Using Online Lectures to Make Time for Active Learning

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ABSTRACT

To make time in-class for group activities devoted to critical thinking, we integrated a series of short online lectures into the homework assignments of a large, introductory biology course at a research university. The majority of students viewed the online lectures before coming to class and reported that the online lectures helped them to complete the in-class activity and did not increase the amount of time they devoted to the course. In addition, students who viewed the online lecture performed better on clicker questions designed to test lower-order cognitive skills. The in-class activities then gave the students practice analyzing the information in groups and provided the instructor with feedback about the students’ understanding of the material. Based on the results of this study, we support creating hybrid course models that allow students to learn the fundamental information outside of class time, thereby creating time during the class period to be dedicated toward the conceptual understanding of the material.
INTRODUCTION

The lecture hall is no longer the primary portal for the dissemination of information. Instead, the college classroom must embrace a new role as a place where students can work with instructors and peers to apply and evaluate the wealth of information that is available (EBERT-MAY and HODDER 2008, HANDELSMAN et al. 2004 & 2007). Students actively engaged in constructing their own learning demonstrate increased learning gains and enhanced retention of course material when compared to students who listen to traditional lectures (KNIGHT and WOOD 2005, UDOVIC et al. 2002, DESLAURIERS 2011). Engagement in active learning exercises like small group learning, requires students to communicate their thought processes. Instructors can then gauge whether the course learning objectives are being achieved and can identify and address student misconceptions (PHILLIPS et al. 2008, ALLEN and TANNER 2005, KLYMKOWSKY et al. 2003). Implementation of active learning in the science classroom recognizes the value of diversity and increases student retention (BUNCICK et al. 2001, FELDER 1993). Given these benefits, national agencies have promoted the inclusion of active learning in undergraduate science education (NRC 2000 & 2003, AAAS 2011), which raises questions about how to implement active learning while maintaining sufficient coverage of the fundamental information.

Instructors have been experimenting with new delivery methods, moving away from the traditional in-class lecture and out-of-class problem set model. For example, many instructors are now incorporating online learning components, which have been shown to improve both student attitudes and academic performance (VATOVEC and
BALSER 2009, GRABE and CHRISTOPHERSON 2008, MCFARLIN 2008). Other models, like team-based learning, flip the standard paradigm and instead require students to read information outside of class to prepare for in-class activities (FOERTSCH et al., 2002). Based on these ideas in an attempt to address the content-process tension, we created a hybrid course model in which students viewed an online lecture before class and then participated in group, problem-solving exercises during the in-class time.

The hybrid model was implemented in the first semester of a large, introductory biology course that focused on ecology, evolution, and genetics. For each of the ten class periods, we produced online lectures and designed in-class activities that targeted the session’s learning objectives. Many of the topics, especially those relating to genetics, are notoriously difficult for students to understand (MARBACH-AD and STAVY 2000). By implementing the active learning exercises, we accomplished two important objectives. First, the instructors were able to clarify student misconceptions and assess what concepts students struggled to understand, and second, the students engaged in challenging problems designed to help the students develop higher-order cognitive skills.

To understand the impact on student learning and their perceived value of the activities, we asked the following questions about the hybrid course model:

1. Did students view the online lectures before participating in the in-class activities?
2. Did viewing the online lectures help students to achieve the session learning objectives?
3. Did students value online lectures as a learning tool?
4. Did the addition of the online lectures increase the amount of time that students spent on the course?

To answer the questions, we used a mixed-method approach that included student performance on clicker questions, surveys, assignments, and other metrics, the results from which indicated that the hybrid course model effectively created time for active learning in the classroom.

