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Of Special Interest

# Report On "The Sophomore Physical and Inorganic Courses"

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*For students who take organic chemistry in the first year, this means an effective elimination of any kind of traditional general chemistry course….*

In this workshop, Mark M. Banaszak-Holl and M. David Curtis took turns elaborating on the recent changes and evolution of The University of Michigan's introductory inorganic chemistry course, in light of an initial switch to teaching organic chemistry as a first-year chemistry course. The resulting weaker background of second-year students in traditional chemistry, particularly in physical chemistry topics, was noted. This situation prompted the following changes: creating a new physical chemistry course for second-year students to make up for the deficiencies in physical chemistry

"The Sophomore Physical and Inorganic Courses" by Mark M. Banaszak-Holl and M. David Curtis was presented at the "Day 2 to 40" workshop symposium held May 10–11, 1997. The two-day event was held in the Willard H. Dow Chemical Sciences laboratory building on the central campus of The University of Michigan in Ann Arbor, Michigan. Each of the articles that comprise this issue was written by one of the group of reporters whom I asked to attend each session to take field notes and then follow up with the session leader and participants afterwards.

*—Brian P. Coppola, Proceedings Editor*

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and narrowing the syllabi topics in the following inorganic course. It was reported that the overall curriculum shift brought about a fundamental re-evaluation of how teaching is approached at U of M with respect to the role of the person of the instructor as a traditional "purveyor of facts" or a "motivator of learners." The use of Internet/multimedia sources to streamline class organization and improve learning were presented, including a proposal to integrate an interactive online question-and-answer site for the inorganic course. Interaction with workshop participants focused somewhat on comparative aspects of these curricular changes to their respective educational institutions but most heavily on test making and grading styles. The major problems associated with the curricula shift at U of M appear to have been identified and addressed, and work is continuing on further fine tuning of the classes.

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## Chronology

1. Workshop participants are questioned as to their experience with teaching organic chemistry in the first year; all participants, with one exception have no experience with organic chemistry as a first year course. A survey of the course titles to be discussed and their sequential ordering in the chemistry major were given: first-year organic chemistry, CH 210 and 215 second-year physical chemistry in the fall, CH 260 and inorganic chemistry CH 302 in the winter semester. It was noted that organic chemistry has been taught as a first-year chemistry course at the University of Michigan for eight years now, though CH 260 has only been taught for three years.

2. The new course for physical chemistry, CH 260, was presented as a solution for the first problem this curriculum shift caused: a deficiency of physical chemistry skills for students entering the second-year inorganic chemistry course, CH 302. CH 302 was reported to be overloaded with material to cover, and fierce disagreement amongst faculty members over what exactly should be in the syllabus further accentuated the need for a new course. On the side, workshop participants agreed that analytical chemistry is easier to deal with in the grand scheme of things, and so its relevance to this discussion was recognized as being small.

3. The workshop leaders presented the syllabi topics for CH 320 and CH 260, and they then discussed the teaching goals of these courses. CH 302 has recently been

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S 1430-4171 (98) 01178-7

offered in two "flavors" each year, taught by different instructors in different sections. Currently materials science and bioinorganic chemistry are the "flavors" available for CH 302. The teaching goals are the same; only the examples used to communicate them are different. It was emphasized by workshop leaders that the current U of M curriculum is not specific to a given sequence of classes, but seeks to provide a general framework for any arrangement of curricula by setting well-defined goals that meet the student's needs. The reasons for placing organic chemistry first are presented primarily as psychological, not academic.

4. The influence which engineering students have had on the course structure was given as an example. Engineers prefer the "case-study" method of approaching problems, rather than spending lots of time learning first principles. This approach has been applied to both laboratory and lecture in the materials science section of CH 302 to diversify the learning experience.

5. The grading and examination styles for CH 320 and CH 260 were explained. An absolute grading system is used. Tests and assignments are given more frequently in CH 302 due to the perceived or real difficulty of the subject material. The rationale is to give students more practice at the subject matter, and more opportunities to make up for low scores.

6. Web/Internet resources are introduced as a supplement to current teaching tools for CH 260 and 302, and they are eventually intended to be a major resource for students. The CH 302 home page is demonstrated with multimedia tools. It currently is being used as a place to obtain reading lists, homework assignments, practice tests, and other text-based course material. It contains links to other chemistry sites relevant to the course.

