SEI comment: “I like how you walk us through each mechanism and problem, letting us work through it first instead of you just showing us right away.” SEI comment: “Makes student understand processes rather than memorize.” SEI comment: “Has in-class practice problems that helps engage the class instead of her just talking all class.” SEI comment: “I also liked the predict mech. exercises, I learned trends instead of memorizing each mechanism.” SEI comment: Most useful: “Her method of introducing the mechanisms – not just writing them down and telling us to memorize!” SEI comment: “In class problem solving helps me self evaluate. Dr. Schenck helped ease the anxiety I had regarding the course with her teaching strategy.” SEI comment: “She always tries to answer the ever-pressing question of ‘Why?’ This is especially important in this course, as it can often become simple memorization.” SEI comment: “I like that we can immediately apply what we learned and then get immediate feedback on what we did wrong.” SEI comment: “In class activities were also very helpful in critical thinking with the material rather than just listening and writing down notes.” SEI comment: “Allowing us to work through problems in class before telling us the answers – gives us a feel for whether we understand it or need more practice/what to improve on.” SEI comment: “Explaining mechanisms and why the happen the way they do helps me put things together during the test if I get stuck.” SEI comment: Most useful: “Taking mechanisms apart piece by piece, then putting them together.”

Effect of Active Learning in a Large Organic Chemistry Lecture

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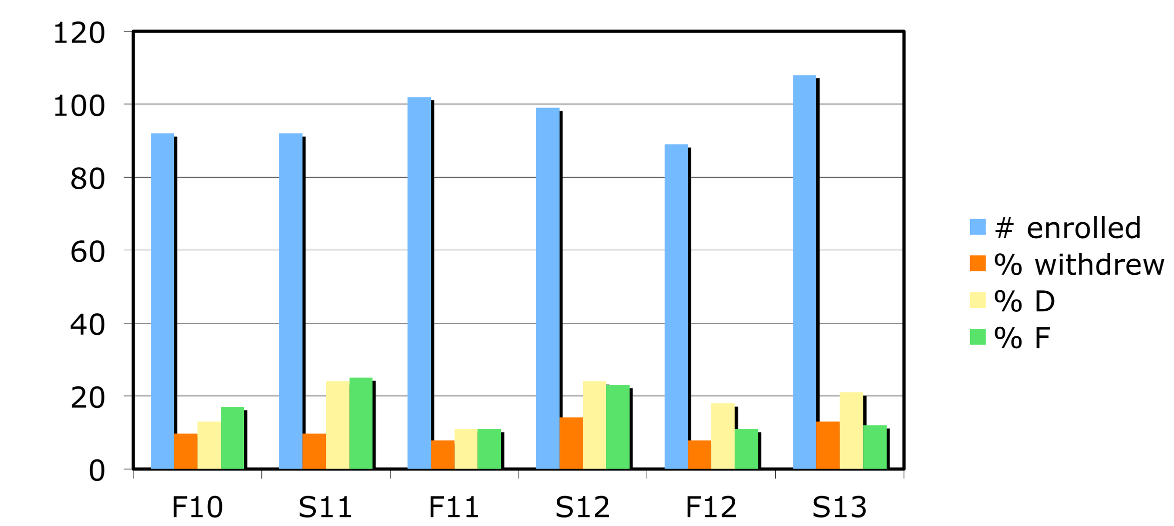
BACKGROUND

Organic chemistry is a gatekeeper course for pre-health care majors. About 10% of enrollees 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 persistors, who did not drop the course.



Most students taking organic chemistry at UW-L 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 students must become more independent and self-directed in their learning.