MATERIALS AND METHODS

Class Demographics

We implemented this project in the first semester lecture course of a four-semester undergraduate biology program, Biology Core Curriculum at the University of Wisconsin-Madison (http://www.biocore.wisc.edu) (BATZLI et al. 2005). Through a competitive application process, students are selected to participate in this program and are informed that the curriculum will require them to learn to work productively in groups and to develop critical thinking skills. The three-credit ecology, evolution, and genetics course enrolls ~130 students each fall and is the foundation for subsequent biology courses. The course meets 3 times per week for 50 minutes in a large, stadium-style lecture hall; most instructors delivered a typical instructor-centered lecture with out-of-class problem sets. For 10 out of 42 lecture periods equally dispersed throughout the semester, we implemented the new teaching intervention that included online lectures to be viewed outside of class time, in combination with, in-class group problem-solving activities. The graduate teaching assistants reviewed the information presented in lecture during the weekly 16 student discussion sections. Summative assessments included two mid-semester exams and one final exam comprised of short-answer essay questions. The
instructors designed the examination questions to test students’ understanding of the content from the out-of-class lectures and their critical thinking skills based on those developed during participation in the group activities. The students in this course are sophomore honor students majoring in the biological sciences and frequently continue on to complete postgraduate degrees.

**Implementation of the hybrid model**

The online lectures were developed by the instructors to provide students with the basic knowledge that was needed to participate in the in-class activity. To produce the online lectures, instructors created a PowerPoint presentation and then recorded the associated sound file (*.wav type). In some cases, the sound file was edited using WavePad 3.05®. The sound file was converted into an audio file (*.mp3 type) in iTunes® and was combined with the PowerPoint presentation using eTEACH® (http://eteach.doit.wisc.edu/). The final presentations were posted on the course website and introduced to students as a required resource to be viewed prior to the class period when the active learning event occurred. The genetics topics included mitosis, meiosis, recombination, quantitative genetics, and probability. The online lectures and their associated learning objectives can be accessed from the Scientific Teaching Digital Library at http://scientificteaching.wisc.edu/library/units/003/.

To evaluate student use of the online lectures, we asked students at the start of each class period whether they viewed the online lecture before class and whether they planned to view the online lecture before the examination. To assess understanding related to the learning objectives based on the online lectures, students answered a series of questions using an electronic audience response system, or “clickers.” The cognitive
level of the clicker questions was ranked using the Blooming Biology Tool (CROWE et al. 2008). The clicker questions, the designated cognitive level, and associated learning objectives can be found in Figure S1. For each of the clicker questions, we compared the average number of students choosing the correct answer for those who viewed the online lecture to those who did not and we looked at whether this difference was statistically significant (p-value<0.05) by using the Mann-Whitney test on the Vassar Stats Website (http://faculty.vassar.edu/lowry/VassarStats.html). When students performed poorly on the clicker questions, we encouraged peer discussion and if necessary provided additional instruction (LEVESQUE 2011).

After the assessment with the clicker questions, students spent the balance of the 50-minute class period participating in group activities. The faculty instructors and teaching fellows (MILLER et al. 2008) designed these activities to extend the students’ conceptual understanding of the information presented in the online lecture and to help the students develop critical thinking skills. Many of the activities involved drawing since this is one of the most effective ways to elicit student misconceptions (DIKMENLI 2010). The worksheet associated with the cell division topic is included in Figure S2 and other genetics themed worksheets can be accessed from the Scientific Teaching Digital library http://scientificteaching.wisc.edu/library/units/003/. Four students worked together in each assigned group, and the faculty instructor, teaching fellow, and teaching assistants circulated around the classroom to guide the students as they processed the material. An integral part of the class period included a discussion where students presented their solutions to the class using a document camera.
The information from the group worksheets was assessed on the examination and students received points toward their overall grade for participating in the in-class activities. For two of the class periods, we gave the students the choice between viewing the instructor-produced online lecture and/or doing an equivalent reading. We surveyed students to find out which of the resources they chose to use to prepare for class. Further information, regarding student use of and attitudes toward the online lectures, was collected on the end of course survey.

**RESULTS**

We implemented a hybrid course model into an introductory biology course. Students viewed online lectures before coming to class and then participated in activities in-class (FIGURE 1A). Instructors spent between three to five hours developing online lectures, which provided students with the basic facts. The online lectures for the cell division unit included an introduction to what occurs during each of the stages of mitosis and meiosis. At the beginning of the class period, students answered five clicker questions testing student understanding of the material covered in the online lectures. Groups of students then worked with the instructor to create drawings integrating information from the lectures with fundamental genetics concepts. These in-class activities allowed the instructors to help the students build a conceptual framework and to elicit and discuss student misconceptions.

