Tailoring Case Studies to Course Learning Objectives Helps Improve Student Performance

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Abstract

Recently there has been a push for more student-centered learning in the undergraduate classroom as a way to enhance student learning outcomes. One tool utilized in many Anatomy and Physiology courses is case studies of the material being presented. These allow students to apply their knowledge to a real-world scenario they may encounter in their future careers. Here we show the importance of tailoring that tool specifically to the learning outcome of the course. Using backward design, we developed targeted case studies to help students understand complex topics. Improved student performance on related exam questions provided evidence for this improved understanding. https://doi.org/10.21692/haps.2020.023

Introduction

In recent years, there have been numerous attempts and various approaches that have been taken to enhance the overall learning experiences of students in undergraduate courses. The Department of Biology at Elmhurst University has made a commitment to follow the guidelines that were created by the Vision and Change in Biology Undergraduate Education published by The American Association for the Advancement of Science (AAAS 2011). One of the major aspects of Vision and Change is working towards incorporating more student-centered learning into the biology classroom. Student-centered learning moves away from a purely lecture-based course to incorporate more activities, such as case studies, that allow students to work through the material and employ active learning approaches (Brush and Saye 2000).

Case studies, or case-based learning, utilize an approach that incorporates a real-life problem to assist students in the process of developing an understanding of a specific topic (Williams 2005). The use of a topic-relevant narrative that is then followed by a set of questions, aids in promoting a higher analysis of the topic in question (Herreid et al. 2011). Case studies serve to make a connection between information that is being taught in the classroom and real-world applications of that knowledge, allowing students to not just reiterate information that was previously presented to them, but to take it a step further to apply the information in a realistic manner. This is done so that students will gain an understanding of the importance of the material that they are learning. Furthermore, students who work in groups to complete case studies show higher engagement as they share their unique perspectives to help each other work through the topic (Taneja 2014).

It has been shown that the incorporation of case studies into the anatomy and physiology classroom can enhance learning and understanding, especially in regards to the clinical application of the material learned (Cliff and Wright 1996). For example, the use of case-study-based learning was shown to increase student understanding of complex topics such as evolution and natural selection in an undergraduate biology course (King-Heiden and Litster 2018). Students who participated in case-based reviews for exams show increased performance on final exams compared to those students who did not use the case-based reviews (Pierce et al 2014). Recent work has shown that incorporating the use of case study exams, an assessment tool that uses case-based assessment questions, has led to an increase in student exam performance, as well as in their ability to understand and apply the information learned (Smee and Cook 2018).

Along with implementing a case-based learning approach, backward design can be utilized to target the case studies to specific learning outcomes. Backward design is the approach of first identifying the end point, or desired result, and then designing your curriculum to allow students to achieve that result (Wiggins and McTighe 1998). This approach is key as it allows the instructor to identify the outcome students are expected to achieve and then create the learning tool to guide students towards achieving this outcome (Hopper 2018).

This study explores the potential effect that case studies have on student performance in complex areas of anatomy and physiology knowledge. Our initial study focused on two specific complex topics that were frequently identified by students as areas of difficulty. Utilizing student assessments, we identified learning outcomes with which students had

previously struggled. Case studies were developed that specifically addressed the assessment question for the learning outcomes of interest. Using this method, we were able to directly address and improve student outcomes on specific complex topics.

Methods

Preliminary data was collected from 24 students enrolled in the fall of 2017 Biology 107 Human Anatomy and Physiology I course. This course is primarily made up of first semester pre-nursing majors, with a small portion of other pre-health professions students. The course is of particular interest for pedagogical innovations due to its history of having a high DFW rate (final grades of D, F or early withdrawal) leading to lower retention of students to enter the second semester of the course.

A single section was used for preliminary data since the instructor was only teaching one section of the course during their first semester at this institution and the need to introduce interventions quickly to help student outcomes was great. At the end of the semester, students were asked to complete a survey identifying which topics they found to be the most challenging during the semester (Supplemental Item 1). Student survey responses were compared to student assessment data and it was determined that transcription and translation as well as the cellular mechanism of skeletal muscle contraction were the top two topics with which students struggled the most during this course.

During the summer of 2018, case studies were created to specifically target these topics in a way that guided students through the process with the goal that students would be able to achieve the learning outcome being assessed. Each case study presented a patient scenario and asked students a series of questions (five to seven short answer questions) that prompted students to explain the science behind the patient's condition (Supplemental Item 2).

