UPENDING THE LECTURE

HOW ONLINE TEACHING METHODS ARE ENHANCING ON-CAMPUS LEARNING

Guided by the instructor and learning assistants, EK27 students spend class time solving problems.

BY MARK DWORTZAN

PHOTOGRAPHS BY CONOR DOHERTY
Collaborating with her peers at 10 clusters of rectangular tables in this well-lit "learning studio," and guided by Assistant Professor Stormy Attaway (ME) and three learning assistants (specially trained undergraduate teaching assistants), 75 students in EK127: Introduction to Engineering Computation solve computer programming problems that apply concepts from online course videos that they viewed from the comfort of their dorm rooms and apartments. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.

"I'm constantly roaming around the room," says Attaway, who has spent most of her academic career standing in front of amphitheater-style lecture halls, directing her remarks at the average student rather than tailoring them for individual students. "I'm now talking to every student multiple times per class, and student engagement is through the roof."

Welcome to the flipped classroom, College of Engineering-style. Rather than delivering a lecture to rote after row of students dutifully taking notes, with little or no interaction between lecturer and note-takers, and then assigning problem sets for students to solve at home—the model for science and engineering for more than a century—Attaway is leveraging leading-edge digital learning technologies to essentially do the opposite. So far she's found the approach has paid off, yielding substantial improvements in student engagement, understanding and performance.

EK127 blends the best of the virtual world—state-of-the-art web hosting and video production technology from edX, a nonprofit online platform offering Massive Open Online Courses (MOOCs)—with Attaway’s teaching approach has paid off, yielding substantial improvements in student engagement, understanding and performance. Some problems are chosen based on common trouble spots pinpointed via mandatory quizzes that accompanied the videos. Students share their work on whiteboard-painted walls (slated to be replaced by electronic whiteboards by Fall 2015) and with Attaway and her learning assistants, who dart from table to table throughout the two-hour class.
the classroom enabled her to grasp the course material much more effectively than the traditional method.

“When studying for a quiz or exam, it was easy to go back to the videos and refresh what I had learned without having to rely on notes, which may not have been entirely correct. In addition, working with other people in the classroom helped me to learn the material more thoroughly. For example, when I was struggling to understand graphical user interfaces, the other students in my group helped clear up my misunderstandings, and when all three of us got stuck, the learning assistant was there to help us.”

Continuing her experiment into the summer, Attaway invited a class of 23 EK127 students to go online and view the first course module (four to five approximately seven-minute lecture videos, primarily consisting of PowerPoint slides with a voice-over by Attaway) before coming to the first class meeting. Once in the classroom, students gathered at small round tables and worked on three or four assigned problems, first as individuals and then in groups of three as a graduate teaching fellow and several teaching assistants milled about, sitting with groups as necessary to explain concepts ranging from data structures to numerical methods.

“The students were actively engaged from the beginning,” says Attaway. “The peer-to-peer instruction worked very well. On a scale of 1 to 5, with 5 being ‘not at all’ and 5 being ‘very,’ the average response on how much the group-in-class exercises enabled them to learn was 4.5. Of the 23 students, 16 earned grades in the A range, 6 in the B range and one in the C range, and there were no D, F, or W grades. In my opinion, the class was a smashing success.”

Building on that success and adding more learning materials for the course site on edX edge, Attaway has now delivered essentially the same experience to her 225-strong Fall 2014 class (three sections of approximately 75 students each) in the new, more flexible Photonics 117 studio space. Compared to the Spring 2014 class, sections of approximately 75 students each) in the new, more flexible Photonics 117 studio space. Compared to the Spring 2014 class, where only one-third of the students learned in a partially flipped classroom, students in the new flexible studio are able to devote most of their class time to working on their projects in the design studio.

“In previous semesters, students would be required to complete a reading assignment before coming to lecture, and then lectures would present material covered by the reading. By halfway through the semester, most students would decide that they could get away without doing the reading and just listen to lecture, so instead of having the lecture to ask questions and clarify their understanding of material, they were hearing everything for the first time. Because the students are now watching the videos and getting the lecture before class time, they have time to figure out what they don’t know, and what to ask.”

EK307 AND EK210: FREEING-UP TIME FOR HANDS-ON ENGINEERING

Supported by DLI funding, Professor Mark Horenstein (ECE) has developed a series of 30-minute course modules on circuit analysis and design to prepare EK307 students for the course’s weekly lab.

Always available to students and consisting of animated, voice-over PowerPoint lectures and lab demonstrations produced with Camtasia and uploaded to a video hosting service, the modules function as tutorials that present essential concepts and practical information to help students get the most out of each lab.

In the course, students design and construct circuits and test their results in the ECE Department circuits and electronics teaching facility. Aside from a basic introduction they get in their physics classes, this is the first course in which they are immersed in the details of circuit design, and the amount of material they’re expected to absorb can be daunting. The lab videos help students to master often-complex concepts, illustrating them with images, diagrams, and schematics.

“The modules function as tutorials that present essential concepts and practical information to help students get the most out of each lab.”

