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FROM THE ACS MEETING

TEACHING ORGANIC CHEMISTRY

Working cooperatively in groups, students take responsibility for mastering material

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The infamous, dreaded "orgo," a marathon of memorization. Unfortunately, that's how all too many college students view their first exposure to organic chemistry. Their trepidation is justified: One-quarter to one-half of beginning organic students don't do well enough to continue on to the next course, according to Jack A. Kampmeier, professor of chemistry at the University of Rochester, New York.

TELL IT LIKE IT IS **Zach Newby (left), a biochemistry major at the University of California, Santa Barbara, and Zachary Tonzetich, a chemistry major at the University of Rochester, explain what helped them learn organic chemistry.**

PHOTO BY PAMELA ZURER

Kampmeier spoke at a symposium on teaching organic chemistry, one of a series at the American Chemical Society national meeting in San Diego that focused on teaching the major areas of chemistry. The two-day organic session, sponsored by the Divisions of Chemical Education and of Organic Chemistry, included a number of presentations that showcased how cooperative groups can help students master the subject.

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At Rochester, for example, peer-led team learning workshops form an integral part of the beginning organic chemistry courses. Groups of six to eight students meet for two hours each week to work on problems as a team. Students who have previously done well in the course and have been trained for their role serve as group leaders.

"The workshop problems are structured to facilitate group interaction," Kampmeier said. "They're designed for exploring whether you really understand the big ideas." For instance, the leader might lay out spectra and other data and help the group work through the identification of a reaction product.

BY COOPERATING in small groups, the students learn to analyze problems and reason their way to solutions, instead of just memorizing and recapitulating what they've read or heard in lectures.

"That sort of development is exactly why you go to college: to learn to operate on your own knowledge, to make up your own mind, instead of operating on 'received knowledge,' " Kampmeier said. "People learn by doing things. In the workshops, students construct their own knowledge. As others have reported, the anticipation of having to explain yourself to someone else dramatically changes how you learn."

With peer-led team learning workshops, the percentage of Rochester students who enroll in organic chemistry, stick with it, and go on to earn at least a C– is 77%, significantly above the 66% who succeed with traditional lecture/recitation classes. The enhanced success rate manifests itself across the spectrum of students, male and female, minority as well as majority. Students participating in workshops receive higher grades, on average, as well.

When asked which aspects of the organic class contributed most to their learning, students identified the workshops and workshop problems as most helpful. The quality of contact and personal support of the workshop leader outranked lectures and quality of contact with the teacher in student evaluations.

"Being a peer leader is a hard job," Kampmeier emphasized. "The leaders need to understand the course content, interpersonal interactions, and pedagogy. One of the jobs of the leader is to make the group into a team."

AT ROCHESTER, leaders can be either undergraduates who meet with one group a week or graduate students who lead two groups a week as part of their duties as teaching assistants. The leaders receive training in a two-credit course that meets weekly and are paid a modest amount for leading the workshop.

The Rochester workshops are part of a much larger National Science Foundation-funded project on peer-led team learning that has been implemented in a number of institutions. First developed for chemistry courses, the model is now being used in some biology and

physics courses as well. Short courses to introduce science professors to the theory and practice of such workshops are being offered this summer.

The lecture portion of the beginning organic chemistry course at Rochester is still fairly traditional, Kampmeier said. At the University of Colorado, Denver, however, associate professor of chemistry Doris R. Kimbrough has introduced cooperative learning in informal groups as an activity that preempts class time that once would have been spent purely on lectures.

"The typical organic curricula are not very flexible," Kimbrough said at the San Diego symposium. "We've got so much we're expected to cover that we've developed this 'damn the torpedoes, full speed ahead' mentality. We're covering the material, but covering it doesn't guarantee that the students are learning it."

Kimbrough has been teaching organic with a blend of lecture and group activities. Lectures work well for introducing new mechanisms, functional groups, or theories, she said. In certain areas, however, students learn better by working together. "Stereochemistry is much easier to teach if the students are working in groups with models," she noted. "For interpreting spectra or applying a mechanism to a new situation, groups do well, too."

