Making It Real: Case-Study Exam Model

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Abstract
Anatomy and Physiology at the University of Canberra, Australia, as in many institutions, is taught to large cohorts at the foundational level. There is a requirement for students to not only retain information regarding physiological systems and their associated anatomy, but also the integration and relationship between systems. Furthermore, students are often employed in clinical settings post-graduation and the need for real-world understanding is paramount. Assessing this type of understanding is challenging and academics must move beyond tradition exam models. Using case studies as the basis for exam questions is an exciting format for eliciting student understanding of physiological systems which, at the University of Canberra, has resulted in 7% higher grades compared to traditional short answer exams. The benefits go beyond grades, with students appearing more confident in answering questions and better able to integrate information.
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Key words: teaching, undergraduate, anatomy and physiology

Introduction
Anatomy and Physiology provides a necessary foundation for students studying in the health science disciplines and students may be employed in a variety of clinical settings following graduation. Work in clinical settings requires not only the recall of information but also the ability to integrate that information for treatment and diagnostic purposes. Cliff and Wright (1996) stated that "Mere accumulation of a massive body of facts can never be the sole goal for this type of course." Furthermore, they add that students "only truly know the information once they can apply that content to real-world scenarios." Successful engagement with Anatomy and Physiology content is fundamental to the retention of the information (Cliff and Wright 1996) and the ability to apply that knowledge to critical thinking is essential for graduates to be effective in their chosen careers.

Though the use of case-studies as a learning tool has been an option for a number of years, it has increased in popularity over the past two decades (Herreid *et al.* 2011). Case-studies are an effective strategy for improving critical thinking and problem-solving skills of students (Dori and Herscovitz 1999). Case studies focus on the "real world" using constructivist learning theory (Hein 1991) allowing students to actively engage with content and understand theoretical concepts in a practical way (Herreid *et al.* 2011). Appropriately designed case studies can create an effective learning approach to guide students, especially if the case studies are specifically designed for a particular class. This ensures that students are engaging at a level that is appropriate to both themselves and the content. Furthermore, case-study learning has been shown to improve exam performance in Anatomy and Physiology (Cliff and Wright 1996).

While exams are generally not considered cutting-edge in the current teaching and learning environment they do have value within certain subject areas, particularly at the foundation level (Butler and Roediger III 2007). There is some evidence that studying for (McDaniel *et al.* 2007) and taking exams (Butler and Roediger III 2007) can actually promote learning, and that exams are not just an evaluation method. "Exams don't just provide a targeted, fit-for-purpose opportunity for students to demonstrate what they know: they also have the power to enhance what students know" (Van Bergen and Lane 2014). Furthermore, a variety of assessment items are necessary allowing students multiple options within varying contexts to demonstrate what they know. Exams, when purposeful and effectively designed are a viable assessment tool that provides a deeper level of understanding as opposed to the mere superficial level learning of the content.

At the University of Canberra, Anatomy and Physiology is taught in first year. It is considered a foundational, or service subject, accommodating up to 600 students who are enrolled in a range of professional degrees such as physical therapy, exercise science (kinesiology), nursing, and nutrition. The cohort is extremely diverse in terms of previous educational background and the degrees they are undertaking. As with many similar courses the concepts introduced at the introductory level are explored in greater detail in higher-level courses.

Over the last few years it became evident that students were not particularly competent in the skill of information integration that requires higher order thinking. Students were focused on remembering rather than understanding or applying information. Physiological systems are inherently related and it is therefore vitally important that students

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are able to understand and explain basic physiological interactions and extrapolate ideas rather than just learn stand-alone information. Case studies were introduced into weekly lecture content and final examination assessment as a way to help students develop the skills of information integration.

Appropriately designed case-studies can create an effective learning approach to guide students (Bonney 2015). The case studies were structured to build on the information, providing a scaffolding-learning environment for students progressing through the topic. Case studies were introduced to the lectures so that students might become familiar with the style of question development prior to their final exam. Furthermore, this fit-for-purpose design of the case studies for lectures and final exam in Anatomy and Physiology utilises authentic learning and aims to encapsulate not only what the students know but also how they apply and integrate that knowledge. This new assessment format requires higher level learning that includes understanding the content and having the ability to apply and analyse the material (Krathwohl 2002).

Guidelines for design

Case studies should be designed as fit-for-purpose vehicles and as such, they should include the following:

- Real-world scenarios that students can associate with and therefore understand more easily.
- Limited extraneous information so as to not dilute what is being asked.
- Clear learning objectives with simple language.
- Scaffolded questions to guide the progression of learning.
- Questions should seek clarification of how anatomy and physiology are integrated in achieving homeostasis.
- An answer scheme that is determined prior to student exposure to ensure that the questions provide adequate information to illicit an appropriate answer.

Incorporating the Human Anatomy and Physiology Society (HAPS) learning outcomes (HAPS 2013) into case-study questions facilitates higher levels of learning such as analysis and synthesis. The example provided below incorporates topics from the HAPS guidelines and learning goals (LG) (identified in bold).

Example Question and Answer

Cardiovascular System (9 points)

Josh undergoes an echocardiogram (a picture of the heart) and everything looks normal until they see his left ventricle. The myocardium here is significantly thicker than normal. Josh's blood pressure is 160-110. (Note: add a picture of normal versus hypertrophy and corresponding ECG trace)

A. Why would doctors be concerned about a thickening of the myocardium (hypertrophy)? (1 point)
HAPS LG 1, 2, 4, 6
Answer: Stroke volume would be reduced (1 point) OR less blood would be pumped (0.5 point)

B. Why would the left ventricle be more of a concern than the other chambers of the heart? (1 point)
HAPS LG 1, 2, 4, 5, 6
Answer: It pumps systemically – to whole body (1 point)

C. How would Josh's heart attempt to maintain homeostasis given this thickening. Provide a physiological explanation (2 points).
HAPS LG 1, 3, 6
Answer: CO = SV X HR (point) therefore if SV decreased HR increased (1 point).