“Mark’s videos have been a hit with our students,” says Aleks Zozula, the course’s lab instructor. “Even without Mark physically in the lab, his voice emanates from speakers and headphones as students use the videos in a self-paced manner to help them with their lab work. It’s like having a personal TA over your shoulder while working, with the added benefit that you can pause the video while you digest an aspect of the material.”

“The videos have been helpful in giving you an overview of what your circuits might look like before you get to the lab,” says EK307 student Fritz Jolivain (EE’17). “They’ve helped me feel more confident in translating a circuit to a breadboard to see how it works.”

Another College of Engineering course using videos to prepare students for hands-on engineering is EK210. Introduction to Engineering Design, a two-credit class aimed at giving sophomores a basic understanding of how to develop a product from concept through design and deployment. Meeting in the Engineering Product Innovation Center’s (EPIC) Lorraine A. Tegan Design Studio, students work in multidisciplinary teams with time and budget constraints on externally sponsored design projects. By viewing web-based lectures at home on topics concurrent with specific phases of the projects rather than receiving this information via in-class lectures, students are able to devote most of their class time to working on their projects in the design studio.

“We’re trying to teach students hands-on engineering design, but we only have them two hours a week,” says EK210 instructor and
In this in-class problem presented in EK301, students analyze forces acting on a horizontal beam and enter their work on iPads. Their solutions are wirelessly uploaded to the file-sharing service Dropbox.

Lecturer Caleb Farny (ME) has dramatically increased active learning in the classroom without producing videos or redesigning the lecture hall, both of which can be expensive and time-consuming. His approach enables immediate access to digital learning technology when studio learning space is not available.
The performance in the sections with an active learning format was higher for all assignments and semesters.

With funding from a BU Redesigning the Undergraduate Learning Experience (BU:ULD) grant, Farny has shown that one can dramatically boost active learning in the classroom without having to produce videos or redesign the physical space. Since the Spring 2012 semester, this required engineering course intended for sophomores, much of the lecture has been replaced by interactive problem-solving sessions and class discussions, all in a conventional lecture hall.

Twice during each 110-minute class meeting, the instructor presents a 15-minute overview of a new concept and students work in groups of four on an example problem. Over 15 minutes, each group uses an iPad and stylus to show each step of its solution—including diagrams that depict the forces acting on a structure—and wirelessly uploads it to the file-sharing service DropBox, where it may be accessed after class.

Meanwhile, the instructor and three graduate teaching fellows and learning assistants circulate about the room to answer questions. When time is up, the instructor projects the selected work on an overhead screen and invites a representative of the group to show how it solved the problem, using its iPad entries to highlight correct steps and common errors.

Class discussions of student solutions are strictly focused on helping students to become better problem solvers, says Rebecca Brooks (ME’16), an EK301 learning assistant and former student of the course. “There’s no judgment when something is done incorrectly. It’s all seen as a learning experience.”

Farny evaluated the new approach to EK301 the first semester it was introduced, offering one section in the old format and a second section in the new, but keeping all quizzes and exams the same. He found that students achieved significantly higher scores with the new format, regardless of grade point average.

“This showed that our new, active learning approach worked well, and it’s been the format of the course ever since, unifying the in-class measurement exercises in which student groups use plug-in sensors and portable data acquisition devices to conduct experiments and share their results onscreen.”

“GoING digITAL, AMONG OTHER THINGS”

While digital learning has been a resounding success in courses that have tried it, the method is only beginning to gain traction at the College of Engineering.

“At this point there is ample evidence that flipped classes with active learning environments work; the focus is now on how to get faculty to adopt these best practices,” says Attaway, noting that transforming a traditional lecture into an online course module—breaking it into bite-sized chunks, recording the video and hosting it on the edX platform—can take up to 200 hours. Simply letting go of the familiar lecture format can be challenging for some faculty.

“Although my primary goal is to improve the learning experience for my students, my secondary goal is to be resourceful for my colleagues so that I can help them transform their courses.”

To that end, a College of Engineering faculty committee on digital learning initiatives is sharing best practices among faculty, redesigning courses (including ongoing efforts to flip EE217 and EE307), and purchasing new digital learning technologies. From electronic clickers that students can use to relay instant responses to questions posed during a lecture, to large, overhead projection screens to display solutions uploaded by student groups at active learning tables. As the College’s team of digital learning enthusiasts expands the use of blended learning technologies and techniques on campus, it also recognizes that one size does not fit all.

Higher test scores stem from improved engagement with and understanding of the course material, observes Panosel Gkalia-moustas (ME/Economics’15), a learning assistant for EK301.

“In a group format like the one in EK301, students are free to ask questions amongst themselves or call on a learning assistant or graduate teaching fellow for help,” he says. “This is important since many students feel more comfortable talking to the assistant rather than to the professor. I realized from my experience as a student in EK301 that I understood the problems we did in class more thoroughly, and was thus able to perform better on exams and quizzes.”

Inspired by the success of EK301, Farny started flipping a senior-level course, ME 310: Instrumentation and Theory of Experiments, in the Fall 2014 semester, replacing ten hours of lecture with 18 course videos on the edX edge platform for home viewing and in-class measurement exercises in which student groups use plug-in sensors and portable data acquisition devices to conduct experiments and share their results onscreen.