Human Case Studies and Demonstrations for Active Learning and Application of Critical Thinking for Improved Mastery of Anatomy and Physiology from the Freshman to the Sophomore Foundational Courses

Project Abstract

The purpose of this project is to support improved student mastery of fundamental anatomy and physiology knowledge and critical thinking skills for health professionals through a longitudinal collaboration across courses in the freshman and sophomore year using innovative NEXUS/POGIL (Process-Oriented Guided Inquiry and Learning) pedagogies. Currently 35% of students do not meet progression requirements for health majors on campus in anatomy and physiology. Multiple pedagogical studies have shown significant success in reversing this trend so that a greater proportion of students master the complex organ system functions essential to their health careers. We propose collaborating across the freshman and sophomore level to redesign four modules using active learning methods and then tracking both immediate student learning gains as well as longitudinal gains over multiple years. Research results will be disseminated in several outlets on campus, at a Lilly Conference on College Evidence-based Teaching and Learning and in a manuscript submitted to *Advances in Physiology Education*

Project Overview

The purpose of this project is the second phase in a multi-year effort to redesign the foundation biology courses in innovative evidence-based pedagogical methods in a step-wise iterative process to improve student mastery of knowledge, skills and critical thinking which is essential for health professionals. Phase I focused on improving three areas:
1**) On-line interactive guided inquiry:** Seventy-five percent of instructors used on-line Mastery, a set of computer-aided teaching tools. Substantial student learning gains and greater use of tutoring services were evident in the pilot courses that incorporated these tools the most.
2) **Hands-on real world engagement** resulted in five students leading a research project involving 48 students over a multi-week period in a randomized controlled study of student response to stress in relation to two levels of music therapy. Students measured and analyzed blood pressure, pulse, typing speed, memory, and knowledge before and after music therapy. All 48 students were engaged in active learning using a wide range of tools immediately applicable to the key course content of the endocrine, nervous, circulatory and digestive systems. For the first time at Philadelphia University, five freshman are presenting evidence-based health research at the 26th Annual St. Joseph's University Sigma Xi Science Symposium and
3) **Career Pathways**: Results for the two pilot sections indicated that development of a scientific resume increased from 17% of students to 98% and applications to an internship or paid position in a field related to their major increased from 20% to 95%.

Phase II will build upon improving mastery of essential content and problem-solving skills which are fundamental to all health professionals. Philadelphia University is rapidly increasing the number of 3 + 2 health graduate programs in which students shorten their over training time and graduate with a combined B.S and M.S degrees. There are over 260 students in the Health Sciences major which leads to graduate degrees on-campus in Physician Assistant, Occupational Therapy, Trauma Counseling and other graduate programs under development. Currently, students are introduced to human anatomy and physiology in the second semester of their

freshman year (BIOL 104 Introductory Biology II) and then take a multi-course sequence in the sophomore year (BIOL 201 and 202 Anatomy and Physiology I and II) which leads to additional courses at the graduate level. Student must master very complex human anatomical structures and physiological pathways for every organ system in the body to be successful health professionals. For progression, a minimum grade of B is needed. In the past two years, 65% of students in Anatomy and Physiology met progression standards, however 35% of 231 students did not and earned a C (51), D (19) or F (11) which is unacceptable. Nationwide, it has been shown if pedagogy is changed the proportion of students able to master key concepts for their profession changes dramatically. Brown et al (2010) found that the rate of students with a D or F was halved and the scores on the comprehensive final exam rose from 68% to 88% when traditional lectures were replaced with active learning activities in Anatomy and Physiology. Armbruster et al (2009) found statistically significant learning gains when student centered methods were used in the lecture period as opposed to being restricted to only the laboratory sections. National trends in science education has shown an increase in student knowledge and critical thinking for active pedagogy over lecture only (National Research Council, 2005). We have chosen to collaborate across classes because Matthius and Jenson (2014) demonstrated that in Anatomy and Physiology pedagogy, coordination and peer-to-peer learning of techniques between faculty was significant for implementation of active pedagogy. In addition, the outside evaluator assessing the Biology Major recommended that active learning methods be taught by trained tenured faculty (Philadelphia University, 2014).

