

Teaching physiology online: successful use of case studies in a graduate course

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Casotti G, Beneski JT, Knabb MT. Teaching physiology online: successful use of case studies in a graduate course. *Adv Physiol Educ* 37: 65–69, 2013; doi:10.1152/advan.00159.2012.—To address the need for greater flexibility in access to higher education, an online graduate course in physiology using case studies was developed and offered in summer 2012. Topics in both animal and human physiology were organized as modules that contained a case study with questions, a prerecorded online lecture, and three research journal articles. We followed best practices for teaching and learning in distance education, including the preparation of materials before the course starting date, a discussion board for responding to pre- and postcase discussion questions, and prompt reply to student queries. For exams, students generated their own questions based on new cases and developed their own case study for the final project. Although only 20% of students had previously taken an online course, all students stated that they would recommend this course to others. Postcase assessment indicated that students found the cases interesting, informative, and presented at the appropriate level. Most students said that the online course took them more time but that they learned more content and used the primary literature more than in a traditional class. Our results indicate that a well-organized physiology course using a case study format is a very effective model for online learning.

online teaching; case studies; assessment

PHYSIOLOGY is traditionally taught as a face-to-face course with a mixture of lecture and laboratory designed to reinforce course concepts (1). In recent years, however, there has been an increasing number of online courses offered and taken by students, with 20–25% of students in the United States enrolling in at least one online class (6). To meet this demand, some physiology courses are now available online. Stephens (8), for example, has offered an undergraduate online Human Physiology course for nonmajors in the summer for 5 yr. Other examples include online courses taught in medical physiology at the University of New England (Biddeford, ME) and exercise physiology at the University of Texas (Tyler, TX). In addition to these courses, there are increasing numbers of online physiology resources being designed for students in health and medical fields (9).

Research has indicated that well-designed online courses taught by experienced instructors can be as effective as traditional courses (3). However, the online environment is very different from a traditional classroom. Because none of the investigators in this study had previously taken or taught an online course, we were tentative about offering one. Thankfully, there are many resources available to assist new online instructors. At our institution, we have an Office of Distance

Education that is devoted to online course development, and there are many helpful guides to define best practices for online teaching and learning (2). Before proceeding, however, we asked ourselves the following questions: What are the limitations to online learning? What type of course can effectively be taught online, and how do we ensure quality of the course? And, most importantly, is this course fulfilling the academic needs of the students in our program?

Offering a distance education course requires careful consideration of student readiness for an online environment. To be successful, students should be technology competent, disciplined, and possess good comprehension and writing skills. We expected that graduate students were prepared to work independently and had developed the necessary communication skills to excel in an online environment. At West Chester University, we have a modest (~45 students) MS program with thesis and nonthesis options. Most students (over 60%) choose the nonthesis track, work full time, and complete their degree part time. Thus, students in our program have time and work constraints that limit their ability to take courses offered in a traditional face-to-face format. For these reasons, we chose to develop an online course for our graduate students.

Before summer 2012, the Biology Department at West Chester University had not offered courses online. To increase course offerings to our graduate students, the Department approved offering an online seminar graduate course entitled “Case Studies in Physiology.” The course was taught over 11 wk, similar to the 2-mo summer model used by Stephens (8), and included eight topics: four topics in animal physiology and four topics in human physiology. The topics were navigation, diving, life in extreme environments, and thermoregulation (for animal physiology), and neurotoxins, ischemic heart disease in women, pharmacogenomics, and space physiology (for human physiology). Each topic was organized as a module that contained a case study with questions, a prerecorded online lecture, and three research journal articles.

We chose to teach this online course using case studies because cases are known to increase critical thinking by engaging students in real-life stories (4). Although commonly used in business school and the social sciences, cases have been used successfully in the science classroom, where content knowledge is developed by exploring questions associated with stories (see The National Center for Case Study Teaching in Science, <http://sciencecases.lib.buffalo.edu/cs/>). Based on a recent survey by Herreid et al. (4), some of the qualities of good cases are that they tell a story, are current and relevant, are interesting, and integrate problem solving. For example, we modified the case entitled “Bad Fish” to incorporate the primary literature and other examples of neurotoxins (http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=540&id=540). For

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our online course, each case served as the anchor and starting point for all of the materials in each module.