7. Before workshop leaders had a chance to elaborate on future directions for the webpage, participants initiated a lengthy discussion on test taking and grading styles, prompted by the previous discussion about using an absolute grading scale. After much debate on the absolute (vs. curved) grading scale, it was agreed that the absolute grading system is the best.

8. A number of additional topics were discussed in relation to grading. Giving "redemption points" to students who improve performance over the course of a semester is mentioned. Types of cheating, how to deal with cheating, and the

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http://journals.springer-ny.com/chedr

S 1430-4171 (98) 01178-7

recommendation of David Harpp of McGill University as an authority on dealing with cheaters was also explored. Multiple choice versus written exams was also debated. It was agreed that written exams are a better gauge of student ability and harder for students to cheat on.

9. Banaszak-Holl resumed discussion of the Web, with an explanation of "Answer Gardens" and their application to peer learning in the course. It was noted that "Answer Gardens" are already being used by beer-making communities on the Net, and software for their construction is available.

10. Answer Gardens allow the community of garden visitors to help each other out with advice and then collectively evaluate that advice in an abstract way (Social Information Filtering Technology, SIFT) to inform future visitors which advice seemed to be the best. This new approach to peer learning will be a graded assignment to induce students to use it, and is also part of a submitted grant by the workshop leaders to greatly expand its capabilities. Workshop participants noted that many incorrect answers could make the garden unreliable as a constructive learning resource. Banaszak-Holl rebutted that caveats will clearly be given to students, and alternate sources of information are made in parallel with the "Answer Garden" site.

## Report

Those familiar with chemical education should be familiar with the experiment being conducted at the U of M: teaching organic chemistry in the first year and the restructuring of these classes to meet student needs. The program has been operating for eight years now, and the topics of this workshop deal with what changes have been made subsequently to physical and inorganic chemistry courses, which follow organic in the course sequence. For students who take organic chemistry in the first year, this means an effective elimination of any kind of traditional general chemistry course from their college experience. Changes have been made to organic chemistry to make up for topics that otherwise would have been completely lost in a traditional first-year chemistry course, such as basic physical chemistry. Deficiencies do still exist, however, and they are now being addressed. The effect of these topical deficiencies is not felt until students enroll in the inorganic and physical chemistry courses in subsequent years.

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S 1430-4171 (98) 01178-7

CH 302, which was initially taught closely along the lines of a traditional third -year inorganic course, soon ran into trouble because the basics of descriptive chemistry and the effect on students as culture shock, gasping at the first use of mathematics-based quantum chemistry. Workshop participant David Zazisky, a senior undergraduate at U of M, indicated that the organic to inorganic to physical chemistry sequence was rather awkward at its inception. He felt the flow from organic to inorganic was just abrupt, and that little, if any, useful physical chemistry learning was accomplished in the organic course. An effective discussion of physical chemistry was not achieved until the third-year physical chemistry course (CH 460). Workshop leaders did not discuss what had been done to make up for the deficiencies in descriptive chemistry. The deficiencies in physical chemistry were addressed though; a new class to precede inorganic chemistry was developed, CH 260.

The previous arrangement of classes meant students would not normally meet a formal physical chemistry course until after they had already taken organic and inorganic chemistry. Now, CH 260 has been inserted between organic and inorganic chemistry, and it deals with the topics of quantum mechanics, thermodynamics, and kinetics, which are incompletely covered in the organic course, but are essential for progress in inorganic chemistry. This class has only been taught for two (three?) years, and most likely debate will continue in the future as to the what the essential topics are. Workshop participants responded that they were impressed and intrigued by these changes, but because most are from smaller colleges, they felt that their smaller departments did not have the resources or the flexibility to implement such a dual curriculum.

The introductory inorganic chemistry course CH 302, which normally follows organic in the third year of traditional chemistry curricula, has been taught to second-year students for eight years now. M. D. Curtis explains that, initially, when the changes were made to organic chemistry considerable resistance was met within the department to effecting the commensurate and needed changes to the inorganic chemistry course. This took the form of resistance to change in the syllabi topics and resistance to conforming to the motivator-of-learners teaching style that was also proposed. It is reported that such differences of opinion persist even though the changes which have been set in motion are probably too far gone to be completely reversed. Compromise solutions have been reached amongst all of the concerned parties and the situation is

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tenable; however, these differences of opinion would seem very healthy for the survival and continued growth of this experiment in teaching.

