APPLICATIONS OF TECHNOLOGY IN TEACHING CHEMISTRY
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PAPER 12

THE COMPUTER CO-OP: TEACHING ORGANIC CHEMISTRY ON A CONFERENCE IN AN INTERDISCIPLINARY MACINTOSH LAB

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ABSTRACT
For 16 organic students in a pilot program at Central College, HCCS, lecture has been replaced by a computer conference. Site licenses (or lab packs) have been obtained for Beaker, Proton Nuclear Magnetic Resonance Spectrum Simulator, The Schatz Index, and Organic Reaction Mechanisms. Using these programs the students respond to questions posed by the instructor. Interaction takes place on-line between students, as well as between instructor and individual students. PacerForum, the conferencing software, allows graphics and sound transmission to augment the student essays. Student participation is critiqued by both the chemistry instructor and the English instructor, who is the director of the Computer Co-op. Initial results indicate improved chemical comprehension and clarity in written expression. Students come early to class!

2.0 OVERVIEW

2.1
After facing an organic chemistry class scheduled twice a week for three hour stints just after lunch--AND after being made aware time and again that memorization of arrows does not always seem to lead to real understanding of a mechanism --AND after suspecting that a concept expressed in one's own words reveals the depth of mastery (or, "You, too, CAN write an essay in organic chemistry!"), we decided to experiment with the structure of the traditional lecture part of a lecture/lab course. In the resulting pilot project, a computer conference replaced much of the traditional lecture portion for one section of the second semester of Sophomore Organic Chemistry. Inspiration for this basic structure came from the above-mentioned observations, and from the availability of a new instructional computing lab full of Macintoshes and free at the time of the class.

2.2

Central College, with enrollment of over 12,000, is one of 6 colleges of the Houston Community College System. At Central College, we teach about 5 sections of Organic Chemistry per semester. There were 16 students in the pilot project, which met in the afternoon once a week for a 3-hour lecture in the computer co-op/lab and once a week for a 3-hour lab in the chemistry lab.

2.3
The class consisted, generally, of three activities: an electronic conference held each week (during class) over the material assigned; a group activity (3 or 4 students per group) involving the study of mechanisms in motion on the computer; and guided examination of the introduction and methods portions of the experiments to be performed in that week's lab. This lab was a standard micro/macro set of experiments selected to augment the lecture.

2.4
Did the students learn using this method? The project produced mixed but (we feel) interesting results. From student performance on individual exams, from interestingly opposing evaluations from the students, and from a grade profile that is at least as good as prior years, we are enthused, intrigued, and curiously concerned about this form of teaching. When we turn to observational evidence from what our students did in the classroom, we see more double signals. Many students came early to class; they left class tired but NOT sleepy; they asked questions--other than what was going to be on the next exam. Students were occasionally frustrated; some students did not equate their active participation in the learning process with good teaching. All students became, we feel, better writers. By the end of the semester, their lab reports reflected a greter understanding of what to emphasize in experimental summaries.

2.5
This paper will detail what we did, what we were pleased with, what we were not, and what we are curious about.

3.0
THIS IS WHAT WE DID:

3.1
The class occurred in the Computer Co-op at Central College. This facility consists of two rooms of networked Macintosh computers used by various departments in situations ranging from entire courses scheduled in the Co-op to classes meeting there once or twice a semester. The Co-op serves additionally as a site for out-of-class communication and learning. The other courses using the facility range from English, to various social science courses, to marketing, art history and beyond.

3.2
The room used for this particular class contains 20 Macintosh LCII's operating on an Apple Share network connected by

phonenet connectors and using a file server (as a place to store assignments and student files). The computers all have color monitors, and students have access to laser printers. Each computer is loaded with a word processing program (Microsoft Word), an electronic conferencing program (Pacer Forum), and several chemistry programs. We obtained licenses for 20 computers for Beaker by Joyce Brockwell, et al. (Brooks/Cole) and for Proton Magnetic Resonance Spectrum Simulator by Kersey A. Black (J.Chem. Ed. Software.) Lab packs (for only 5 computers) were also obtained for the Schatz Index by Paul Schatz (Falcon Software) and Organic Reaction Mechanisms by Jeffrey B. Buell (Falcon Software).