METHODS

Preparing to Teach Online

Attend a workshop. We attended a 2-wk workshop offered by the Office of Distance Education. The first week consisted of a demonstration of tools available for teaching online courses. The second week was taught online and included discussion boards as well as synchronous and asynchronous lectures. In addition to having direct experience with an online environment, the workshops helped us to identify important contacts and resources.

Find a faculty mentor or team teach. Faculty members with experience teaching online are extremely valuable when developing an online course. They can offer ideas and advice ranging from organization of materials to creating an online community of learners. An advantage to team teaching an online course, especially for the first time, is that faculty members can discuss strategies and ideas that might not have occurred to an individual instructor. Team teaching is particularly rewarding when faculty members possess different strengths (i.e., J. T. Beneski and G. Casotti have website design experience and M. T. Knabb has case study experience).

Use new technology. Teaching an online course can be daunting if you believe that you are required to use every new technological tool. Be prepared to learn some new technology but also keep simplicity and the needs of your students as your top priority. We decided to create screen capture lectures for our course and used either Camtasia (M. Knabb) or ScreenFlow (G. Casotti). We created a password-protected website (J. T. Beneski) for our course materials but also used the Desire2Learn (D2L) course management system (<http://desiretolearn.com>) for the discussion board and assignment collection. An additional advantage of using D2L is the plagiarism check function via Turnitin (<http://turnitin.com>).

Develop case study materials. Some case studies were modified from existing cases found in the National Center for Case Study Teaching in Science (<http://sciencecases.lib.buffalo.edu/cs/>). Others were new cases we developed based on topics we thought would be interesting to our students. We used a standard template for all course modules to ensure that the course was consistent in its organization with clear deadlines and expectations.

Prepare assessment materials. We prepared three types of surveys for the course: precourse, postcase, and postcourse surveys. Ethical permission to administer surveys was obtained through our university's Internal Review Board and was determined to be exempt (IRB proposal no. 20130108). A precourse survey was developed to see whether students had prior experience with online courses and what their course expectations were. The postcase survey provided feedback on students' perception of each case study and asked them whether the case was informative, interesting, and at the appropriate level and whether the materials were well integrated. The postcourse survey asked reflective questions such as course satisfaction, time commitment for the online versus a traditional graduate course, and what components of the course were most valuable for learning.

Two rubrics were developed for grading the case study questions and the discussion board. The case study rubric ensured that the students answered questions correctly and integrated assigned activities, such as online lectures and journal articles, in their answers. The discussion board rubric ensured that the students' postings were of the appropriate quality and length.

Prepare and test all materials before the course starts. Unlike a traditional course where it is possible to put the finishing touches on a lecture shortly before a class, all materials in an online class should be prepared and thoroughly tested on the start date of the course. All course materials were available before the first day of class, allowing students who wished to progress at a faster pace through the material

to do so. We recommend 6 mo for preparation of materials before offering an online course.

Teaching the Course

We followed examples of best practice for online teaching and learning as suggested by Conrad and Donaldson (2). Some of the best practices included 1) implementing an icebreaker activity at the beginning of the class, 2) obtaining student feedback throughout the course, 3) constructing grading rubrics to provide learners with effective feedback, and 4) ensuring that there was a mix of activities and that activities were sequenced appropriately. Our icebreaker activity using student profiles is highlighted in *Course Details*. Student feedback was gathered after every case using the postcase survey. Grading rubrics for each weekly case study and the discussion board postings were developed, and feedback was provided weekly to the students (see *Preparing to Teach Online* for details). Finally, we designed a mix of activities for each case study, and modules provided a logical sequence of activities for the students (see *Course Details*).

To create a sense of community within the online classroom (2), it is essential for students to interact in a timely fashion with the instructor and each other. We typically responded to student e-mails and discussion board posts within 24 h of the submission and always graded assignments within 48 h after the submission deadline. The asynchronous discussion board provided a forum where students were able to share information with each other as well as the instructors. For every module, each student was required to post twice to the discussion board, with one general post describing a personal experience related to each case and one post designed to extend the knowledge gained in the case. In addition, students were required to respond to the posting of another student (3 postings/case). The discussion board emerged as one of the most important components of the course.

