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Organic Education Resources
A *cCWCS* Community of Scholars

Flipped Organic at Dartmouth College

Cathy Welder converted her Organic II course from a traditional lecture to an active learning classroom this past summer. She spent time in the fall, winter, and spring quarters recording lectures to be viewed by students prior to class and creating problem sets to be worked in groups during class meetings.

Dartmouth covers in a 10-week quarter what most schools cover in a semester. As such, the pace is faster, but the face-to-face class time typically matches that of a longer semester. Classes meet 3 days a week for 65 minutes and once a week for 50 minutes. Overall, just over 16 hours of video lectures, recorded in small chunks ideally not more than 10 minutes per video, replaced a full term of traditional lectures, cutting the lecture time by more than half and removing the lecture from the face-to-face interactions.

Prior to each class period, students were instructed to view lecture videos and were encouraged to read the corresponding sections in their textbook. During class, they worked in carefully designed groups of 5-6 to solve problems presented on the screen. (Groups, referred to as teams, were made as diverse as possible considering race/ethnicity, gender, self-identifying as leader or follower, and especially their grade in Organic I with each group having strong, average, and struggling students.) Cathy and 3 teaching assistants roamed the room of 9 teams to assist as they attempted each problem. After solving the problems, a team would report out their answer to all. (A key was also posted on the course learning management system after class.) During the solution reporting, students had to explain their thought process and had to field questions from both instructor and classmates. After the solution was presented, any student in the classroom was encouraged to ask additional questions before the next problem was posted on the screen. To help prevent boredom, the type of problem and the method of sharing out was varied. For instance, some days teams worked at whiteboards. Other days involved a think-pair-share variant of answering multiple

choice questions using simple index cards with letters written on them to indicate their responses. Most days, students worked at their team table and reported out from there.

In preparation for the flip, Cathy read a number of articles and books, listened and asked questions at five cCWCS-sponsored Active Leaning in Organic Chemistry workshops, worked with Dartmouth's educational designers and the Dartmouth Center for the Advancement of Learning, and took a couple of online courses on evidence-based teaching in STEM fields. Some of the best advice from others who walked this road before her was to sell the concept of an active learning classroom to students on the first day and never look back! And sell she did! 30 minutes of the first (65 min.) class period was used to discuss the theories regarding why active learning is better than a traditional lecture, why they would be working in teams in her course, and effective vs. inefficient study habits. In the last 15 minutes of class, students came up with guidelines that they felt would help their team function well over the term. Most important guidelines include attending class; listening to each other; preparing for class each day by reading the textbook and watching videos; asking questions; and making sure that everyone contributes to the team problem-solving discussion. Some teams added that there are no dumb questions – that anyone should be able to ask any question of the team.

After returning the first exam, Cathy followed the advice that Saundra McGuire gives in her book *Teach Students How to Learn: Strategies You Can Incorporate into Any Class to Improve Student Metacognition, Study Skills, and Motivation.* Cathy spent an entire 50 min. class period teaching students about metacognition, Bloom's Taxonomy, and impactful study strategies including what to do before, during, and after class to make sure you can answer the questions why, how, and what if. One of the key points that Cathy took away from McGuire's book is that we should challenge our students to do well and convince them that we believe, really believe, that they can accomplish the challenge. Cathy challenged them during the metacognition talk soon after exam 1 to have a class average of 80% on exam 2. (Honestly, she wasn't sure if they could do it!) They exceeded expectations with an <u>unprecedented</u> average score of 84% (median 85%) on the second exam in Organic II!

While a statistical analysis has not yet been performed, Cathy anecdotally reports better performance by this class than that of students who took previous offerings as a traditional lecture with her. Exam scores were higher and DFW rates were lower in summer '17. In the last offering of the traditional lecture course, 15% of the class withdrew and 7% of the class earned a D or failing grade. In summer '17, only one student withdrew, and that was for medical reasons, and one student (2.5%) earned a D. No one failed.

Most students were extremely positive on the course evaluation. Many commented that they will take study skills learned from the metacognition presentation to future courses. All but one or two out of 46 students appreciated and preferred the active learning classroom over a traditional lecture. Students put a great deal of effort into studying for

the course, and Cathy feels the effort was focused on effective learning strategies which resulted in greater learning and retention.

Another key factor in the high course ratings was the less competitive/more cooperative learning environment. Dartmouth students typically compete against each other as median grades are often publicized prior to the start of the course. As such, helping someone else could end up hurting you. Cathy announced at the beginning of the term, and reaffirmed as students asked again after a strong performance on exam 2, that students would be assigned the grades they earned based on their demonstrated learning of the course objectives, not based on how others in the class performed. This reinforced a collaborative learning environment that seemed to take away a lot of unnecessary stress while supporting effective group learning strategies.