3.3
Students would choose the program they wished to launch by clicking on buttons presented through At Ease software, making opening programs effortless and helping protect the hard drives of the computers from prying, curious eyes. Students had open access to the Co-Op every afternoon (except when reserved for class instruction) and some evenings and weekends. The interdisciplinary nature of the lab was reinforced by how we worked together. Carolyn Judd structured the class and provided basic training in the chemical aspects of the chemistry programs. Robert Ford, as director of the facility, provided additional training, support, and assistance with the use of the computers. He also supervised the part-time lab assistant who helped with programs, printers, and cable problems.

3.4
ELECTRIC CONFERENCING

3.4.1
The electronic conferences were conducted over PacerForum, which supports graphics and sound as well as text. This is a fairly user-friendly conferencing program, one that operates through buttons for each conference being maintained on the system. Students would choose the conference they wished to enter by clicking on its button. They would then scroll through the opening messages from the instructor and then click another button to type and send a message to the teacher. The Macintosh operating system makes it easy to jump from one program to another. As a result, a large part of the conferencing time consisted of students going from PacerForum to one of the chemistry programs for an experiment or observation and then to Microsoft word to copy data and then back to PacerForum to send a message to the teacher.

3.4.2
When they entered the classroom, students were presented with a short summary of the material assigned for the day (prepared in advance by the instructor). Then a question was posed, to which students responded. Sometimes the questions were very particular: "Identify the compound for which the NMR Spectrum and the molecular formula is given over the PacerForum conference session." Students were asked to respond in complete sentences, explaining the chemical shifts

and the splitting pattern. Students would be allowed access to their textbooks, as well as to the four computer programs available for their use.

3.4.3
This type of exercise was the best, because the students were able to verify the correctness of their answers by accessing their proposed structure from either Beaker or Proton Magnetic Resonance Spectrum Simulator. The interpretation still had to be sent over the PacerForum. Each student received a response from the instructor on the answer submitted; all on the conference were immediately able to see all responses from the students. During the course of the class session, the teacher would send responses; all would see these as they were posted. Usually comments from the teacher included posing another question for the student to consider. For instance, if the original spectrum had been for ethanol, then the instructor would ask the student to explore the spectrum of chloroethane, 1-propanol, etc. Each student would be given a slightly different response, based on the response he or she had provided. Thus, as the class progressed, the conference contained multiple interpretations of the same data or example.

3.4.4
The Macintosh operating system (System 7) allows students to use more than one program at once, so while a student would be examining a question in PacerForum, he or she could access the Proton Magnetic Resonance Spectrum Simulator, consider and develop a response, and then jump back to PacerForum to send a response. Usually, the students also went on to consider other compounds, furthering their understanding of NMR spectral interpretation. Their responses in PacerForum included some of these observations.

3.4.5
In another conference, on the discussion of allylic carbocations, Beaker was used to help students see the result of the addition of HBr to 1,3-butadiene (can we say enough about Beaker -- just in reinforcing correct nomenclature?). Selecting "Perform a Reaction" from the Menu of Beaker, the students could see the possible products (1,2-addition vs. 1,4-addition.) The mechanism is shown for both additions, including resonance structures; students could study the mechanisms as many times and as long as desired. The response from the students (sent through PacerForum) might predict the major product and give a rational for its preferred formation -- again in complete sentences to explain what the student observed.

3.4.6
In another conference, students were asked to compare mechanisms of the acid-catalyzed hydration with the base-catalyzed hydration of a ketone. They were asked to discuss the differences in the first steps of the mechanisms, whether the intermediates had charges, the shapes of the intermediates, and the final product. Students were asked to

explain why catalysts were needed.

3.4.7
During all of these activities, students could answer the questions at their own pace. The entire conference could be printed and taken home by the students -- or they could print just the specific sections they wished for review. A side benefit of all of the time spent using the computers is that the students became quite capable at fairly complex uses of the computers (as they used, perhaps, four programs at once, accessing both the hard drives of their computers and the storage areas on the file server). Throughout the semester, also, students received assistance with the operation of the computers and the printers, and with accessing programs and saving documents. Another benefit lies in faculty computer training -- we now have at least one faculty member in the English department who is an expert on Beaker; he's trying to figure out how he could use this program to launch composition students into a writing assignment.