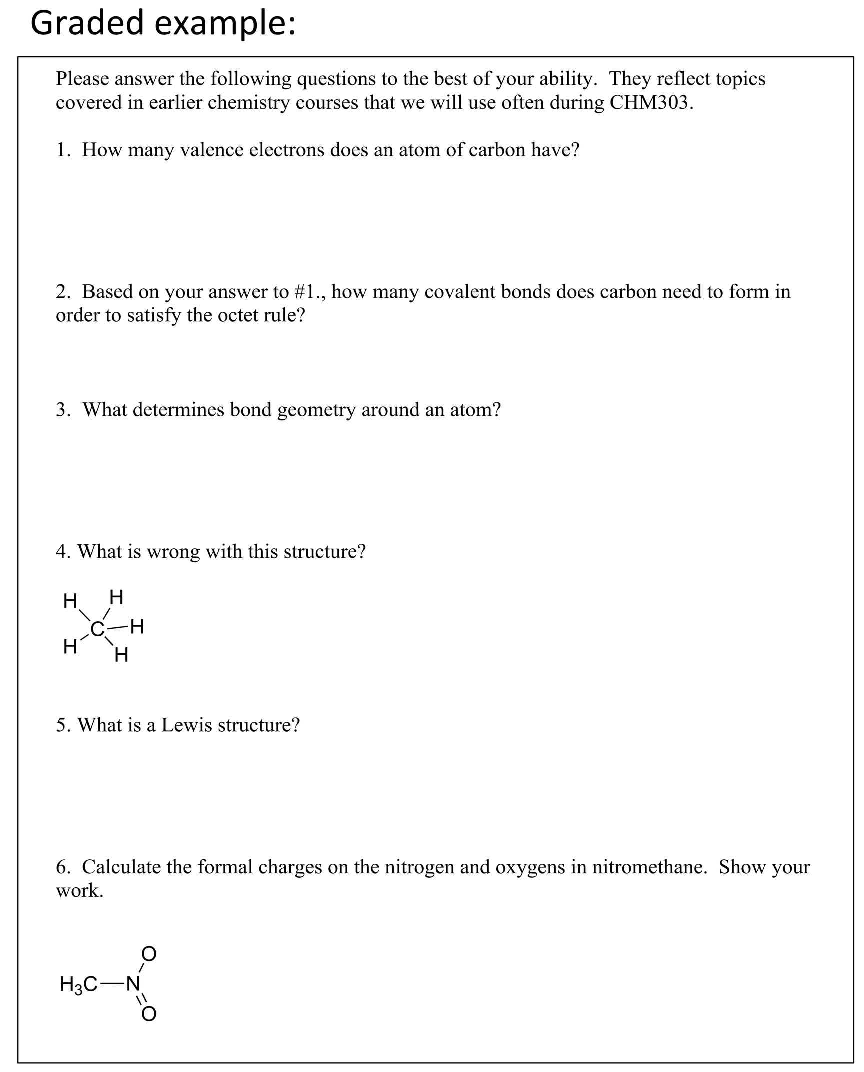
I believe a significant percentage of Drop/D/F students in organic never figure out how to study successfully on their own, and/or how to rebound after problem-solving failure. I hypothesized that forcing students to engage by problem solving in class could foster independent thought. The lecture hall 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 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:



Please answer the following questions to the best of your ability. They reflect topics covered in earlier chemistry courses that we will use often during CHM303.