What follows is a summary of our online graduate course covering topics in animal and human physiology using case studies. What we learned through the development of this course as well as the data gathered from students' perceptions of their experience are summarized to encourage other faculty to consider this approach.

Precourse Survey

On the first day of class, we presented students ($n = 8$) with a questionnaire to see if any of them had previous experiences with an online course (Table 1). Few students had any experience with online classes. Of their previous courses, one student said it was positive and one student said it was a negative experience. Most students were confident about taking an online course, but a few students were concerned about time management (Table 1).

Course Details

Student profiles. When developing an online class, icebreaker activities are useful to establish the presence of individuals and open lines of communication for the learning community (2). For our icebreaker activity, students were asked to type a short (~100 word) biography and post a picture on the course website. This strategy seemed to work well, and students read each other's profiles and told us that they felt part of a class and not isolated.

Course topics. The material for each case study was presented as an integrated module composed of a case study with questions, a prerecorded lecture providing relevant physiology content, videos, three journal articles, and discussion board questions. There were also two exams and a final project where students had to prepare and present their own case study. Because it was a graduate course, we wanted to concentrate on specialized topics within physiology. This led us to choose the topics shown in Table 2.

Each week, a different module was based on a single case study. We provided students with a list of activities and an estimate of how

Table 1. *Precourse survey results*

Question	Answer Summary
1. Have you previously taken an online course? If yes, how many and in what disciplines? If no, go to <i>question 3</i> .	Two students said yes. One student had taken an earth science and education course; the other student had graduated from a cyber high school.
2. What was your experience with the online course?	One student's experience was positive; one student's experience was negative. Both classes lacked content development.
3. List your reasons for taking this online course.	The following reasons were provided: convenience, saving of time and money on driving, summer offering, and interest.
4. Do you have concerns about your readiness to take an online course?	Most students said no. Some students said "I am afraid I am underestimating the amount of time to complete assignments and keeping on top of the discussion boards."

n = 8 students.

long each activity should take to complete (Table 3). Students had 1 wk to complete each case (module) and answer a list of assigned questions. To successfully answer the questions, students were required to watch a prerecorded lecture (lasting ~45 min) divided into 15-min segments, watch one or more online videos associated with each topic, and read three designated journal articles from the primary literature. Students needed to integrate information from all of the components to answer the questions posed in the case.

We met face to face with students twice during the course. On *day 1*, we explained the course outline and how to develop a case study using an example. This introduction served to clarify our expectations for the course and address any technical concerns. We also met on the final day of the course for students to present the case studies that they developed as a final project.

The discussion board. Integral to each case were postings to an online discussion board. To ensure that students were participating in the discussion board, we required students to submit a minimum of 3 postings/wk. The first posting was due 48 h after the start of the case. Students had to post (in no more than 100 words) how the case related to their lives. For example, in the case on animal navigation, students were asked to "Post a situation where you had trouble navigating and how you solved it." In this manner, students were asked to relate to the case on a more personal level.

The second posting was required at least 48 h before the case study closed. Students had to identify one question that occurred to them while reading the case study and find and post a journal article that addressed that question. Posts were to be no more than 250 words and the article had to be attached to the posting.

For the final posting (in the last 48 h before the case study closed), each student had to reply to another students' second posting. This time there was no word count restriction. Creating multiple deadlines facilitated both student-student and student-faculty online interactions and ensured that the students viewed the discussion board frequently throughout the week. Based on the number and quality of postings to

the discussion board, students enjoyed sharing what they learned. In contrast to a traditional classroom, every student had a voice, even those that typically do not participate in class.

The exams. For the exams, we asked students to read and view videos for two new case studies. They then needed to choose one of the cases, develop three questions, and answer each question using appropriate references from the primary literature. For example, in *weeks 2–4*, students examined different aspects of animal respiratory and cardiovascular physiology (diving), life in extreme environments,