**Use of online lectures**

Students were surveyed at the beginning of the class period to determine whether they viewed the online lecture. Over the five years that we have used this model, we have found that between 70%-85% of students viewed the online lecture before coming to
class and that 97-99% of students plan on viewing the lectures before the examination. When students were asked why they did not view the online lecture before coming to class, the most common response was that they did not have enough time due to other coursework.

**Achievement of learning objectives from online lectures**

During the class period, we used clickers to assess whether students attained the learning objectives associated with the online, pre-class lecture. Responses to questions that tested lower-order cognitive skills, such as knowledge and comprehension, indicated that students who viewed the online lectures performed better than those who had not viewed them; five of the seven questions reached statistical significance ($p<0.05$) (FIGURE 2). Results from the five questions that focused on the higher-order cognitive skills (application and analysis), however, showed no difference in performance between the students who had and had not viewed the online lecture. These results support the idea that the online lectures helped the students to achieve the lower-order cognitive skills, but that the online lectures were not sufficient for the students to demonstrate the higher-order cognitive skills.

**Identification of student misconceptions during in-class activities**

To help the students to develop higher-order cognitive skills, the rest of the class period was devoted to group problem-solving activities and reporting out, with instructor facilitation as needed (FIGURE 1B and C). During the group work time, students continually modified their responses as they gathered more information and solved the problems at hand. For the cell division unit, students drew a heterozygous, diploid cell, which they showed undergoing mitosis and meiosis, and then were asked to use their
diagram to illustrate independent assortment of alleles. The heavily edited student worksheets (Figure S3), illustrate how students’ answers were evolving during the activity—indicators of their problem-solving skills and application of their knowledge. Instead of lecturing, instructors were available to clarify instructions and to address student misconceptions. Common misconceptions that we identified during the cell division unit are included in Figure S2.

**Value of the online lectures.**

Students’ answers to survey questions support that the students valued the online lectures as a learning tool. We found that 95-98 percent of students reported that the online lectures were helpful or very helpful toward the completion of that day’s in-class activities. Most of the students reported attentively viewing the online lectures with only six percent reporting that they watched the online lecture while doing other things. We found that the students preferred viewing the online lecture over doing an out-of-class reading, with less than five percent choosing to do the reading instead of the viewing the online lecture and 85 percent of the students viewing the online lecture before coming to class.

On the end of course survey, students responded to an open-ended question to relate the value of the online lectures to their learning: 64 percent of students’ comments were positive, 26 percent were mixed, and 10 percent were negative. A representative example of a positive quote illustrates how students valued the paired online lecture and in-class activity: “It let us learn the information then apply those new concepts in in-class activities.” The students’ comments identified additional advantages of the online lectures. One student noted, “I also liked the ability to pause and digest the material at
my own pace.” Another pointed out that the pairing was “Very helpful because I could watch the online lecture at my own time (ie, 4:30AM) and could use the online lecture to review confusing information.” These comments indicate that the online lectures allow the students to learn the information at their own pace.

A low percentage of students had negative comments regarding the incorporation of the online lectures. One concern was the length of the online lectures. The students preferred that the length of online lectures be limited to 20 minutes or less to maximize student engagement. This prompted us to create two lectures, one on mitosis and one on meiosis, for the cell division unit. An additional concern was a perception that the online lectures significantly increased the student workload outside of class. To address this concern, we compared the number of hours students reported spending outside of the class each week to the number of hours estimated in the previous year. The only major change between the two years was the addition of online lectures. We found no significant difference in student reported workload in years with or without online lectures. In both cases, 75 percent of students reported spending fewer than six hours per week studying for the course, which contradicts the perception that the online lectures increased workload outside class time.

**DISCUSSION**

Students used and valued online lectures in an introductory biology course. Students who viewed the online lectures before class performed better on lower-order cognitive learning objectives. Moving content from the class period to the online format allowed instructors to use class time to help students achieve the higher-order cognitive
learning objectives and to assess student understanding of essential concepts. The curriculum restructuring did not reduce the amount of course content or alter the amount of time students reported spending on the course. The results of this study support the implementation of a hybrid course model, combining online lectures with in-class group problem solving.