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

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

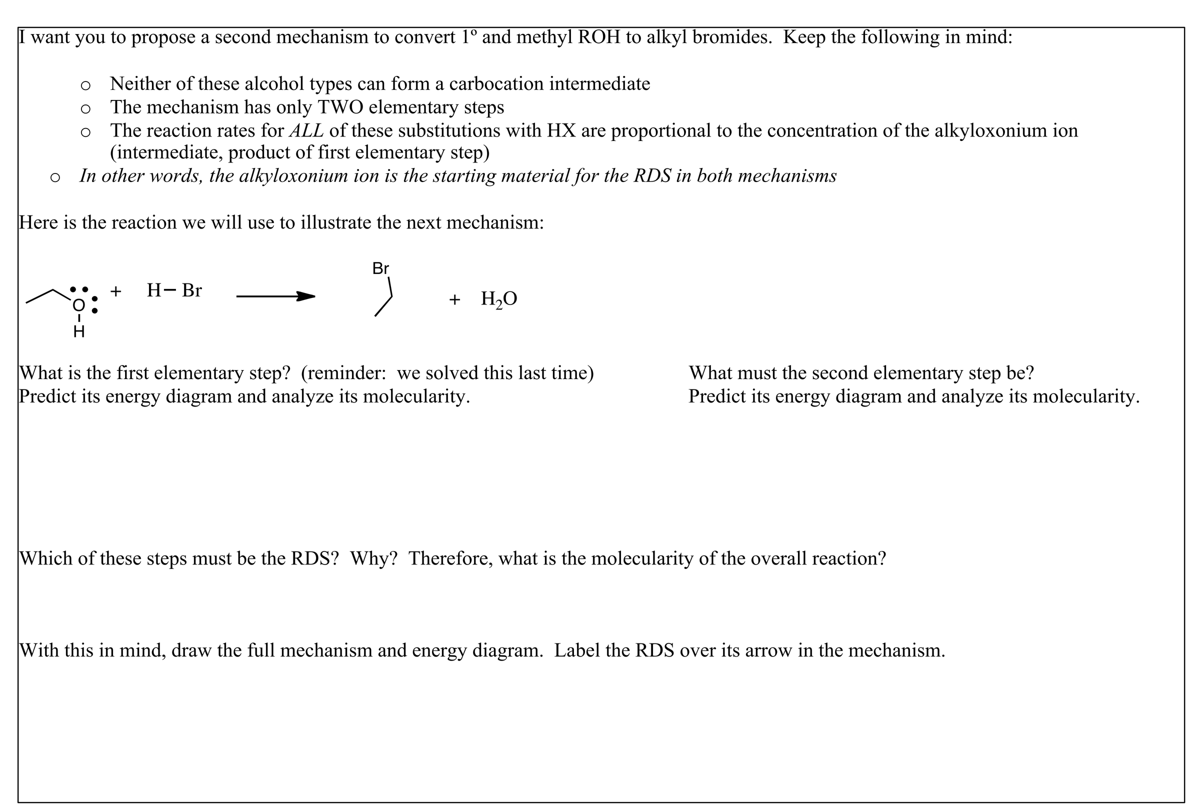
3. What determines bond geometry around an atom?

4. What is wrong with this structure?

5. What is a Lewis structure?

6. Calculate the formal charges on the nitrogen and oxygens in nitromethane. Show your work.

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:



I want you to propose a second mechanism to convert 1° and methyl ROH to alkyl bromides. Keep the following in mind:

- Neither of these alcohol types can form a carbocation intermediate
- The mechanism has only TWO elementary steps
- The reaction rates for *ALL* of these substitutions with HX are proportional to the concentration of the alkyloxonium ion (intermediate, product of first elementary step)
- *In other words, the alkyloxonium ion is the starting material for the RDS in both mechanisms*

Here is the reaction we will use to illustrate the next mechanism:

What is the first elementary step? (reminder: we solved this last time) Predict its energy diagram and analyze its molecularity.

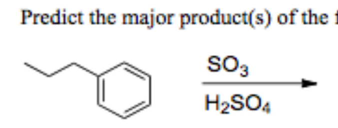
What must the second elementary step be? Predict its energy diagram and analyze its molecularity.

Which of these steps must be the RDS? Why? Therefore, what is the molecularity of the overall reaction?

With this in mind, draw the full mechanism and energy diagram. Label the RDS over its arrow in the mechanism.