Table 3. *Example of a case study teaching module on diving physiology*

Module: Diving Physiology	
Objectives	
1.	Understand what the normal partial pressures of gases are in the circulatory system and how they change with depth and altitude.
2.	Define and know the symptoms of hypoxia and hypercapnia.
3.	Understand what leads to decompression sickness and what are its treatment options.
4.	Understand how marine mammals such as whales cope with and often avoid decompression sickness.
5.	Understand why fish do not suffer from decompression sickness.
Tasks	
1.	Go to the Discussion Board on D2L and describe a situation when you had to go under water and how that made you feel (100 word limit). Post this to the discussion board within 48 h. (Time commitment: 15 min)
2.	Read the case study on "The Deep" to familiarize you with the questions being asked in the case. (Time commitment: 15 min)
3.	View the online lecture on diving physiology. (Time commitment: 1–1.5 h)
4.	Read the following journal articles posted as PDFs on the course website. (Time commitment: 6 h) A. McMullin AM. Scuba diving: what you and your patients need to know. <i>Cleve Clin J Med</i> 73: 711–721, 2006. B. Tyack PL, Johnson M, Soto NA, Sturlese A, Madsen PT. Extreme diving of beaked whales. <i>J Exp Biol</i> 209: 4238–4253, 2006. C. Hooker SK, Baird RW. Deep-diving behaviour of the northern bottlenose whale, <i>Hyperoodon ampullatus</i> (Cetacea: Ziphiidae). <i>Proc R Soc Lond</i> 266: 671–676, 1999.
5.	Answer the questions in the case study on "The Deep" by integrating information from the lecture material and readings. Limit your answers to four typed pages. Submit your answers to the DropBox in D2L. (Time commitment: 2 h)
6.	Identify one question that occurred to you while reading the case study and journal articles. Find one paper (a journal article) that addresses this question. Post your question on the discussion board, a link to the paper, and what was interesting about your discovery (i.e., primary post) (250 word limit). This post is due 48 h before the discussion board closes. Read and respond to the post of at least one other student (i.e., secondary posts). (Time commitment: 1 h)

D2L, Desire2Learn.

Table 2. *Course schedule and topics*

Week	Topic	Due Date
1	Introduction to case studies and CS 1 (Navigation)	
2	CS 2 (Diving Physiology)	CS 1
3	CS 3 (Extreme Environments)	CS 2
4	CS 4 (Thermoregulation)	CS 3
5	Midterm exam	CS 4
6	CS 5 (Neurotoxins)	Exam
7	CS 6 (Ischemic Heart Disease in Women)	CS 5
8	CS 7 (Pharmacogenomics)	CS 6
9	CS 8 (Spaceflight Physiology)	CS 7
10	Final exam	CS 8
11	Final project (CS presentations)	Exam

CS, case study.

Table 4. *Postcase survey results*

Question	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
1. I learned new information from this case.	2	1.9	1.7	1.5	1.6	1.9	1.5	1.9
2. This case was interesting to me.	1.6	1.6	1.2	1.3	1.9	1.9	2	2
3. This case was at an appropriate level based on my previous coursework and knowledge.	1.8	1.6	1.5	1.4	1.6	1.9	1.7	1.9
4. The materials in the case were well integrated with the lecture, videos, and journal articles.	1.8	1.9	1.7	1.1	1.9	1.9	1.7	2
5. Given the materials in the case, the questions asked were appropriate.	1.5	1.5	.8	1	1.7	1.8	1.3	1.8

n = 8 students. Scores for each case were an average of the following: strongly agree (2), agree (1), disagree (−1), and strongly disagree (−2). See Table 2 for the case topics.

and thermoregulation. For the first exam, one case dealt with a person hiking to the top of Mt. Everest and was based on a true story from the book *Into Thin Air* by Jon Krakauer.

The final project. At the end of the course, students gave a 15-min presentation of their own case study with appropriate questions embedded in the presentation. The questions had to be answered with material from the primary literature.

RESULTS AND DISCUSSION

Postcase Assessment

At the conclusion of each case, we anonymously polled students using a five-question online survey. Student responses are shown in Table 4.

All students agreed or strongly agreed that they learned new information for the case, except for one student for the thermoregulation case (*case 4*). Students seemed to be genuinely interested in the cases presented, aside from one student who disagreed for the extreme environment case (*case 3*). All students agreed that the cases were at the appropriate level based on their previous course work. For the most part, students thought that the case materials were integrated well, except for one student who disagreed for the thermoregulation case (*case 4*). All students agreed or strongly agreed that the questions asked in cases were appropriate, except for one student who disagreed for the navigation case (*case 1*) and one

student who disagreed for the extreme environment case (*case 4*; Table 4).