Students learning will be tracked from the introductory to the beginning professional levels for four specific complex human anatomy and physiology systems: endocrine, nervous, excretory (osmoregulation) and musculoskeletal. POGIL methods will be used in BIOL 104 and BIOL 202 in Spring 2016 including on-line animations and interactive games in MASTERY, peer analysis of human case studies and mini-demonstrations of key principles such as test strips of levels of glucose in urine for diabetes compared to normal function. It will be an iterative learning process to identify gaps in student understanding and misconceptions at both the freshman and sophomore levels. In the future, this effort would be continued to the graduate level of Anatomy and Physiology so it would track specific health related concepts throughout the students' entire academic career at Philadelphia University.

Project Advances NEXUS learning

This project advances NEXUS learning at two levels:

Assessment of Immediate Changes in Student Learning: All active teaching activities inserted into BIOL 104 and BIOL 201 and 202 will be active, collaborative, and real-world and infused with skills and knowledge from the Liberal Arts and Sciences. Core content will be retained and enhanced by engaging students and increasing mastery.

Longitudinal Mastery:

Students learning will be tracked from the introductory to the beginning professional levels for four specific complex human anatomy and physiology systems. It will be an iterative learning process to identify gaps in student understanding and misconceptions at both the freshman and sophomore levels. This pedagogical research effort established the foundation so that changes in

student skills, knowledge and attitudes for key health concepts could be assessed systematically from freshman year through graduate school completion.

Specific Project Goals and Learning Outcomes

The goals of the project are to redesign BIOL 104 and BIOL 202 with four new modules in endocrine, nervous, excretory and musculoskeletal systems. The proportion of student meeting progression standards for each of the individual modules will rise from a mean of 65% to 75% with a corresponding reduction in non-satisfactory grades. Learning gains related to each of the specific health modules will be assessed before and after and then compared to traditionally-taught modules in a cross-over design. We will then be able to compare learning between new pedagogical approaches to traditional approaches for the same student in BIOL 104 or BIOL 202. Given that new pedagogies were tested in BIOL 104 in Spring 2015, we will also be able to track differences in retained knowledge for this subject matter as a pretest in BIOL 202 compared to students who did not participate in the pilot sections this semester.

The specific learning objectives for the modules are:

Kidney, Osmoregulation and the Excretory System

- Identify and describe the internal anatomy of the kidney
- Trace the blood supply of the kidney from renal artery to the renal vein
- Describe the anatomy of a nephron
- Define glomerular filtration, tubular reabsorption, and tubular secretion and indicate the nephron areas involved in these processes
- Describe the importance of tubular secretion and list several substances that are secreted
- List the physical characteristics of urine and indicate the normal pH and specific gravity ranges
- Describe how sodium and water reabsorption are regulated in the distal tubule and collecting duct
- Describe the mechanisms underlying water and solute reabsorption from the renal tubules into peritubular capillaries
- Describe the forces (pressures) that promote or counteract glomerular filtration
- Describe the general location, structure, and function of the urethra
- Compare the course and length of the urethra in males and females
- List several abnormal urine components and name the condition characterized by the presence of detectable amounts of each

Endocrine System:

- Identify the major endocrine glands and tissues of the body
- Describe the locations of major endocrine glands in the body
- Explain how hormone release is regulated
- Describe the structural and functional relationships between the hypothalamus and pituitary gland

- Discuss the structure of the posterior pituitary and describe the effects of the two hormones it releases
- Correctly identify the histological structure of the thyroid, parathyroid, pancreas, anterior and posterior pituitary, adrenal cortex, and adrenal medulla by microscopic inspection or in an image
- List and describe the chief effects of anterior pituitary hormones
- List three kinds of interaction of different hormones acting on the same target cell
- Explain how hormones contribute to body homeostasis by giving appropriate examples of hormonal actions
- Describe the effects of the two groups of hormones produced by the thyroid gland
- Indicate the general functions of parathyroid hormone
- List hormones produced by the adrenal gland and cite their physiological effects
- Discuss some mechanisms that stimulate release of hormones from endocrine glands
- List and describe the chief effects of anterior pituitary hormones
- Compare and contrast the effects of the two major pancreatic hormones
- Explain the differences between Type I and Type II diabetes