D. The doctor diagnosed Josh's left ventricular hypertrophy after noting an increased R wave amplitude (peak of QRS complex) on his electrocardiogram. Why was this section of the electrocardiogram affected by hypertrophy in the left ventricle? (3 points)
HAPS LG 1, 4, 5, 6, 8
Answer: This represents ventricular depolarization (1 point). The more "muscle" there is, the greater the amplitude of the QRS complex (1 point), which means there is more muscle to be electrically excited (1 point).

E. From the information provided, what other condition does Josh have? (1 point) And how might it relate to his left ventricular hypertrophy diagnosis? (1 point)
HAPS LG 1, 6, 8
Answer: Josh has hypertension (1 point). Individuals with elevated blood pressure have greater peripheral resistance. Thus the heart must work harder (0.5 point) and as with any muscle the result is an increase in hypertrophy (0.5 point).

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Student outcomes/instructor observations

The results have been promising. The average percent for the traditional short answer exam questions on the final exam in 2014 (n = 450) and 2015 (n =484) was 46.01%. Upon introduction of the case-study model in 2016 (n = 490) and 2017 (n= 534) the short answer component of the final exam increased to 51.39% and 53.18% ($p<0.05$) respectively.

Student comments:

"*The case studies are great in assisting me to think critically about the content learned and not just learning it*."

"It gives you something to relate to in the real world and see why it is relevant."

"The case studies in the exam allowed me to show how much I knew about each topic"

From our observations in face-to-face laboratory classes, students are able to breakdown and piece back together the physiological systems with greater understanding of the processes. They are better able to apply basic physiological information to an array of scenarios, not just the ones that are presented in lecture. Students appeared to be more confident in their knowledge and were more willing to engage in class discussions. In the final examination, students were more assured in attempting questions and incorrect answers were more academically logical.

Anecdotally, colleagues teaching upper level units have commented that students display improved ability to integrate information. Furthermore, students have greater understanding of the physiological foundations and can practically apply that information more successfully to a variety of contexts.

Discussion

Traditionally, learning in an Anatomy and Physiology setting used a surface approach where facts were memorized and then regurgitated back to answer questions (Pandey and Zimitat 2007). However, academics from a range of diverse settings, agree that educational success, regardless of the discipline, depends on learning concepts rather than memorizing facts (Hughes 2011). Deeper level learning, the process of learning for transfer, permits students to take knowledge from one situation and apply it to another. Thus, this approach seeks for students to find meaning within the material and be able to interpret it and fit it with what they already know (Pandey and Zimitat 2007). In Anatomy and Physiology being able to move to a deeper level of learning "may require a preliminary stage of rote learning that is difficult to distinguish from a surface approach" (Enwistle and Ramsden 1983). As such this surface level or rote learning approach, specifically in the development of the necessary complex anatomy and physiology vocabulary/terminology, is required to permit an understanding at the deeper level (Laurillard 1984). For students, being able to develop deeper approaches to learning is essential as it is believed this enhances students engagement with the content and ultimately results in improved analytical and critical thinking skills (Hall *et al.* 2004).

Different approaches to learning are also important when developing assessment items including examinations. For example, multiple choice question (MCQ) examinations are perceived to assess knowledge-based (lower levels of) academic processing with better performance associated with the employment of surface learning strategies (Scouller 1998). In contrast, students are more likely to be successful in tasks which are perceived as assessing higher levels of cognitive processing, if deeper strategies are used (Scouller 1998). Case studies use higher levels of cognitive processing and thus use deeper level learning. Case studies, purposefully designed for exams, allow students to demonstrate their understanding and ability to interpret the information as they apply that information to real-world scenarios (Cliff and Wright 1996). Case studies also permit active engagement with the content.

Conclusion

The use of case studies as the basis for exam questions at the University of Canberra has been a successful tool and student engagement with this format has resulted in better retention of the information and improved interdisciplinary application. The use of case studies provides students with exposure to scenarios they could encounter in clinical practice. This demonstrates the relevance of the foundational unit/course content long-term. Since this format has only recently been introduced, follow up with students and their supervisors during clinical placements or work-integrated learning internships in future years would be beneficial. Further research into student perception and engagement with this format is also warranted.

About the authors

Disa Smee, PhD, is an assistant professor of anatomy and physiology at the University of Canberra, Australia. Dr. Smee completed her BMed Sci (Hons) and her MCom at The University of Sydney and earned her PhD in physiology (University of Canberra) in 2015 but has been teaching at the tertiary level for 20 years. She teaches a variety of anatomy and physiology service units to freshman students and is passionate about ensuring their success.

Julie Cooke, PhD, is a senior lecturer in anatomy and physiology at the University of Canberra and is the Program Director of the Australian Biology Olympiad Program. Julie commenced her teaching career in 1998 at the Copenhagen International School. She completed a BSc (Hons) at Flinders University, South Australia, and received her PhD from the University of Adelaide in 2000. She teaches anatomy and

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physiology to freshman students and Sports Medicine at the junior and senior level. Julie has a passion for teaching and enjoys engaging students so that learning is easier and more enjoyable.

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