The case studies were given to 71 students enrolled in the same instructor's Biology 107 Human Anatomy and Physiology I course in the fall of 2018 and fall 2019. The topic was first covered during a traditional lecture, as was done in Fall 2017 for the preliminary data, and students were given class time to complete the case study pertaining to that topic. Students were placed into groups to work through the case study together and then the instructor led a class discussion of the questions following completion of the case studies. A flowchart depicting the design and implementation process is shown in Table 1.
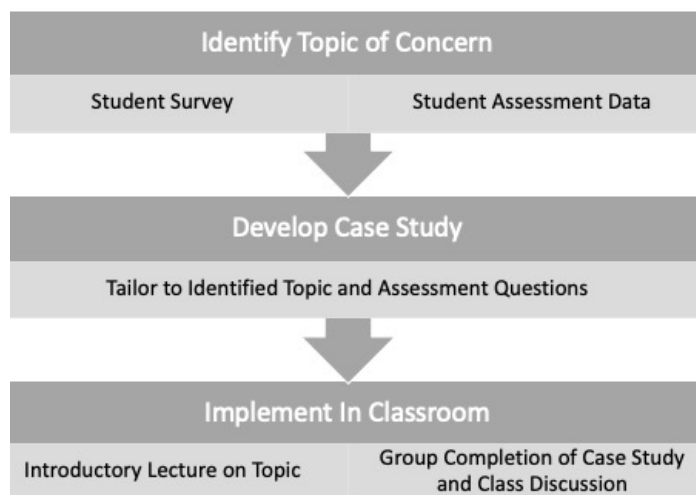

Table 1. *A Step-by-Step Representation of the Tailored Case Study Development Process.*

Students were evaluated via two specific assessments on the respective exams. A typical exam for this course consists of a mix of multiple choice, matching, and short answer questions. For the first case study material, students were asked to compare and contrast transcription and translation, providing details of each process. For the second case study material, students were asked to provide an explanation of the events of muscle contraction, including the roles of calcium and ATP. These questions were similar in format and difficulty to other short answer questions on course exams.

Average scores on the assessment question were compared before and after the use of the case study. The same assessment questions were used in each semester, allowing for analysis of change in student comprehension of the material following the development of case studies that were specifically targeted to course assessment questions. An unpaired t-test was used to determine statistical significance of the data. This project was approved by the IRB of Elmhurst University (IRB # FY19-005) and informed consent was obtained from all participants.

Results

The assessment question given during exam 1 that asked students to compare and contrast the process of transcription and translation was worth four marks. The average score $\pm$ SD on this question during the fall 2017 exam was 1.29 ± 1.69 out of four (Figure 1). In contrast, students who completed the case study in fall 2018, 2019 performed significantly higher ($p<0.01$) on the same assessment question, with the average score increasing to 2.77 ± 1.48 (Figure 1).
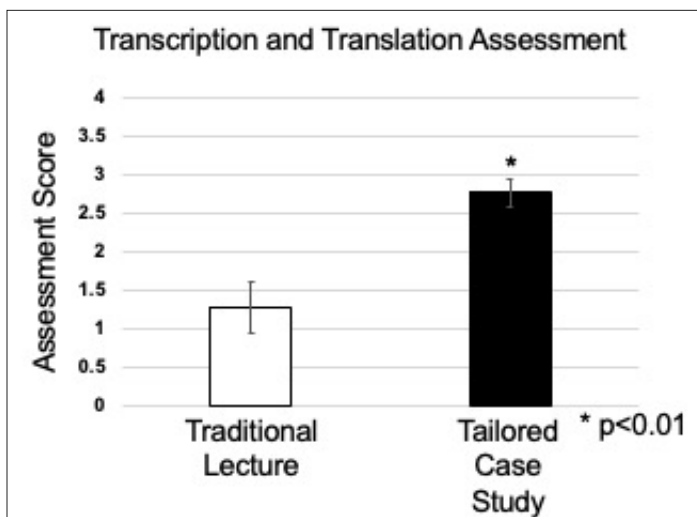
Transcription and Translation Assessment

Figure 1. *Student Performance (± SEM) on Transcription and Translation Assessment. Average assessment score was significantly higher for students who completed a targeted case study than those who received only a traditional lecture on transcription and translation.*

