CAC Report

Jay Baltisberger
4/15/97

Chemistry Teaching Techniques and Other Related Projects

Introduction

The format for teaching chemistry courses has traditionally been the standard lecture with limited involvement by the students in the actual classroom experience. Active learning by students has primarily come from the laboratory component of these courses. The main reasons for this probably stems from the intrinsic difficulty in reaching the "cutting edge" of knowledge in a field as developed as chemistry. Even in upper division courses, students address few real problems which have not already been solved. Under these circumstances it is difficult at best to inspire students to actively participate in the learning process. I have attempted to improve my chemistry courses (CHM 261 & CHM 262, physical chemistry; CHM 121 & CHM 122, general chemistry; CHM 113, nursing chemistry, and GST 232, natural science) through the introduction of techniques borrowed from my colleagues in the humanities which promote active learning. The successes and failures of these techniques in my courses is partially documented, though complete data analysis will not be completed until January 1998.

General Chemistry

In the general chemistry sequence two major changes were attempted. Both changes were designed to encourage students to prepare for class actively. The primary goal was to give incentive to read the chapter assignments prior to each lecture and be accountable for this reading. Unlike a small discussion section in a writing course, the larger general chemistry section is not conducive to student discussion. We have a very specific quantity of material which must be covered and we do not have time to arbitrarily wander down dead-end academic roadways. While student lead discussions can be quite fruitful in some other introductory courses, in general chemistry the students lack the fundamental knowledge to really push their fellow classmates and extend the knowledge of their peers. In addition the large size precludes most students from having the opportunity to participate extensively. I adopted a more primitive but relatively effective tool of daily quizzes. This entailed a short multiple choice problem designed to be answered without extensive calculation but requiring knowledge of the current lecture material. The goal was first to encourage reading ahead and second to pinpoint specific problems which we can answer over the course of the lectures. In addition, these questions are used (often in identical form) as the basis for portions of the midterm exams (each test had 5 multiple-choice questions worth 20 points of 100 total). Students see these same sorts of questions when facing the standardized exams given at the conclusion of each course sequence as well as on tests such as the MCAT (Medical College Aptitude Text) or GRE (Graduate Record Exam).

The second change involved daily journal requirements. This basically was designed to encourage a better study style than most students had learned from high school. Because most students in general chemistry are freshman who have never previously been academically challenged heavily in their lives, the concept of using a journal to improve classroom and examination preparation was probably a bit mysterious to them. Basically, students were required to turn in a minimum of one page each week from a duplicate entry journal which detailed the times, dates and material studied for every day that week. Students were encouraged to go beyond the simple bookkeeping to include notes (for example recopying lecture notes, transcribing or interpreting book reading or listing formulas) as well as problems. In particular, I encouraged students to use the journal every time they opened their general chemistry textbook. While this utilization of journals is quite powerful, most students did not proceed beyond the minimum journal requirements. Grades were given each week and constituted about five percent of the total class grade. Unfortunately, since my minimum requirements were relatively easy to achieve (and rewarded students with 70% to 80% of the available points) many students choose not to do anything extra with their journals. I think the idea of using journals has a great deal of potential but is difficult to implement due to the massive grading requirements as well as the general apathy of the students. Ironically, the ones who worked hardest on their journals were often students who didn't need the extra help. Finally, one common factor observed in many of these journals was the poor decisions made in terms of time management by many students. Often times students would proudly tell me they worked on general chemistry for 2-6 hours in a given week in which there were 3 hours of lecture and 3 hours of laboratory work for the course. Many faculty would agree that a 1:1 ratio of in-class to out-of-class time is probably not sufficient to achieve optimal performance, and unfortunately most of these students demonstrated that was true.

Physical Chemistry

The physical chemistry courses are designed for Junior and Senior chemistry majors. In general, they in general are much smaller in size (between 5 and 20 students) and are at a much higher difficulty level than general chemistry. These course tend to build upon the concepts learned in general chemistry and other chemistry courses. Students discover very quickly that very few problems in physical chemistry can be solved by the simple "plug-and-chug" approach favored in general chemistry. In addition, many of the results are difficult to visualize (for example, calculating $(\partial S/\partial T)_P$ or other derivative functions). A number of techniques have been attempted to improve the learning environment in physical chemistry. The first of these was the idea of having a student do a "problem-of-the-day" in front of the class, the second involved allowing the students greater control over the laboratory portion of the course and a third method attempted more group projects and grading.

