Teaching a Flipped, Fully Online Class Using Small Group Work

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Abstract
The majority of my students are either out of state or international students who live on campus during the regular academic year and return home during the summer months. Thus, most students cannot attend face-to-face summer classes held on campus. In 2015, I developed a flipped, completely online human physiology course to meet the needs of these students. Human Physiology Online is composed of an asynchronous portion, where students review course material on their own (out of sync), and a synchronous portion, when we all meet online at the same time (in sync). Here, I describe the asynchronous and synchronous components of Human Physiology Online in detail, including how I use technology to recreate the small group environment of my regular face-to-face class during synchronous class sessions. I also present student feedback for Human Physiology Online from anonymous course surveys. https://doi.org/10.21692/haps.2020.100

Key words: Online, flipped classroom, guided inquiry

Introduction
My institution is a 4-year residential university that attracts students from across the United States and internationally. During the summer months, most students return home to visit their families and pursue internship, research, employment, and volunteer opportunities. In 2015, I developed a completely online version of my 300-level undergraduate human physiology course to meet the needs of students who wanted to take summer classes but could not attend face-to-face class on campus. Important considerations for course development included the need to teach all of the learning objectives from my face-to-face course to students in a variety of time zones. In addition, many summer students have other intensive time commitments, including summer internships and employment. Finally, few of my students had previously taken fully online classes in 2015.

To meet these challenges, I adopted an online flipped classroom model. In this 6-week class, students spend approximately 15 hours per week working on asynchronous material and attend two 90-minute synchronous sessions per week where they breakout into teams of three to complete active learning activities. The days, times, and format of the required weekly synchronous sessions is published in the institutional course atlas, making students aware of this commitment upfront, prior to course registration.

In face-to-face classes, the flipped classroom is an educational approach where students prepare in advance of class by, for example, watching prerecorded videos, reading, or completing assignments, while class time is spent engaged in active learning activities facilitated by the instructor (Berrett 2012; Hodges 2015; Tucker 2012). Styers et al (2018) have shown that students in flipped classes demonstrate gains in critical thinking skills including the ability to summarize the pattern of results in a graph, and identify the suitable solutions for real work problems. These are vital skills for my students who plan to apply for medical and allied health care professional programs as well as graduate programs in biomedical research. Additionally, Styers et al (2018) demonstrated that students who are members of underrepresented minorities benefit more from the flipped class approach, consistent with work by Eddy and Hogan (2016) who showed that classes with a moderate amount of course structure greatly reduce the achievement gaps between black and white students and first-generation and continuing-generation students.

Possibly, learning gains by students in flipped classrooms may result from the greater use of active learning techniques over traditional lecture-based instruction (Jensen et al 2015). Together, these results indicate the flipped classroom approach is an effective pedagogical technique that benefits students from a broad range of backgrounds in face-to-face classes. In a recent comparison of face-to-face and online flipped formats of a graduate course in applied physics, Stöhr et al (2020) found similar average student performances, though the online flipped format led to a significantly larger spread in performance. Further work is required to determine whether this result is broadly generalizable to different types of students in other disciplines.

Online learning activities can be categorized as being asynchronous, that students complete individually on their own time, and synchronous, where students meet online at the same time to work together in sync. Asynchronous course material offers maximal flexibility in terms of when students interact with course content while synchronous sessions

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offer students an opportunity to have questions answered and to receive social support from peers and instructors in real time. Comparing the benefits and limitations of these two educational approaches, Hrastinski (2008) concluded synchronous and asynchronous online learning activities are complementary, recommending that instructors adopt a combination of both methods in their online course design. An online flipped classroom format takes advantage of the benefits of both asynchronous and synchronous learning activities.

Asynchronous component of Human Physiology Online

Asynchronous course material for Human Physiology Online includes mini-lectures that cover the entire asynchronous course learning objectives, assignments, and quizzes, based on mini-lecture content, and midterm and final exams. I recorded all of the fifty-six mini-lectures using Screencast-O-Matic screen capture software. Each mini-lecture is approximately five to ten minutes in duration and covers one to two learning objectives. Students access mini-lectures posted on our learning management system class site. While students can download the mini-lectures as MP4 files for future use following the course, most students report saving the PowerPoint files used to make the videos for future studying for standardized exams such as the Medical College Admissions Test.