For exam 2, the assessment question asking students to provide the steps of excitation-contraction during skeletal muscle contraction was assigned a value of five marks. Students in the Fall 2017 course scored an average of 2.42 ± 2.28 out of a possible five points on the assessment question whereas those writing after the introduction of the targeted case study performed significantly higher on the assessment, with scores averaging 3.31 ± 1.59 (p<0.05; Figure 2).
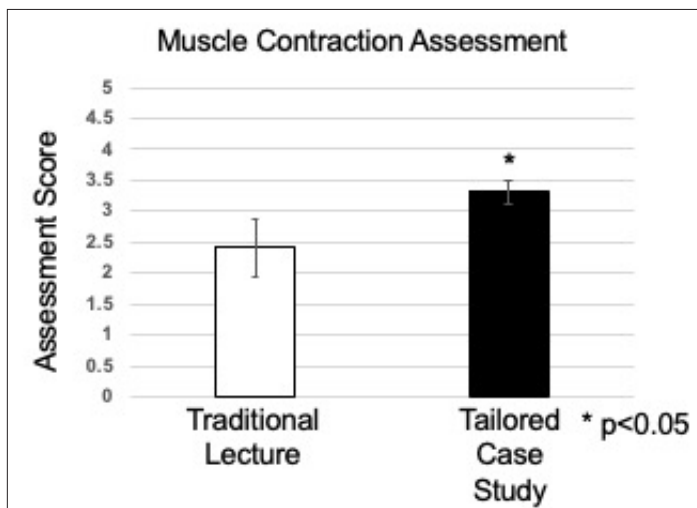
Muscle Contraction Assessment

Figure 2. *Student Performance (± SEM) on Muscle Contraction Assessment. Average assessment score was significantly higher for students who completed a targeted case study than those who received only a traditional lecture on transcription and translation.*

With both topics, prior to the case study there were many students who either left the question blank or had a complete misunderstanding of the topic. Following implementation of the case study answers that did not receive full credit more often lost points for missing details rather than a complete misunderstanding. It should be noted that an overall difference in exam performance was not noted between the 2018 and 2019 cohorts assessed in this study.

Discussion

Case studies are frequently used in college courses to allow students to gain a new perspective on a topic and apply their knowledge to a real-world application. However, instructors often have to use readily available resources that are general to a topic being covered in the course. Our goal was to determine if by creating a brand new, specifically targeted case study we could enhance student understanding of a challenging concept. We utilized backward design, starting with the learning outcome we wanted our students to achieve.

Following implementation of the targeted case studies, our students showed significant improvement on assessments of those specific learning outcomes. This data supports the previous findings that indicate case studies have the potential to improve student learning and understanding (Cliff and Wright 1996; King-Heiden and Litster 2018), while also showing that tailoring these case studies to the course learning outcome can provide for increased student performance on assessments of those outcomes. This was very encouraging to see that implementation of additional, specific teaching techniques could lead to improved student performance on assessments.

Our initial study focused on two select topics, yet there are many other areas in the Anatomy and Physiology course that could benefit from targeted case studies. It would be beneficial to apply this method to additional topics to see if consistent improvement is observed across the curriculum. Our intent is to implement similarly designed case studies into the Anatomy and Physiology II course to assist with the understanding of more complex physiological processes, such as urine formation and respiratory dynamics.

While the results are promising, several limitations need to be taken into consideration. Every attempt was made to control all variables in this study, such as involving course sections taught by the same instructor and providing the same introduction lecture to both cohorts. However, there is always the potential for variations. While we did not note any significant overall performance differences between groups, it is possible that the case study cohorts were better prepared for the course or had access to the assessment questions due to the use of the same assessment over all three cohorts. The impact of access to exam assessment questions

likely did not have a major impact here, as we do not note a major improvement on other questions that students have potentially had access to as well.

The learning outcomes for any given course are very important standards that we as instructors want to ensure our students are reaching by the end of their time in our course. While there are numerous sources with previously written and tested case studies, these may not always cover a specific learning outcome in your course. This study illustrates the importance of tailoring your teaching tool to the learning outcome and assessment tool.

About the Authors

Amy Hebert, PhD, is an Assistant Professor at Elmhurst University. She received her BS from Benedictine University and her PhD from University of Illinois at Chicago. Amy focuses her research on the role of inflammation in neurodegenerative diseases.

Courtney O'Donnell is an undergraduate student at Elmhurst University. Courtney is double majoring in both Biochemistry and Psychology and has minors in Spanish, Medical Humanities, and Religious Studies. Upon graduation from Elmhurst in Spring 2021, Courtney plans to attend medical school.

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SUPPLEMENTAL MATERIALS

Anatomy and Physiology Survey

All chapters of the Anatomy and Physiology textbook we used first semester are listed below with main concepts under each. Please circle **one** of the concepts under each chapter you feel you struggled with understanding most. If the concept you struggled with most in that chapter is not listed, please write it in the "other" category.