The “problem-of-the-day” approach was derived from a methodology discussed in small group setting with Ed McCormack, which he used in his business classes. In his approach, each day the discussion might be lead by two students chosen at random from a hat. In the application to physical chemistry, I select student names at random each day. I use a weighted average approach so that students who have successfully completed a problem have a lower probability of being drawn. The student who is drawn each day is responsible to produce a problem on the board related to the current lecture material which is taken from the problems in our textbook. Alternatively the student may select a similar problem from other textbooks which are available in the library. If a student fails to have a prepared solution, this student is penalized by an increased probability (by an amount equivalent to losing one problem of the day) and the next name on the list is used. If more than four names fail to have finished problems then a volunteer is selected. I prefer to not select volunteers as these tend to be the same students over and over (those who are always prepared.) Some students have a lot of difficulties being prepared and thus tend to fall to higher and higher probability. In practice, this ultimately forces these students to bring worked problems to class. I have not had to penalize students more than one or two times in general. There are no points affiliated with the problem of the day and students face no pressure for getting right or wrong answers. If errors are detected, we talk through them and fix them in class. Many times the students choose some of the easier problems and thus the exercise is not particularly valuable, but other times they choose very insightful problems which stimulate discussion and answer difficulties students may have had. I have not found a consistent method for attracting students to the later variety of problems. This exercise tends to use a moderate amount of class time (probably 10 minutes per 50 minute lecture) and thus is questionable in terms of the time value. In general these courses are already very difficult to finish all the material on a standard syllabus in the allotted time and this sort of technique certainly can slow down the material. The big advantages seem to be the extra preparation students spend before classes.

The second technique of student control of laboratory experiments has been more successful than the “problem-of-the-day” technique. What I basically have done is allowed students greater flexibility in choosing their laboratory assignments. This is initially accomplished at the beginning of each semester by requiring the students to read the Journal of Chemical Education and select a physical chemistry experiment (there is usually about one every other monthly issue that is appropriate.) Students then present the experiment to the class in pairs in an oral presentation with a “proposal” format. That is to say, the pairs are attempting to “sell” their lab experiment to the class. Once all proposals have been presented, we vote as a class as to which experiments we wish to pursue. In addition, previous “working” laboratory experiments are added to the available list of experiments. No more than two or three new experiments will be attempted on any given semester (due to the difficulty in building new apparatus and uncertainty in success). On the whole we have created about four or five new labs in the physical chemistry courses which I have added to the "working" list. These experiments tend to be innovative and fun for the students, with such topics as "Photophysics in a Disco" and "Liquid-Liquid Phase Diagrams" added to the successful experiment list over the last year. On the whole, the physical chemistry laboratories are meant to only sample a tiny portion of the massive number of physical chemistry possibilities. As such, choosing different laboratory experiments each year does not adversely affect the students since there is no single lab which I would consider "essential" to continuing success in chemistry.

The final methodology employed was the idea of increased numbers of group projects. Essentially, chemistry is a group science in that almost all research and laboratory work done in the real world is performed by teams rather than individuals. In this regard, students need to recognize the importance of and participate in group experiences. The kinds of group activities that are involved in physical chemistry revolved primarily around laboratory experiments in the past. Most often the students work in groups of three or four while performing the experiments as well as writing up formal laboratory reports in groups. In addition, while not formally graded in groups, homework assignments are routinely solved in a group setting by the students outside of class. I have attempted to add more in-class group projects in the form of in-class exams which are solved in a group format. One student nicknamed this a "communist" style of examination with rather derogatory implications. A similar project I attempted was to have a "communist" style take-home exam. In both cases, a few students felt that they had to work harder than they normally would have and were irritated that they got the same grade as their peers. These students preferred to stand on their own merits and not share grades with other students. Some of the weaker students seemed to enjoy the interaction as well as the improved grades. On the whole these new attempts to engage the students in more group activity have not been well received and are not something I recommend.

In conclusion, of all the modifications implemented in physical chemistry, the most successful were those involving the students in the selection of laboratory assignments. The students greatly appreciate all efforts to hand the controls over to them. The "problem-of-the-day" has been continued this year and has had limited success. I think my mind is still wavering on the educational value relative to the time required for this exercise. Finally, the idea of group grading, while useful for laboratory and homework assignments, seems less useful and poorly received in the form of examinations.

Nursing Chemistry

In the nursing chemistry course, some of the same modifications tried in the general chemistry course were applied here, including daily quizzes and journal entries. Again, the results are similar to those in general chemistry. The journals tended to be used mostly as a bookkeeping notebook saying "I studied 3 hours on...." and not really a notebook to record questions about reading and lectures. Few students seem able, at least at this level, to use the journal effectively as a study tool. They tend to view it as something that needs to be a well-written and polished final result rather than something that is a work in progress intended to aid them. They tend to focus on the time details more than the real questions. In terms of the quizzes, I feel that the daily quizzes help the students learn in a similar fashion to the learning which has occurred in general chemistry. Nursing students cover very similar material (at least in the first half of the course) and arrive with weaker backgrounds usually. As such, the quizzes give the students a basis to help study for exams and to prepare ultimately for the standardized exams they will take throughout their careers. The other innovation in nursing chemistry comes from using the world-wide web (WWW) as a means to help students monitor grades in the course. Each student was assigned a secret individual code which could be used to access their own grades as well as the grades of the course as a whole. The WWW published gradebook gave them percentages and ideas about how they stood in the course (estimating current grade). The students used this resource some, but it was difficult to keep the gradebook current as the tools I used for putting the information on the web were probably not sufficiently advanced to make the task easy. I think the future of this type of open gradebook approach is growing as more web tools are developed. This is more than just a simple easy route to checking grades though, since it frees the students from having to wander in and face me one-on-one. If they feel ashamed, perhaps it provides them a way to see the whole picture without feeling embarrassed. I am not sure that this is a positive side-effect, since students feeling this way maybe should be visiting me on a more regular basis. On the other hand, any method to encourage students to take an interest in their performance cannot be all bad. On the whole, I think this technique is very promising but just not something I am ready to do on a regular basis yet.

