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## Inside the Flipped Classroom



Ben Sklar for the Chronicle

Rather than lecture, Maha Zewail-Foote (left), a chemistry professor at Southwestern U., works with students, including Sara Infante, during class time.

By Katherine Mangan

Sara Infante listens intently and scribbles notes as her chemistry professor describes how to identify the masses and atomic numbers of two isotopes of carbon. When it's time to fill in a table showing that she understands the lecture so far, she clicks her mouse, and the lecture, which is being delivered online, freezes on the computer screen.

The questions that Ms. Infante and her classmates at Southwestern University ask their professor, Maha Zewail-Foote, will help shape the next day's session in the classroom. There, moving on to more-complex topics, she'll help them tackle the kinds of problems that used to be given as homework.

It's Ms. Infante's first experience with the flipped classroom, where traditional classwork is done at home and homework is done in class.

"I like this because when you're listening to the lecture at home and you don't get something, you can rewind and replay it as many times as you need to," says Ms. Infante, 19, a sophomore majoring in animal behavior who hopes to become a marine-mammal trainer.

"And when you're working through problems," she adds, "you aren't sitting in your room pulling your hair out because you didn't retain the information from the lecture."

The video for the semester's first flipped class, with its accompanying tables and diagrams, lasted just under 10 minutes. They're usually five to seven minutes, which Ms. Zewail-Foote describes as the attention span of most students. But in

her opinion, a well-crafted, concise, 10-minute video that students can pause and replay as many times as they want packs more teaching in than a 20-minute lecture.

The course Web site include outlines that students fill in while they're listening to her recorded lessons, each of which ends with a short quiz.

"Between the lecture outline and video, they should come to class ready," Ms. Zewail-Foote says. "They understand how to calculate average atomic mass, so we can jump right in."

At colleges nationwide, more and more professors are inverting homework and classwork this way, using technology to give students a head start on classroom sessions where they can be active participants and not just listeners.

The flipped classroom is not for everyone. Many students feel lost without a traditional lecture to get them started, and some instructors are reluctant to give up the podium for a role on the sidelines, says Carol A. Twigg, president of the National Center for Academic Transformation.

Since 1999 the center has helped redesign about 300 courses on 159 campuses, often in a flipped format, using technology to cut costs and improve learning. (Southwestern did not work with the center on the revamped chemistry course, but it did consult with other proponents of the technique, as part of a project, supported by the Howard Hughes Medical Institute, aimed at making Southwestern's science curriculum more hands-on.)

Many of the national center's course redesigns have been in remedial math, financed by \$2.2-million from the Bill & Melinda Gates Foundation. The center has also helped flip courses in subjects as diverse as Spanish, psychology, nutrition, and anatomy.

"The traditional classroom typically consists of a lecture of some kind where students are listening or watching the professor," Ms. Twigg says. "Then they do the hard work, solving problems, on their own. The notion is, flip that experience so the professor can help students when they need the help."

Switching from the role of "sage on the stage" to "guide on the side" requires a professional and cultural shift that many faculty members resist, she says. "It's easier to stand up and give the same lecture you've been giving for 20 years than it is to rethink your course, come up with new activities, and really engage your students."

The problem-solving and personalized interaction that take place face-to-face sets these classes apart from massive open online courses, or MOOCs, which too often consist mainly of recorded talks, she says, explaining that flipping the classroom requires more than simply moving lectures online.

Teaching to the masses is tempting, but it's not the same as offering a flipped course, she says. "Let's say I am the most brilliant lecturer of intelligent design, and now I'll have an audience of 200,000 instead of 200.

"The problem is, the success rates are awful," she adds, in a not-so-subtle jab at Sebastian Thrun, the former Stanford University professor who co-founded the MOOC platform Udacity last year, after his online "Introduction to Artificial Intelligence" course attracted more than 160,000 students worldwide. About 23,000 of those students completed the course.

While MOOCs can be effective at delivering content, flipped classrooms make students active participants in their education, says Southwestern's new president, Edward B. Burger. The former mathematics professor at Williams College has created more than 3,000 instructional CD-ROMS and videos in math that are used in classrooms from kindergarten through college. Instead of having students struggle to figure out problems in their dorm rooms at 2 a.m., he says, "I want to be there when students hit those roadblocks."

Although he didn't call it a flipped classroom at the time, Mr. Burger cultivated the technique of "inverting the roles of homework and classwork," an approach that contributed to his winning a national teaching award in 2010.

Back in the common room of her dormitory suite at Southwestern, Ms. Infante has finished listening to the online

lecture and asks her roommate, who's curled up in an armchair across the room, for a scientific calculator so she can take the quiz.

Her roommate's own chemistry professor, Emily Niemeyer, offers the format once a week, on what she calls "flipped Fridays."

Ms. Infante aces the quiz and doesn't have any questions for her professor. Other students were stumped by a few questions, Ms. Zewail-Foote notes the following morning as she prepares for class. One student asked: "Will there ever be a time when an atom is not neutral and the number of protons and electrons don't balance each other out?"

The explanation would normally come up in Chapter 4, but Ms. Zewail-Foote decides to work the answer into today's classroom problem-solving session. Reviewing the quiz results, she can tell that students generally understand the material, so she is comfortable accelerating the pace a bit.

There's little danger that students are going to nod off in her class, because she peppers it with questions that they must answer using their hand-held clickers. If 29 students have clicked their answers, she pauses before moving on until all 30 have weighed in.

Shortly after the class begins, students cluster their desks into groups of three or four to work on problems as she walks around, occasionally crouching next to those who seem stuck.

When the semester's first flipped-classroom session is over, at least one student isn't yet sold. "I'm going to fail this class," says Alex Petrucci, a 20-year-old sophomore. The pre-class video didn't adequately prepare her for the problems she was asked to solve in class, she complains, and even with a cluster of classmates to confer with, she felt lost.

That kind of reaction isn't uncommon when classes are flipped.

An aeronautics-engineering professor at Mississippi State University who taught a course in statics, in a flipped format, encountered similar resistance from some students who couldn't get used to online lectures.

Masoud Rais-Rohani, who worked with the National Center for Academic Transformation to revamp the statics course, says having students watch videos, take quizzes, and reflect on what they learned before each class session made it possible to spend class time doing hands-on projects that the course had never before had room for, like working with physical models of bridges and calculating the loads they can carry.

Nevertheless, the flipped format was put on hold for the statics course this year, after tests revealed that learning outcomes were about the same in the flipped classes, which cost the same, or slightly more, because of the extra tutors and teaching assistants required. In addition, students were grumbling.

"Some complained that the instructors were good, but they were wasted if they weren't standing in front of the class lecturing," says Pasquale Cinnella, head of the aerospace-engineering department.

If engineering enrollment continues to increase, and the classes become more cost-effective, Mr. Cinnella says, he may reinstate the flipped format.

Eventually, Mr. Rais-Rohani hopes to win over skeptics like the student who responded to his survey by saying: "If I am paying for a class and a professor to teach me, then I do not want to teach myself for homework and have homework for class."

In time, the professor hopes, more students will come around to agreeing with the student who found that the flipped format forced him to improve his study skills and take a more active role in his learning. "Now," that student wrote, "I'm responsible for my grade."