Effect of Active Learning in a Large Organic Chemistry Lecture
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BACKGROUND

Organic chemistry is a gatekeeper course for pre-health care majors. About 10% of enrolled students drop the course, usually due to low initial scores. Larger percentages of D's and F’s are also assigned at the end.

The graph shows initial enrollments, percentages of drops, and final exam D’s and F’s in six historical semesters of CHM303 (first semester organic theory) taught by me. Percentages of drops and final grade D’s and F’s from other instructors are similar. Grades are among persisters, who did not drop the course.

Most students taking organic chemistry at UWL are not chemistry majors. The subject has a reputation for weeding out many would-be health care professionals.

Traditional organic chemistry pedagogy includes illustration of reaction mechanisms and prediction of products from reactions.

The student role in standard organic pedagogy is relatively passive. Active learning strategies such as "clickers" used in other courses have few counterparts in organic coursework. "Note-taking" is still the norm in organic, and the course is notorious for requiring extensive memorization (see margin comments).

Organic chemistry does not include "discussion sections" like those used in CHM103 and 104. Discussion sections give an opportunity for students to work problems and ask questions of the professor. Organic must become more independent and self-directed in their learning.

I believe a significant percentage of Drop/D/F students in organic never figure out how to study successfully on their own, and/or how to rebound after problem-solving failure. I hypothesized that forcing students to engage by problem solving in class could foster independent thought. The lecture hall provides a "scaffolded" learning environment so that students can be coached into developing effective problem solving strategies. The value of applying known trends to solving a new problem can be emphasized in the lecture hall in real time. With this practice, "solving it myself" can ideally become a familiar experience, which could mitigate test anxiety. A certain percentage of students who walk in the door every semester who fear this course (see margin comments).

DESIGN AND METHODS

In F13, graded reviews of material from prior courses, mechanism coaching, and extensive predict-the-products in-class exercises were added to my curriculum of CHM303.

Exercises were designed to coach students in self-directed learning, and to decrease the intimidation factor in solving new types of chemistry problems. Review material was covered in class and in graded "pre-evaluations."

Students needed to use prior knowledge to answer pre-evaluations, a more engaging exercise than writing notes about prior knowledge.

Graded example:

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These answer the following questions in the text of your ability. They satisfy topics covered in earlier examples that are still visible during a lab work.

1. How many valence electrons does an atom of chlorine have?

2. Based on your answer in #1, how many covalent bonds does carbon need to form in order to satisfy the octet rule?

3. What determines bond geometry around an atom?

4. What is a strong acid?

5. What is a Lewis structure?

6. How do the formal charges on the nitrogen and oxygen in ammonia change? Show your work.
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Students proposed the first reaction mechanism rather than copying something written by me during class. Students were coached on their proposal of each step, and the full mechanism was presented at the end of the lecture. Later mechanisms built on this exercise. In lecture example:

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Students predicted products for example reactions, the concepts for which had been introduced in that lecture. A major portion of organic chemistry content and the primary gauge of content mastery is correct prediction of product structure for reactions. In lecture example:

Predict the major product of the following reaction:

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RESULTS

Introduction of active learning exercises greatly increased persistence among low-scoring students.

In my ten preceding semesters of CHM303, the median drop rate was 10%; the lowest drop rate was 8%. In F13, only 4% of students dropped my section of CHM303.

The greater persistence of low-scoring students DID NOT CORRELATE with increased %'s of D's and F's at the end of the semester.

Rigor was preserved.

The Department of Chemistry & Biochemistry prides itself on generating meaningful grade distributions that reflect the differential abilities of its students. The distribution of final exam grades (not shown) from F13 was on par with preceding semesters taught by me.

CONCLUSIONS

Coached mechanism exercises, "just in time" reminders of prior knowledge, and in-class problem solving are valuable techniques to help organic chemistry students master required content. Student comments (margins) indicate that independent problem solving and careful discussion of mechanistic behavior can foster comprehension and permit self-evaluation. These methods also appear to reduce the memorization burden and to benefit the most challenged students, improving persistence and success among those who might ordinarily drop the course. Organic chemistry is a notorious bottleneck for students in pre-health majors. Greater throughput of students with passing grades can increase the size of the pipeline for these majors at a time when a shortage of health care professionals is predicted for the future.

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