The weekly schedule for Human Physiology Online, including deadlines for asynchronous activities and synchronous class times, is found in Table 1. Prior to attending synchronous class sessions, students watch five to six pre-recorded mini-lectures and individually complete assignments on their own time. Each assignment is comprised of 10-15 multiple choice and true and false questions that are automatically graded to provide immediate student feedback. The best nine out of eleven asynchronous mini-lecture assignment grades count toward 10% of the final course grades. In addition to mini-lecture assignments, students also complete an end-of-week assessment based on synchronous and asynchronous course content. On weeks one, three, and five of the six-week class, students take a quiz on the material covered on those weeks. Midterm exams are taken at the end of weeks two and four and a final exam is taken at the end of week six. Quizzes and exams are composed of a combination of multiple choice and short answer questions. Only the midterm and final exams are closed book and live-proctored using a proctoring service.

Synchronous component of Human Physiology Online:

Synchronous sessions are held twice weekly when students and I meet together online at the same time using Zoom videoconferencing software (Table 1). These sessions are a mandatory course component and participation in synchronous group activities is worth 10% of the final course grades. On rare occasions when students are absent and excused from a synchronous class, for example due to illness or computer failure, they can complete missed activities on their own and receive credit.

Synchronous class time begins with a review of submitted work from previous synchronous session activities and commonly missed questions from mini-lecture assignments, quizzes, and exams. Next, students spend the majority of class time working together on physiology guided-inquiry activities in teams of three in breakout rooms, sub-rooms within the class meeting that allow students to work collaboratively. Many of these activities have been modified from Brown (2016), Jensen et al (2014), and the HHMI BioInteractive website (https://www.biointeractive.org/).

A sample question from an endocrinology activity with a representative student group answers is found in Appendix A, while an entire neurobiology activity, along with teaching

<table>
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<th>Sun</th>
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<th>Sat</th>
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</thead>
<tbody>
<tr>
<td>12noon (EDT) End-of-previous week’s assessment closes</td>
<td>8am (EDT) Pre-class mini-lecture assignment due</td>
<td>8-9:30am (EDT) Synchronous class session</td>
<td>8am (EDT) Pre-class mini-lecture assignment due</td>
<td>8-9:30am (EDT) Synchronous class session</td>
<td>7am (EDT) End-of-current-week assessment opens</td>
<td>8-9:30am (EDT) Online office-hour</td>
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Table 1. Sample weekly schedule for Human Physiology Online (Biology 336)
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resources and an answer key, can be downloaded from Cafferty (2019). This neurobiology activity, composed of twenty-seven multiple choice, multiple answer, and short answer questions, is aligned with HAPS learning outcome modules H 7.1, H 7.5, and H 8.3 (HAPS, 2019) and takes my students approximately one hour to complete. Synchronous session activities are built as ungraded practice quizzes into the class site on our institutional learning management system.

During synchronous sessions, students are randomly assigned into breakout rooms allowing everyone an opportunity to meet and collaborate with each of their peers by the end of the semester. Using this approach, students work with classmates from a broader range of backgrounds, are exposed to a wider range of ideas, and may build a greater sense of community than if students chose their partners or remained in the same group for all of the synchronous sessions. Once students enter their virtual breakout room, they self-select one of three defined team roles including the roles of reader, reporter, and recorder.

The team’s reader reads the text of the activity out-loud to their teammates, which helps keep everyone on track. Following group discussion, the recorder types the group’s consensus answers to questions into the activity. Teammates can more easily provide input to their work when the recorder shares their screen with their group throughout the activity. Finally, the reporter shares group responses to questions with the rest of the class at the end of the synchronous session.

While students follow prompts and answer questions in the group activity, I move from one breakout room to the next to monitor progress and answer questions when needed. During the final 10-15 minutes of synchronous class, students are brought together for a discussion of the synchronous activity and reminders of upcoming deadlines for asynchronous class material. More detail about the benefits and use of activity roles during small group work, and examples of alternative roles, can be found in Hoffman and Richardson (2019).

**Student feedback and evidence of success:**
Based on anonymous survey responses (n = 76) over the past three years, most students have a positive experience learning human physiology online. For example, while only 27% of students had completed a fully online course prior to taking human physiology, 91% of students reported they would enroll in another fully online course in the future. In addition, most students viewed the synchronous and asynchronous components of the course positively. For instance, 95% of students either strongly agreed or agreed with the statement, “The asynchronous mini-lecture assignments helped me in this course,” and 94% of students either strongly agreed or agreed with the statement, “The synchronous group activities helped me in this course.” Selected student comments regarding course components to keep or add to the class are presented in Table 2.