3.5
GROUP ACTIVITY

3.5.1
In the group activity, students gathered about the 5 computers loaded with the Schatz Index and Organic Reaction Mechanisms. The purpose? To observe the reactions these programs simulate, to see how the molecules move as the reaction occurs. We were able to load these programs on only five machines, so students were forced to work together for these activities. We could have demonstrated these reactions using an LCD panel, but we didn't for two reasons. First, (the embarrassingly practical reason) our LCD panel was on order but didn't arrive during the course of the semester, and, second, we wanted the students to work in small groups. While the first assignment required them to WRITE to each other, this assignment encouraged them to TALK to each other about what they were observing (HEY!). In these discussions, to augment the NMR Spectra studies, the real spectra provided by the Schatz Index were considered and compared with the simulated spectra. The Schatz Index also provided quick access to hundreds of actual IR spectra.

3.5.2
The more complex mechanisms studied in the second semester of Organic Chemistry often leave students with hurting brains and no clue about the directions of movements of arrows. Organic Reaction Mechanisms provides a marvelous addition to the written page or blackboard, because it shows mechanisms in action. Several of the mechanisms also show graphically the role of the solvent. Students discussed the mechanisms, going back over parts, looking at the written descriptions, and especially at the resonance structures.
Because of the condensed nature of the material presented by Organic Reaction Mechanisms, a group of students discussing it all together was reasonable.

3.5.3
Where was the teacher during these observations? Various places. Sometimes, she directed the students at individual terminals, helping them see how they should use the programs. Sometimes she was sending messages through PacerForum in response to the earlier messages. The next time this course occurs this way, the teacher will most likely also be using an LCD overhead display to keep the entire class on track. Sometimes, five small groups ended up veering in different directions. However, even with the addition of the overhead, we still want the students to work in groups, to encourage the collaborative discussion.

3.6
LAB REPORTS

3.6.1
Can guidance in the writing of the introduction and methods of a laboratory experiment help with the student comprehension while he/she performs the experiment? This is a question we had at the start of the class; one we are still curious about, but one we feel we saw some results. Early in the semester, students were given an outline of the proper way to write a lab report. Our hope was that we could turn out better lab experiment-ers if we could help our students write with clarity. Therefore an half-hour of lecture class was devoted to writing about the lab to be done that week. This assignment was done through the PacerForum conference also, to encourage sharing.

3.6.2
Toward the end of the semester, after reviewing lab reports, we devoted one hour of lecture time to a joint discussion of a good lab report from a prior class. Based on a writing teacher's understanding of a chemistry teacher's goals, expectations, and needs from a lab report, we emphasized the importance of clarity of thought, transitions between sections, the use of examples of color, time, or texture, and conclusions that follow the results actually experienced by the student -- not just those suggested by the basic procedures. Ten percent of the grade of the lab reports was based on these emphasized points, because we wanted students to view the writing of these reports as a serious undertaking.

4.0
THIS IS WHAT WE WERE PLEASED WITH:

4.1
The mechanisms depicted in modern textbooks are great -- color coordinated, etc. We cannot do as well on the chalkboard. The computer conference augments, rather than re-creating, the textbook. It adds another way to learn. Can enough be said for 3-hours of activity, rather than sitting in a desk? Especially since the class occurred during and after the lunch hour, we feel that the energy we felt in the class was a real strength, although a relatively simple one,

of this form of instruction.

4.2
A comment from one student: ..."I have gained a lot of knowledge from the instructor, the extremely user friendly Macintosh computers, the use of PacerForum, which allows the students to as well, TEACH EACH OTHER,..." Because of the conference, the students all seemed part of a larger whole. The students often discussed answers to the questions posed, but did not ever copy from one another. Our class became one big study group, one collaborative team investigating the subject.