THE GROUP sessions take place during time slotted for lectures, so Kimbrough is able to wander around and help the groups. "It's cool, because you get instant feedback," she said. "It's easy to take the pulse of the class."

With such a blend of lectures and cooperative groups, "you can't cover all the standard material," Kimbrough acknowledged. "You are going more slowly, making sure the students understand. But they really learn what you cover. They learn how to learn organic chemistry. My perception and the students' perception is they are learning the material better, though less of it."

At the University of Missouri, Columbia, associate professor of chemistry Rainer E. Glaser also breaks his organic chemistry classes into small groups. The groups meet once a week outside the scheduled lectures to work together on projects that tie what they are learning in class to real-world chemistry that's in the news. The collaborative activities help the students solidify what they are learning and prepare them to be informed citizens, Glaser said.

"ONE OF MY GOALS in teaching chemistry is for the students to be able to walk out and use what they've learned in their regular lives," Glaser said. "For example, the new Administration's policies on carbon dioxide and global warming are currently under much discussion, as is California's energy crisis. Our economy is based on the combustion of fossil fuels, and the current controversies in the news open doors to discussion of alternative energy sources such as fuel cells."

For each section of his organic course, Glaser provides online links to recent news stories on topics related to chemistry. In conjunction with a chapter on nucleophilic substitution and elimination, for instance, students read a newspaper article on the proposed ban of five organophosphate pesticides. Online links lead to the structure of methyl parathion and to Glaser's editorial comments noting the potential for that compound and other pesticides containing good phosphate leaving groups to damage cellular materials. Questions guide students to think about the material, for which they are held responsible on exams.

"Use of the Internet introduces the students to major newspapers like the Los Angeles Times, the Washington Post, and the New York Times," Glaser said. "It broadens their horizons."

During the second half of the term, the collaborative groups each pick a current news article related to the science they are studying. They identify the underlying chemistry and build a website with links to related material and pertinent questions. The student groups then evaluate each other's work through a structured peer review process.

The news-based group activities "motivate students to come to class," Glaser said. "They have an increased interest in the lecture and get more out of it after the group sessions."

With a grant from the Camille & Henry Dreyfus Foundation, Glaser will host a conference in September to introduce faculty members to the "Chemistry in the News" approach. Once similar courses are established at other colleges and universities, Glaser said, peer review of the collaborative groups' websites could be expanded across campus boundaries.

Central to all the cooperative learning projects presented in San Diego is the goal that students become active participants in their own education. "Students need to take responsibility for their own learning and become more proactive," Kimbrough noted. "Working together, they learn to do that."

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STUDENT VOICES

Bottom Line: Organic Chemistry Is Intense But Doable

In most symposia on teaching, professors hear only from other professors. In San Diego, however, professors also learned from a panel of students who had taken organic chemistry.

The panel's advice to other students:

•"Organic is not as terrible as the rumors say, but it's labor intensive."

•"Read the textbook. It was my best friend for the better part of the year."

•"You have to study a little at a time; you can't cram everything in just before a test."

•"Go to class. Go to group help sessions even if they are not mandatory."

•"Work extra problems. Build models. Recopy your lecture notes--you may realize there are things you don't completely understand."

•"Model sets are a great resource. They're essential to understanding stereochemistry. There's nothing better than being able to hold a model in your hand and twist it and turn it."

•"Working on syntheses ties together everything you've learned."

•"If you know the underlying reasons why stuff happens, you can figure out a reaction you've never seen before."

Suggestions for teachers:

•"Professors should keep in touch. Misunderstanding snowballs. Teachers turn their backs to write on the blackboard and don't turn around until 10 weeks later."

•"Place more emphasis on the lab. Some of the most interesting things are learned in lab. Have students make observations for themselves."

•"Instructors should bring in their research and show how it is related to what the students are learning."

•"Use cooperative learning. In discussion sessions you get to know students; you're up-to-date weekly on what they've learned."

•"I'd like to see more correlation between the lecture and the lab. Finding out why things don't work fosters greater understanding."

•"Don't lower the bar. Organic is a lot of work and it goes very fast, but it's doable."

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