrated significant increase in understanding of the physiology of the *Drosophila* heart tube and neurotransmitters that are released from the tenth cranial nerve in the frog, *Drosophila*, human models.
- Students did not demonstrate significant change in their understanding of how *Drosophila* heart tubes are innervated.
- Students' responses showed significant improvements in self-efficacy for all measured categories which broadly included the following areas: human, frog and *Drosophila* heart/heart tube anatomy; cardiac neurophysiology; and measuring changes in heartrate.
- Students demonstrated learning gains on understanding the origins of LPS about how LPS directly effects organs.
- Students' responses demonstrated largest gains in self-efficacy when describing what happens when LPS is introduced to the *Drosophila* heart tube and frog cardiac tissue.

Future Directions

Compare qualitative and quantitative findings to support survey results and characterize students' understanding and perceived self-efficacy in relation to CURE dimensions (i.e., science practices, discovery, broadly relevant/important work, collaboration, iterative) .

Use the data from this study to make modifications to the lab and implement the next iteration in spring 2022.

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University IRB & IACUC protocols were followed.