Ch.1 - The Human Body: An Orientation
(1)   Homeostasis
(2)   Body cavities and membranes
(3)   How Anatomy and Physiology is related
Other:_____

Ch. 2 – Chemistry Comes Alive
(1)   Acids/Bases/pH
(2)   Organic Compounds and Proteins
(3)   Enzymes and Enzyme Activity
Other:_____

Ch. 3 – Cells: The Living Units
(1)   Exocytosis and Endocytosis
(2)   Passive and Active Transport
(3)   Transcription and Translation
Other:_____

Ch. 4 – Tissue: The Living Fabric
(1)   Epithelial Tissue & Functions
(2)   Glandular Tissue & Functions
(3)   Connective Tissues & Functions
Other:_____

Ch. 5 – The Integumentary System
(1)   Layers of skin and functions (Epidermal & Dermis)
(2)   Sweat & Oil Glands
(3)   Hair and Keratinocytes
Other:_____

Ch. 6 – Bones and Skeletal Tissue
(1)   Endochondral & Intramembranous Ossification
(2)   Bone deposit vs. Bone resorption
Bone healing
Other:_____

SUPPLEMENTAL MATERIALS

Ch. 8 – Joints
(1) Fibrous and Cartilaginous joints
(2) Synovial Joint
Other:_____

Ch. 9 – Muscle and Muscle Tissue
(1)   Muscle Contraction
(2)   Cross bridge formation
(3)   Actin and Myosin filaments & function
Other:_____

Ch. 11 – Fundamentals of the Nervous System & Nervous Tissue
(1)   Neuroglial cells
(2)   Generation of an Action Potential
(3)   The chemical synapse – neurotransmitters
Other:_____

Ch. 12 – The Central Nervous System
(1)   Function and structural areas of the cerebral cortex
(2)   CSF, meninges, and ventricles of the brain
(3)   Motor and Sensory neurons/pathways
Other:_____

Ch. 13 – The Peripheral Nervous System & Reflex Activity
(1)   Cranial Nerves
(2)   Reflex Arcs
Other:_____

Ch. 14 – The Autonomic Nervous System
(1)   Sympathetic vs. Parasympathetic neural pathways
(2)   Sympathetic vs. Parasympathetic effects on organs/systems
(3)   Sympathetic vs. Parasympathetic neurotransmitters/effects
Other:_____

Ch. 15 – The Special Senses
(1)   Parts of the eye and function
(2)   Layers and function of the retina
(3)   Structure and function of the ear
Other:_____

SUPPLEMENTAL MATERIALS

Inheriting Huntington's Disease.
# A Case Study on Transcription and Translation

by

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Case Presentation

Molly was diagnosed with Huntington's disease after experiencing anxiety, mood swings, weight loss, and problems balancing. After speaking with her doctor, Molly understands that Huntington's disease is an inherited disease that results in nerve cells in the brain progressively degenerating.

Molly still wishes to know more about the disease, so she is conducting her own research and asking you, an anatomy and physiology student, questions to help her along.
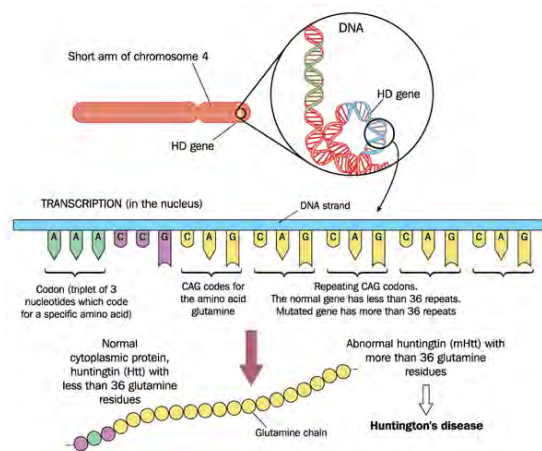
Questions

1. Molly reads that the "HTT gene" is the inherited gene responsible for Huntington's disease. Explain to Molly not only what a gene is but what it is made up of.

2. The HTT gene aids in the synthesis of the protein named huntingtin. The function of this protein has not yet been determined; however, it has proved to play an important role in nerve cells in the brain. Molly has discovered that Huntington's disease is caused by mutations in the HTT gene. Molly now wants to know the different types of mutations that may affect the synthesis of a protein. Define the following types of mutations: substitution, deletion, inversion, and insertion

3. Molly tells you that Huntington's disease has been determined by a CAG (cytosine, adenine, and guanine) trinucleotide repeat. What type of mutation could she classify this as?

4. In Huntington's disease, there is an excess number of glutamines in their huntingtin protein. During translation, the amino acid, glutamine, is coded for by the repeating codon CAG in the mRNA. Molly is asking you to explain the steps of translation (initiation, elongation, and termination).

SUPPLEMENTAL MATERIALS

5. Naturally, not all CAG segments of mRNA that code for glutamine are considered "bad". It is only when an excess of CAG's are present in the huntingtin protein. Molly is curious as to what the three nucleotides on the original DNA strand would be present to transcribe into a CAG segment on the mRNA strand during transcription. Name the three nucleotides and explain the steps of transcription (initiation, elongation, and termination).

Image Credit: Huntington's Disease Society of America, 2018.

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