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A report submitted to Dr. Kim Black, Director of Assessment
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by

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Introduction

Purpose of the Project

Human Anatomy and Physiology (A&P) classes historically have a high Drop-Fail-Withdraw (DFW) rate at institutions around the world. A&P classes at the University of Northern Colorado are no exception, with BIO 246 (Advanced Human Anatomy and Physiology) having a 24% DFW rate between 2015-2018 [1]. This class predominantly serves students in nursing and other allied health programs. Physiology topics are known to be challenging for students to learn, due to the difficulty of establishing effective study strategies for broad systems-level content. Our aim was to address these challenges by implementing Problem-Based Learning (PBL) as a part of the BIO 246 laboratory curriculum. BIO 246 is a 3-credit hour course that includes two one-hour lectures and one three-hour lab meeting weekly, and it is a required course for nursing and allied health majors at UNC. PBLs present students with ill-structured problems that can be solved by following a variety of inquiry paths and is further characterized by longitudinal group work. In medical education, PBLs are frequently used to train future physicians to integrate and apply knowledge about multiple body systems. Using an iterative, design-based research approach, we designed a similarly structured PBL for BIO 246 students at UNC to support their learning of physiology.

To investigate factors related to student learning in BIO 246, and to investigate whether PBL supports student learning, we are asking the research questions (RQ):

RQ1: How do student attitudes relate to learning outcomes?

RQ2: Is Problem-based Learning an effective pedagogical tool to improve systemic thinking and learning outcomes for undergraduate nursing and allied health students in anatomy & physiology?

Methods

Participants

We have completed three semesters of data collection in BIO 246 labs. The Spring 2019 (n = 30) and Fall 2019 (n = 105) semesters were comparison pedagogy semesters, and the Spring 2020 (n = 20) semester was the first in which we implemented the PBL.

Data Collection

To address our research questions, we chose quantitative measures for Learning Outcomes, Student Affect, and Systems Thinking. These were collected during lab meeting times via a pre-test survey at the beginning of the semester, a post-test survey on the last week of lab, and class assignments collected from instructors throughout the semester (Table 1).

Learning Outcomes: We collected students' *final course grades* and *laboratory entrance quiz grades* as proxies for learning in our context. Additionally, we used the previously validated *Homeostasis Concept Inventory (HCI)* [2] to assess undergraduate students' conceptual understanding of physiology.

Student Affect: We surveyed students about their sources of motivation with the 25-item Likert-scale *Biology Motivation Questionnaire (BMQ-II)* [3]. We also used 61 items from the *Motivated Strategies for Learning Questionnaire (MSLQ)* [4] to assess students' self-regulation and learning strategies.

Systems Thinking: Systems thinking refers to the ability to think about the interactions among the parts and whole of a network, including hierarchical and time-bound relationships, such as those present in physiological systems. We administered the *Lawson Classroom Test of Scientific Reasoning*

(CTSR) [5] to examine the level of systems thinking students had coming into the course. We collected students' submissions for five *concept map assignments* that were assigned as formative assessments throughout the semester. While these received a grade from the Teaching Assistant, we are currently coding the maps from to further assess components of their complexity and validity.

Student Demographics: We collected self-reported data on students' gender identity, racial/ethnic heritage, first generation student status, pre-requisite course completion, and major.

Table 1. Instruments used at various points of data collection.

Pre-test Survey	Throughout Semester	Post-test Survey
HCI	MSLQ	HCI
BMQ-II	Concept Maps (5)	BMQ-II
CTSR	Lab Quiz Grades (12)	Demographic Questions
	Final Course Grade	

Design-based Implementation

Design-based research is characterized by iterative revision and implementation of changes within learning environments. During the Spring 2019 semester we assigned weekly concept maps to be completed in-class. After reviewing student feedback, we created a Concept Mapping Workshop to train students how to make concept maps, and then used the maps as formal assignments starting in the Fall 2019 semester, with five assigned throughout the semester. Laboratory assignments in these comparison semesters included four case studies and four lab report handouts completed in groups.