Natural Science

Natural science is a course required of all students at Berea College and is generally feared, hated or loved. Few seem to leave this course without some strong feelings, some positive and some negative. Two major changes I have been working towards in this course involve changing the content and changing the format. This is a team taught course, so the opportunity to institute effective change is somewhat limited and rather slow to happen. Still, I feel my comments have been heard and taken seriously by the senior faculty members involved in the course and in fact I was given the opportunity to teach this course (along with Megan Morgan-Carr and Eric Pearson) in the summer of 1996. In the smaller summer school setting we tried some ideas out which were new relative to the format as taught in the spring and fall terms normally. One of the ideas was the abolition of the lecture notes and requirement that students actually read the textbook. A second involved adding a large number of "laboratory" experiments to replace some of the traditional discussion sections. Finally we tried to add a little fun and relevancy by showing some different evening movies to help remind students of the role of scientists in the public eye. These changes seemed to be well received by the students, though I am not sure we can document a specific change in overall happiness with the course or in terms of total information retention. I think that natural science, like all courses, should be continuously evaluated and changed as the students attitudes and abilities shift from year to year and decade to decade.

Chemistry Seminar

Our chemistry seminar course has traditionally been a capstone course to allow us to evaluate the relative preparation of a graduating senior to successfully read a current journal article and present it intelligently in front of their peers. The writing and speaking components have focused on the lead article extensively with presentation format and literature references being of high concern. I have recently added a concept I learned about from Ed McCormack and Tom Boyd involving interviewing as a means of evaluating the preparation of our seniors. In the spring of 1997 we added the requirement that each senior turn in a final-draft resume and complete a mock interview with myself (the course instructor). In this interview I have the opportunity to ask questions about the student's chemistry background which may not be rehearsed as might be the case of the senior seminar. In addition, the interview provides us an opportunity to track where our students are headed after graduation both long and short term. Finally, I have used these sessions as a chance to try to tune up any presentation problems a student may have. If they include something on their resume, they should be prepared to discuss it intelligently and to some degree of depth. I have tried to illustrate the kinds of questions a student may encounter from a prospective employer evaluating a resume. I think it is a relatively low stress and high productivity meeting that lasts no longer than 30 minutes and allows the students to really ask some questions they might not have had the opportunity to previously. On the whole, the students who have undergone this evaluation seem to appreciate it. Again, the time commitment is small and the potential benefit is well worth the energy it takes to achieve it.

Interdisciplinary Majors

I have been working the last five months on the development of a proposal that the college include in the catalog interdisciplinary majors, specifically in the areas of biochemistry, chemical physics, earth science and others. This idea stems from discussions I have had with other faculty from other institutions through my Project Kaleidoscope connections. Many students these days seem interested in the hot topics and our traditional majors do not always carry the flash that maybe “biochemistry”, “applied computer science”, “chemical physics” or “polymer chemistry” might have. The ideas about interdisciplinary majors are not new and in fact the current college strategic plans seem to point us in that direction. As well, many of the national organizations (National Science Foundation among them) have been suggesting similar ideas. This is one proposal, however, that I will not be able to complete entirely on my own, so I view my work in this area more as a dialogue facilitator. I opened this dialogue at the fall science faculty retreat and felt that some were open to these ideas. As in all things there are a diversity of ideas and problems that need to be dealt with before any such proposal becomes a reality, but I think that it is a good project for me to be involved in and pushing forward as best I can.

Conclusions

In conclusion, the CAC4 project has been very rewarding personally. I feel I have learned a great deal by talking with my colleagues in other departments and these ideas have been translated into real applications in the classroom. Many of the readings and other materials were highly useful (I would especially recommend the *Classroom Assessment Techniques* by Angelo and Cross.) I plan to continue analysis of the materials I collected over the various courses I have tried new ideas. The net result will probably be additional experiments followed by more refinement. I am not sure it is productive to necessarily try to “reinvent” any given idea, but it certainly doesn’t hurt for met to tax my intellect occasionally and challenge traditions. Even if traditional techniques prove to be superior, insights learned in new ideas can always be translated back into useful applications.