Peripheral nervous system and reflexes

- Define the peripheral nervous system and list its components
- Describe the main aspects of sensory perception
- Define exteroceptor, interoceptor, and proprioceptor
- Classify the general sensory receptors by structure, stimulus detected, and body location
- Outline the events that lead to sensation and perception
- Describe receptor and generator potentials and sensory adaptation
- Describe the general structure of a nerve
- Name the 12 pairs of cranial nerves; indicate the body region and structures innervated by each
- Describe the general structure of a spinal nerve and the general distribution of its rami
- Define plexus. Name the major plexuses and describe the distribution and function of major peripheral nerves arising from each plexus
- Outline the three levels of the motor hierarchy
- Name the components of a reflex arc and distinguish between autonomic and somatic reflexes
- Compare and contrast stretch, flexor, crossed-extensor, and tendon reflexes

Musculoskeletal

- List four important functions of muscle tissue
- Compare and contrast the three basic types of muscle tissue

- Explain how muscle fibers are stimulate to contract by describing the events that occur at the neuromuscular junction
- Follow the events of excitation-contraction coupling that lead to cross bridge activity
- Explain the connection between motor neurons and skeletal muscle and discuss the structure and function of the neuromuscular junction
- Describe thick (myosin) and thin (actin) filaments and their relation to the sarcomere
- Describe the sliding filament model of muscle contraction
- Discuss the structure and location of T tubules and terminal cisterns
- Describe the microscopic structure and functional roles of the myofibrils, sarcoplasmic reticulum, and T tubules of skeletal muscle fibers
- Describe the structure of skeletal muscle from gross to microscopic levels
- Demonstrate how a physiography or computer with data acquisition unit can be used to record skeletal muscle activity
- Describe the sliding filament model of muscle contraction

Description of Activities and Timeframe

The present grant application for 2015-16 builds upon previous curricular changes in BIOL 104 in 2014-15. The timeline is:

Summer 2015

- Redesign four Anatomy and Physiology modules for POGIL/NEXUS activities for BIOL 104 and BIOL 202 with assessment and pre/post-tests developed to track longitudinal change
- Equipment and supplies ordered with student worker piloting directions and preliminary learning

Fall 2014:

- Continued redesign, testing, and loading of materials to Blackboard
- Human subjects review submitted
- Assessment materials refined, pilot with subgroup of students and reviewed

Spring 2015:

- Implement POGIL/NEXUS activities in two sections of BIOL 104 and BIOL 202
- Assessment and data collected on student learning changes
- Preliminary results dissemination on campus
- Final report written and manuscript developed for Lilly presentation and *Advances in Physiology Education*

Project Assessment

Student Learning: Targeted changes in student learning on mastery of learning outcomes for Anatomy and Physiology following Bloom's taxonomy will be measured as pre and post tests using MASTERY (on-line program) which is now used in both BIOL 104 and BIOL 202 from

the previous NEXUS grant. Longitudinal learning changes for the same student over a two year period will be tracked to show trends from introductory knowledge to levels of mastery. Grade distributions in courses will be compared to previous years.

Documentation and Dissemination

We will disseminate key findings at the College of Science, Health and the Liberal Arts faculty meeting, Roxboro House Roundtables and to the Health Advisory Board. Results will be presented at a Lilly Conference on Teaching (competitive peer-reviewed). Publications will be to science teaching journals such as *Advances in Physiology Education*

Project Personnel

The PI will lead the NEXUS learning curriculum development and faculty training in pedagogical methods. She has lead curriculum development efforts at Philadelphia University over a 15 year period in multiple science courses and has collaborated with and published results from two separate National Science Foundation education initiatives: SENCER and NCEP. She teaches Biology 104 Introductory Biology II where 1/3 of the course material is the ntroduction to anatomy and physiology. POGIL activities will be incorporated and student learning measured in this course.

The consulting faculty member will bring expert knowledge of Anatomy and Physiology subject matter. She teaches BIOL 201 and BIOL 202 Anatomy and Physiology I and II. She will implement POGIL activities in BIOL 202 and student learning will be measured.

Budget Narrative and Worksheet (attached excel file)

The budget consists of summer stipends for a team who will design and test active learning modules on osmoregulation, endocrinology, nervous system function and sensory motor. The team includes the principal investigator ($2,000) pedagogical design, the consulting faculty member ($875), anatomy and physiology expertise and a student assistant who test the hands-on equipment and work on design. The student will benefit professionally as they will be included in the scientific publication process. Equipment needed ($1456) for kidney, endocrine, nervous and muscle models and kits. Supplies ($667) include simulated urinalysis, biodot sensory indicators and endocrine indicators. The total is: $5998.40 for two faculty and one student.

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