We implemented the PBL during the Spring 2020 semester. In lieu of lab handout assignments and case study assignments, three PBL Case Reports were assigned. PBL Case Reports began with a patient scenario and each week students were given "Guiding Questions" that integrated the patient's lab results and symptoms with the week's lab activities. Students were required to ask and investigate original "Research Questions" each week and report back findings to the group as they investigated potential diagnoses for their patient. After the transition to online learning, students completed their PBL Case Reports by meeting each week virtually with their lab groups via Microsoft Teams.

Analysis: Data collection and PBL implementation will continue for the next academic year. Paid student research assistants are coding the complexity of the concept maps based on types of components. When data collection is complete, we will build regression models with all survey factors to predict course and learning outcomes, and we will compare learning gains and concept map complexity gains between the comparison and PBL intervention cohorts.

Findings

<u>Finding 1: BIO 246 students are highly motivated.</u>

The BMQ-II scores were not normally distributed, with the majority of reported scores being at the upper anchor of the metric across all motivation subscales (Grade, Career, Self-efficacy, Self-determination, and Intrinsic Motivation). However, students who report higher levels of self-efficacy and self-determination at the beginning of the semester tend to receive higher final grades (respectively, $r = 0.18$, $p = .026$; $r = 0.18$, $p = .023$).

Finding 2: Students with structured learning strategies fare better in BIO 246.

Using Pearson's correlations to relate the MSLQ subscales with final grade, we know that across all cohorts students who report that they stay engaged despite distractions (Effort Regulation; $r = 0.39$, $p < .0001$), manage their studying time and space (Time and Study Environment; $r = 0.33$, $p < .0001$), monitor their learning progress (Metacognition; $r = 0.19$, $p = .022$), organize the information they need to learn (Organization; $r = 0.17$, $p = 0.034$), and use rehearsal study strategies (Rehearsal; $r = 0.17$, $p = .042$) tend to receive a higher final course grade in BIO 246. Additionally, students who report low levels of test anxiety also tend to have an overall higher final grade ($r = -0.29$, $p = .0003$).

Finding 3: The HCI may not be sensitive enough to capture learning over one semester.

In the comparison cohorts, students did not score differently on the HCI at the end of the semester compared to their pre-test scores (paired t-test: $p = .223$). As educators, it is discouraging to wonder if students did not learn anything over a semester of instruction, and so we investigated whether the HCI metric was appropriate for our context. We decided to survey graduate students using the HCI to see if the metric was sensitive enough to distinguish experts from novices and found that graduate students did score higher than undergraduates on the pre-test and post-test (unpaired t-test: $p = .0002$; $p = .0007$). Interestingly, we found that graduate students' scores on the HCI also did not improve after a semester of graduate-level physiology coursework (paired t-test: $p = .529$).

Finding 4: PBLs may support the learning of physiology for undergraduate students.

While our sample size for the PBL treatment cohort was small and the semester was interrupted with the pandemic-related campus closure, our initial results indicate that these students, unlike those in the comparison cohorts, did significantly improve on the HCI (paired t-test: $p = .019$). The S20 cohort on average had a larger gain in HCI score between the pre- and post-test compared to the comparison cohorts ($M = 1.3$ and $M = 0.2$, respectively), though this difference was not statistically significant (unpaired t-test: $p = .064$). Our next steps include analyzing the concept maps more deeply to investigate changes in systems thinking across all cohorts.

Dissemination

We are preparing the PBL activities to be submitted for publication in *Course Source*, which is an online collection of peer-reviewed undergraduate biology curricula. With the comparison cohort data, and in collaboration with the student researchers who are analyzing concept map complexity, we will prepare a manuscript reporting on longitudinal trends in concept map complexity.

We have given oral presentations about our Bonus Finding concerning HCI performance in graduate and undergraduate students at the 2019 BioTAP Virtual Conference and the 2020 Society for the Advancement of Biology Education Research West regional conference. Additionally, we are preparing a manuscript about these findings that will be submitted to the peer-reviewed journal *Advances in Physiology Education* by the end of summer 2020.

References

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