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:

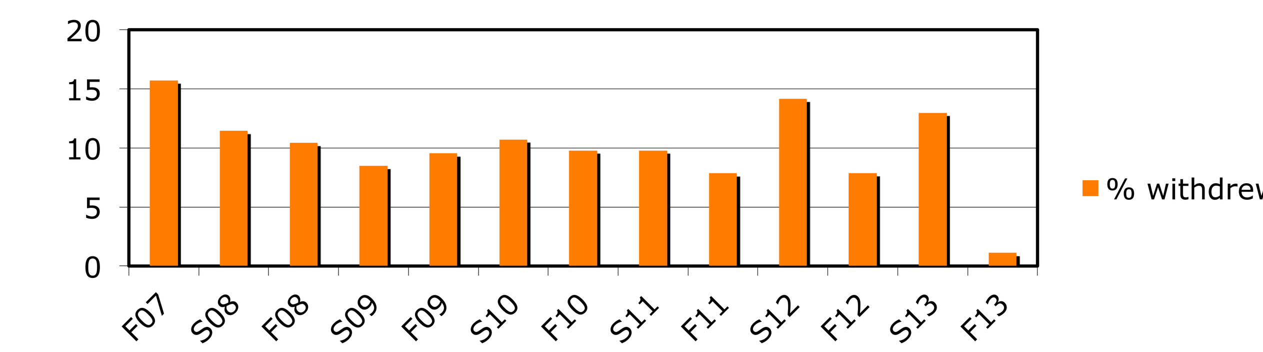
Predict the major product(s) of the following reaction.



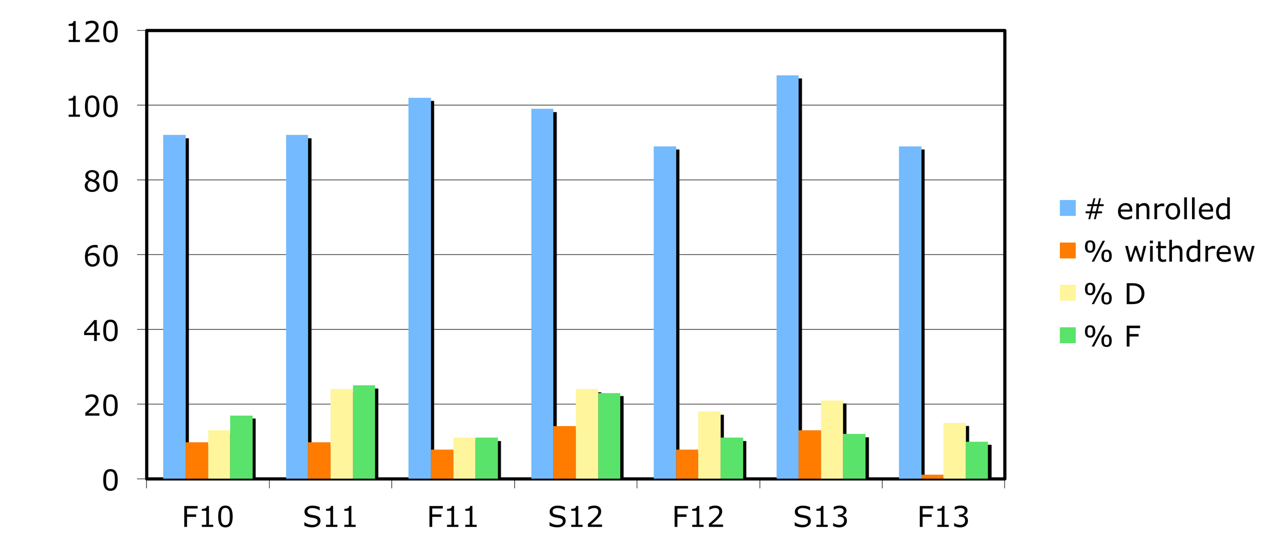
RESULTS

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 1% 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.

ACKNOWLEDGEMENTS

Funding for the pedagogy revision, as well as tactical guidance, were provided in summer 2013 by the Learning by Design program sponsored by the Center for Advancing Teaching & Learning at UW-L. Helpful discussions with W. Cerbin and A. Monte are also gratefully acknowledged.