4.3
Obviously, not as much material can be covered with this question and answer format. The emphasis was on learning the basic mechanisms well and therefore building a foundation so that application of that knowledge could be made by the students. The attempt is to make our students expert in basic mechanisms.

4.4
Careful inspection of the mechanisms in Organic Reaction Mechanisms prompted questions from our students about small differences between these mechanisms and those in the textbook. A real attempt to UNDERSTAND, rather than just memorize, mechanisms came from the discussions about these subtle differences. Students realized that most mechanisms are not engraved in marble, and therefore students might actually try to figure out a mechanism.

4.5
The student retention rate was improved. Student achievement as measured by exams showed improved scores on two exams and depressed scores on one exam when compared to prior classes.

4.6
Laboratory experiences were much improved. Students did come to lab prepared, they did know better what they were going to do, and the reports of ALL the students were of a higher quality. We feel that this result derives from the students having to explain themselves in the PacerForum conferences. They couldn't just give "right" answers. They had to explain what they observed, in effect participating in the discussion of science.

5.0
THIS IS WHAT WE ARE NOT HAPPY WITH:

5.1
Sigh--this is the hard/honest part of this paper. Here goes: a student writes, " ... The teacher when asked a question either answers with a question or gives you an answer which literally confuses you more than before. As a student I am here to be taught and when there is no instruction by the teacher, why should we call it a class, when we are all on our own."

5.2
Change is frightening, and many of our students need reassuring. As we've reviewed this semester's experience (and as we've constructed the paper you're reading right now), we realize that although we see benefits of this form of teaching, we're also even painfully aware of our shortcomings. In our enthusiastic experimental mode of early in the semester, we didn't emphasize enough the goals and objectives of the experiences the students were about to begin. We needed to contrast this course with their previous chemistry classes, to give them a greater understanding of the nature of our focus. We know that receiving a question as an answer to another question is confusing, but we also view such a response as an incentive to press further. Unfortunately, we didn't convey this idea/goal as clearly as we should have. Thus, we know that we should devote more time and attention to explaining that this course will not follow the usual pattern of instruction. We also need to delineate the goals for the course more clearly.

5.3
Quite properly, some students pointed our that our method left out some auditory learners. In the future, about one-third of the lecture time will be devoted to a vocalization of the goals for that day, and verbal summaries of the points covered at the end of each session. We probably used the computers more than we should have; we will not use them as exclusively.

5.4
We're also aware that we need more materials to fuel the activities of this sort of class. We simply ran out of good commercially available software to explore this course. Some is on order for our next experience in the lab; some is under development at our school, supported by a new administrative office here, Instructional Computing, and their staff of trained, curious, enthusiastic programmers, artists, and writers. We also now have access to a videodisk player controlled by a computer. With some new software we should receive this summer, students can explore video images of chemical reactions, either as a group or at their own pace.

6.0
THIS IS WHAT WE ARE CURIOUS ABOUT AND THEREFORE POSE THESE QUESTIONS FOR DISCUSSION:

6.1
Can non-experts learn from each other, especially in a complex field like Organic Chemistry?

6.2
Why is Organic Chemistry often identified as the hardest course a student takes? It is not the quantity of material (biology has millions of terms). It is not the math. Do we pride ourselves in its inaccessibility?

6.3
Consider a research lab, with a lot of collaboration going on. Can we achieve some of that excitement if we encourage student collaboration during lecture?

6.4
Can anyone lecture for 3-hours after lunch -- can anyone really listen for 3-hours?

6.5
Can writing lead to understanding? Does better writing reflect clearer thinking?

6.6
How much material can be cut from a course without discrediting the course?
Can we agree on a bare minimum of general mechanisms and principles, with which our students will be able to tackle more advanced courses?

6.7
Memorizing tons of mechanisms does not lead to mastery, but can understanding the basic mechanisms lead to mastery?

6.8
The network itself depends upon the teacher. What are your experiences and ideas about teaching through electronic conferences?

6.9
With the help of appropriate software, can we make experts of our students, even the beginning organic chemistry students? Can they explore and verify the correctness of their answers themselves?

6.10
Finally, based on all of the above, do we serve as teachers if we only help provide the directional signposts?