Postcourse Assessment

Our postcourse survey revealed that all students viewed the course positively and would recommend it to others (Table 5). Interestingly, most students said that it took more time than a regular class and was just as challenging, but the trade off seemed to be the greater flexibility offered by the online format and the time- and money-saving benefits (5). Most students also liked the in-class interactions on *day 1* and the final day, and most would not change that part of the experience, although some students offered suggestions for using an online rather than a face-to-face meeting (Table 5).

Some improvements could be made to the course, including allowing students more time to complete exams, increasing the point value of the discussion boards (which took students more time than expected), and some minor adjustments to assignment due dates. Overall, students had a positive experience.

Lessons Learned

This course proved to be a very positive experience for both the instructors and students. Team teaching resulted in the creation of unique modules and ensured that “another set of eyes” reviewed the quality of the online materials and system

Table 5. *Postcourse survey results*

Question	Answer Summary
1. Were you satisfied with the course format? Describe your experience compared with a regular class.	Every student described the experience as positive or very positive. One student said it was better than a regular class.
2. When comparing the online course with regular graduate classes, which took more time? What was the most time-consuming part?	The majority of students said that the online format took them more time. Exams and the case study question took the most time.
3. Would you take another online class?	All students said yes, as long as it was run efficiently and was well structured.
4. What did you like most about the course?	Students stated the following: time flexibility, the level of content knowledge in the journal articles, the lectures, discussion boards, the exam format, and the ability to link different cases together to understand physiology.
5. What did you dislike about the course? What improvements can you suggest?	Students stated the following dislikes: due dates on discussion boards, point value of discussion boards, and timing and format of the exams. Students provided the following improvements for the course: change due times from noon to midnight, have discussion boards worth more points, have only one exam at the end of the course, and give more time to complete the exams.
6. Would you recommend this course?	Students stated “yes.”
7. Could the course have been taught effectively as 100% online? If so, how?	Most students said to “leave it as is.” Some students said to make a video to explain the course on <i>day 1</i> and have the final presentations uploaded for students to view.
8. What components of the class enhanced your learning the most?	Results were mixed. Most students said lectures, followed by discussion boards, the final project, videos, journal articles, and the exams.
9. Rank the case studies in terms of interest.	Students ranked the case studies in order as follows: pharmacogenetics, spaceflight, diving, cardiovascular, neurophysiology, life in extremes, navigation, and thermoregulation.

performance before the course started. It was critical to organize materials before the start of the course because it allowed us to engage in the discussions and respond to student questions rather than concentrating on developing materials. During the course, sharing communication responsibilities so that there was always “backup” for student questions and concerns was another benefit of team teaching because providing feedback in a timely fashion is important for success in an online course. The discussion board served as the most rewarding component for us because the students helped us learn new information and challenged us to find additional resources to address their questions. Additionally, the discussion board gave a voice to the students who might be reluctant to share their ideas in a traditional course. We found that creating modules using case studies as an anchor made the material more interesting and relevant for us and the students, leading to high course satisfaction. In future iterations of the course, we intend to increase the point value for the discussion board from 10% to 20% because students spent more time on their postings than we anticipated, and we also will allow students to continue their discussions rather than closing the discussion board. We plan to clarify the due dates for materials and provide clearer instructions for the exams.

Conclusions

Our goal was to create a high-quality online graduate physiology course as a flexible alternative to a traditional class. Attending a distance education workshop, team teaching, preparing all materials before the class begins, and knowing what technologies to use are important considerations when developing an online course. Offering the course during the summer expanded the course offering availability for the students. Having students post regularly to an asynchronous discussion board ensured that they remained engaged with each other and were active participants in the course. Student surveys admin-

istered during and at the end of the course communicated our commitment to offering a rich and rewarding learning experience for students. Based on survey results, we achieved our goal, and we encourage others to try this approach.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: G.C., J.T.B., and M.K. conception and design of research; G.C. and M.K. performed experiments; G.C. and M.K. analyzed data; G.C., J.T.B., and M.K. interpreted results of experiments; G.C. and M.K. prepared figures; G.C., J.T.B., and M.K. drafted manuscript; G.C., J.T.B., and M.K. edited and revised manuscript; G.C., J.T.B., and M.K. approved final version of manuscript.

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