For more on Cathy's course this summer, see this article written by Elli Goudzwaard at Dartmouth.

Recommended Readings

How Learning Works: 7 Research Based Principles for Smart Teaching by Susan A. Ambrose and Michael W. Bridges

Make It Stick by Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel

Reaching Students: What Research Says about Effective Instruction in Undergraduate Science and Engineering by National Research Council and Division of Social Sciences and Education, available as a free electronic copy here.

Teach Students How to Learn: Strategies You Can Incorporate into Any Course to Improve Student Metacognition, Study Skills, and Motivation by Saundra Yancy McGuire

Understanding by Design by Grant Wiggins and Jay McTighe

Data Comparing a Second Semester GOB Course Before and After Flipping

Doug Schirch (2014 cCWCS Workshop in Denver, CO) teaches a combined organic and biochemistry course for nursing majors at Goshen College, IN. Demographic shifts at the college have given the opportunity as well as the challenge of teaching more 1st generation and commuter students. After nine semesters of teaching the course in the traditional format he "flipped" the course, moving all lecture content to self-recorded videos (using Screencast-O-Matic and a graphics tablet).

This freed class time for extensive group problem-solving work with checks on student answers and assistance for groups needing help. Student readiness for problem-solving was checked with quizzes and having students show their notes from the pre-class videos. The quizzes tested mastery of information communicated beforehand to the students as "essential" for problem solving (e.g. organic functional groups, types of intermolecular attractions, key information about carbohydrate structures). These quizzes penalized wrong answers with double deductions; this resulted in increased student efforts to learn the content, but, somewhat surprisingly, no student complaints.

The effectiveness of the course changes was evaluated by comparing scores on ACS final exams and student survey responses. Despite students with lower SAT scores (an average of 1039 in the 7 semesters prior to flipping vs 1007 afterwards) the median scores on the same ACS final exam were higher (64.9 vs 70.4 correct answers of 120 questions, ranked at the 61st vs 70th percentiles). The percentage of students getting a W, D or F in the course also decreased from 15% to 7%.

Because the flipped system had students watching lecture videos outside of class – a time when many students spent little time doing the homework in a traditional course – the instructor expected that flipping the course would result in students spending more time outside of class doing classwork. Indeed, the median number of hours students self-reported as having spent outside of class increased from 5.0 hours the year before flipping the course to 8.4 hours in the two years afterwards. Another perceived benefit of switching to recorded lecture videos would be the option for students to rewatch a video if they needed an explanation again. After the course, when queried how often they rewatched a video, three-fourths of the students said they did so for at least 10% of the videos, and nearly a fourth said they rewatched 30% or more.

Not only did the flipped format lead to increased student time-on-task and higher exam scores, but students perceived the flipped format as beneficial. When asked to respond on a Likert scale if they agreed or disagreed with the statement, "I preferred the switch, having videos of the lectures and doing homework in class," 77% agreed and only 14% disagreed. Strong majorities also felt the course improved their study skills (82% agreeing and 5% disagreeing) and rated the course as excellent (80% agreeing and 5% disagreeing)

Board Members' Picks

Some publications, presentations, and events that caught our interest

From Alexey Leontyev

Austin, A. C.; Hammond, N. B.; Barrows, N.; Gould, D. L.; Gould, I. R. Relating motivation and student outcomes in general organic chemistry, Chem. Educ. Res. Pract. **2018**, Advance DOI: 10.1039/C7RP00182G

Liu, Y.; Raker, J. R.; Lewis, J. E. Evaluating student motivation in organic chemistry courses: moving from a lecture-based to a flipped approach with peer-led team learning, Chem. Educ. Res. Pract. **2018**, Advance DOI: 10.1039/C7RP00153C

From Jennifer Muzyka

Carey, Benedict; *How We Learn, Random House*: New York, 2015.

Upcoming Events

2018 National Science Teacher Association (NSTA) National Conference, March 15-18, 2018, Atlanta, GA

255th American Chemical Society National Meeting & Exposition,

March 18-22, 2018, New Orleans, LA

Central (CERM), ACS Regional Meeting, June 13 – 16, 2018, Toledo, OH

22nd Annual Green Chemistry & Engineering Conference, June 18-20, 2018, Portland, Oregon

25th International Conference on Chemistry Education (ICCE), July 10-14, Sydney, Australia

25th Biennial Conference on Chemical Education, July 29 – August 2, 2018, South Bend, IN

8th Edition of International Conference on Chemistry Education and Research, August 27-28th, 2018, Zurich, Switzerland