Like others, we found the online format offers benefits not found in traditional lectures, including the flexibility for students to view and review the lectures at their convenience (CARDALL et al. 2008). Instructors also appreciate the increased flexibility offered by online learning (MAYADAS et al. 2009). A meta-analysis of online learning from the Department of Education suggests that students perform well in online learning situations and even better when online learning was paired with face-to-face instruction (OPEPD 2010). Therefore, we promote combining online and in-class learning activities and outline recommendations for effective development and implementation of a hybrid course curriculum in TABLE 1.

The success of active learning is associated with effective pedagogical approaches to curricular design (ANDREWS 2011). We took a constructivist approach to active learning, accepting that students must integrate new information with their existing knowledge frameworks (CHI 2009). We designed the in-class worksheets to identify common student misconceptions and to emphasize conceptual frameworks rather than isolated facts. During the implementation phase, students presented multiple answers to the worksheets. By comparing and contrasting answers, we were able to appropriately address student misconceptions. Addressing these misconceptions was critical because the subsequent topics in the course built upon information covered in these units.
Instructors emphasized that the skills students were developing during the in-class activity would be assessed on the course examinations. This is one strategy that has been reported to help address student resistance to curricular change (SILVERTHORN 2006).

Our study has several limitations. We did not assess whether the hybrid model was associated with learning gains or improved retention; however, other researchers have established these benefits of small group learning (SPRINGER et al. 1999). Students in this study selectively enrolled in the honors course knowing that participation in the curriculum would require active learning and group problem solving. Students in this course may have different abilities and motivation levels than other class populations, which may limit the generalizability of this study.

Curricular innovations are rarely effective in all situations (TANNER 2011). Instructors must modify the model to meet the needs of their student population, classroom environment, and resources. One addition to the hybrid model, implemented in a computer science course, was to have students complete an online, graded quiz after viewing the online lecture. The quiz motivated students to view the lectures and helped the instructor to identify topics requiring additional coverage during the class period (MOSES and LITZKOW 2005).

In conclusion, there are meaningful benefits associated with curricular redesign that integrates online lectures and in-class active learning exercises. This hybrid course model allows instructors to effectively identify student misconceptions on key concepts and to devote in-class time to developing students’ higher-order cognitive skills.

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FIGURE 1. Hybrid course model. A. Students were assigned to view an online lecture before coming to class. In class, students answered a series of clicker question to assess whether they could demonstrate the learning objectives associated with the online lectures and then participated in group activities designed to build critical thinking skills. B. Instructor aiding a group of students with an in-class activity. C. Presentation of the students’ solution to the cell division in-class activity.

FIGURE 2. Students who viewed the online lecture before class performed better on the questions designed to test lower-order cognitive skills. For each clicker question the number of students that answered the question correctly was grouped by whether the students had viewed the online lecture before coming to class. The seven clicker questions on the left side of the figure were designed to test lower-order cognitive skills and the final six questions were designed to test higher-order cognitive skills. Clicker
questions showing a statistically significant difference (p-value < 0.05) between students viewing the online lecture and those students who did not view the corresponding lecture are indicated with an “*”.

TABLE 1. Tips for effective development and implementation of a hybrid course

Maximize student engagement

1. Align online lectures and in-class activities with the course learning goals.
2. Keep the online lectures short (15-20 minutes).
3. Post online lectures at least 2 days prior to the in-class activity.
4. Use clickers to assess whether students have achieved the learning objectives associated with the online lectures and follow challenging questions with peer discussion.
5. Use in-class group work to extend the students’ conceptual understanding of the material and to address students’ misconceptions.
6. Hold students accountable for material in the online lectures and in-class activities on summative assessments.

Minimize instructor input

1. Create slides and record lecture using PowerPoint.
2. Use online lectures with a subset of the class periods.
3. Choose topics from less rapidly evolving fields so the same presentation or minimally modified presentation can be used for multiple years.
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Figure 1

A

Online Lecture \[\rightarrow\] Clicker Questions \[\rightarrow\] Group Activity

Out-of-Class \[\rightarrow\] In-Class

B

C
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FIGURE 2

[Bar chart showing percentage of students answering questions correctly for lower-order and higher-order cognitive skills with online versus no online lecture.]

- Lower-order cognitive skills
- Higher-order cognitive skills

% of students answering question correctly:
- 100%
- 90%
- 80%
- 70%
- 60%
- 50%
- 40%
- 30%
- 20%
- 10%

- online lecture
- no online lecture