<table>
<thead>
<tr>
<th>One thing I would like to KEEP in Biology 336 is:</th>
<th>One thing I would like to ADD to Biology 336 is:</th>
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<tr>
<td>… the group activities. I really like the aspect of going into breakout rooms because it makes the class a lot more interactive, and I have been able to meet my classmates through this. I think it is especially important to interact with classmates and make friends in the online course setting, so we can share struggles, talk about the class together, and ask/answer each other’s questions. I have found online courses to be a lot of work, and having friends while studying is more encouraging and motivating.</td>
<td>A way to force everyone to be better prepared for group activities. A lot of the time the other group members did not know anything and I was left to figure things out which didn’t help me too much in terms of talking out the material and working as a team.</td>
</tr>
<tr>
<td>The mini-lectures were really cool and provided a good experience for the asynchronous activities.</td>
<td>Less group activities and spending that time more on lecturing about confusing concepts and/or answering questions.</td>
</tr>
<tr>
<td>The in-class activities. It is always helpful to review out-loud with other students to re-inforce learning.</td>
<td>More synchronous session teaching.</td>
</tr>
<tr>
<td>This was more organized than any class I’ve taken before! So the organization is a keeper. In terms of content, I really (struggled through and then) enjoyed the cardiac physiology unit.</td>
<td>An easier way to cover all this information.</td>
</tr>
</tbody>
</table>

**Table 2.** Selected student responses to anonymous survey questions.
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**Discussion:**
Offering Human Physiology Online has successfully increased the availability of this course to students who do not live locally, including to students who have taken the class from Belgium, China, India, and Taiwan. Course survey results reveal 60% of Human Physiology Online students would not have been able to take this course on campus for a variety of reasons, including not being able to afford the additional housing costs necessary to remain on campus over the summer, having family obligations in their hometowns far away from campus, or having the opportunity to participate in summer undergraduate research programs at research institutes across the United States and beyond.

However, the requirement of synchronous session attendance might present a technological barrier for students who lack Internet connections strong enough for live videoconferencing or who live in time zones that make class attendance difficult, for example, students in the Pacific Time Zone must attend synchronous sessions at 5am local time. To accommodate students who cannot participate in synchronous group work for these reasons, a future section of Human Physiology Online may be offered using modified online group activities for asynchronous completion.

O’Brien (2020) has modified guided inquiry activities for an asynchronous chemistry class and recommends making activity completion a collaborative team effort. Alternative ways of providing social support to students will also have to be incorporated into a completely asynchronous section of Human Physiology Online as past students have reported enjoying synchronous group work as a way to meet, interact with, and share their course experience with their peers (Table 2).

I have taught my online human physiology course every year since 2015. The discussions I observe while facilitating synchronous group activities are consistently insightful and draw upon information from asynchronous course material. In addition, online students perform similarly or better on the same final exam as students in my traditional, face-to-face classes (unpublished findings). Together, these observations suggest online students are thoughtfully engaged with the material both during independent and group work and are learning as much content as students in the face-to-face class.

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**About the Author**
Patrick Cafferty, PhD, is a Senior Lecturer in the Department of Biology at Emory University in Atlanta, Georgia. He teaches courses in Introductory Biology, Human Physiology, and Developmental Neurobiology.

**Literature Cited**


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APPENDIX A

A sample question from an endocrinology synchronous session activity aligned with HAPS learning outcome module J 9.1 (HAPS, 2019) is presented in Figure A1. Sample responses by two different student groups are shown in Figure A2. To answer drawing questions in synchronous session activities, students are invited to use any drawing software of their choosing, or alternatively may hand-draw illustrations and take pictures of their work. Students can upload their responses as JPG or PDF files into the activities.

Endocrine disease can result from changes in hormonal secretion or altered responsiveness of the target cells to hormone.

- Alterations of hormonal secretion can result too little hormone (a hyposecretion disorder) or too much hormone (a hypersecretion disorder).

- Altered responsiveness of the target cells to hormone can arise from reduced responsiveness to a hormone (a hyporesponsiveness disorder) or increased responsiveness to a hormone (a hyperresponsiveness disorder).

Two types of diabetes mellitus exist. The most common form of diabetes is the hyporesponsiveness disorder, type 2 diabetes mellitus (also called adult-onset diabetes mellitus). Individuals with type 2 diabetes mellitus produce the hormone insulin, however, their cellular sensitivity to insulin is reduced. A less common form of diabetes is type 1 diabetes mellitus (also called juvenile diabetes mellitus) results from insulin hyposecretion. This disease results from a reduction in the number of active pancreatic β cells.

**Question:** Draw a model to show the pathophysiological states of:

1. **Type 1 diabetes mellitus** for an individual who has a reduction in the number of active pancreatic β cells that secrete insulin.

2. **Type 2 diabetes mellitus** for an individual who has reduced cellular sensitivity to insulin.

*Hint - If you’re unsure where to begin, first draw a homeostatic reflex arc to reflect normal glucose homeostasis. How can this arc be modified to reflect the pathophysiological states of types 1 and 2 diabetes mellitus?*

Upload your model here.
Figure A2. Sample submissions of two student groups to synchronous activity question