Both workshop leaders teach these classes and were able to speak with relative authority for most of the other inorganic faculty who teach CH 302. They are mostly proponents of the motivator-of-learners style, rather than the purveyor-of-facts style. They feel that, beyond the rearrangement of courses, it is the style of teaching and overall greater sensitivity to student needs which lies at the heart of the program. As workshop participants discussed the place of analytical chemistry in the curriculum, the point was made by Banaszak-Holl that virtually any field of chemistry can be chosen to start the sequence of classes: “Everywhere I said organic, I could put ‘inorganic’...what matters is the people and the groups...”. The particular choice of placing organic chemistry first serves to place incoming students on a much more level playing field, as few would have been exposed to organic chemistry in high school. M. D. Curtis stated that most incoming students, having previously seen much of the material covered in traditional general chemistry previously in their high school classes, are not very motivated in general chemistry courses. The novelty of learning organic chemistry right away is a psychological device, designed to prompt their interest, as much as it serves other teaching goals.

As an example, Banaszak-Holl explained that many engineering students wind up in the materials section of CH 302, to get a fresh perspective on subject material at least partially dealt with in their own department. Their preferred method of learning in class is the case-study method, where a minimal input of first principles knowledge is used in favor of just digging in and tackling problems using a more intuitive approach. In contrast, chemists spend a lot of time learning first principles before they feel comfortable enough to begin applying their skills to problem solving. To make the class more appealing to the engineers, and to simply diversify the approach to teaching, the case-study method has been used in extensively in CH 302. The corollary of the perspective change that engineers bring is the focus on the macroscopic; engineers need to solve problems with their hands; they prefer things that are tangible with the naturally endowed senses and not some artificial extension like NMR. M. D. Curtis stated that it is generally an interest in the macroscopic that brings new chemists into the field, though current instruction leads students away from this valuable and formative perspective of chemistry.

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The response to the U of M program, however, was mixed overall. The decision by the instructors of CH 302 to split the class into bioinorganic and materials-focus groups was well received by the audience, and Craig Bieler responded that this would be an idea he would consider implementing at his institution. The perspective of workshop participants was mostly that of small college instructors; workshop participants decided such changes were beyond the resources of their departments, even those participants who reacted favorably to the changes described. Joel Tellinghuisen interpreted the disruption of the inorganic and physical courses as a deterrent to completely neglecting traditional general chemistry in favor of organic only in the first year. Professor Tellinghuisen would still like to give his first-year students more background in organic chemistry, particularly to address the needs of biology students, but would do so in a more limited context in light of the workshop discussions. The absence of Professor James Penner-Hahn from the workshop roster meant that the aspects of physical chemistry were not fully discussed, and this was lamented by several workshop participants. Although analytical chemistry was not a planned discussion topic, several workshop participants showed an interest that again went unaddressed.

Many more details were discussed concerning course modifications, but the most profound approaches appear to be in the application of Web resources to the course. Banaszak-Holl first displayed the course home page. Its function for the course is as a secondary organizational site, outside of the classroom or his office. It appears similar to applications of the Web by other institutions in that syllabi recommended reading materials, supplemental materials, homework assignments, and sample exercises and tests can all be obtained here. The minimization of paperwork and expansion of logistical capabilities by such an arrangement was well appreciated by workshop participants. What is unique is the development of a novel type of Web forum, the Answer Garden. As indicated by Banaszak-Holl, this has been developed and used primarily for Web browsers by beer-making sites. Using a computer technology called SIFT, Social Information Filtering Technology, the Answer Garden assimilates a wide number of questions from the garden visitors, the answers to those questions submitted by other garden visitors, and then ranks the usefulness of the answers by the number of referrals that a particular suggestion obtains. This allows the community of garden visitors to collectively, albeit unconsciously and somewhat chaotically, determine the best possible solutions to given problems. It would apparently work best when there

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are a large number of active garden visitors, thus a statistically meaningful number of responses to be processed by the SIFT algorithm. The Answer Garden is currently a submitted proposal and not yet in operation for CH 302.

The inception of an Answer Garden for the course experiments may address a few observed problems. U of M students are located on a campus that is very large, both in population and spatially. The students tend to have little contact with other than small groups of their classmates, and many students can go through a course without having made meaningful contact with any of their classroom peers. Since Web access is now universal for the students through campus computer clusters, the Answer Gardens allow all students to interact with each other, although in an abstract way; Banaszak-Holl termed this “asynchronous communication.” Students also are very selective with their out-of-class time, and if this resource is something they can work into their schedules, rather than having to work around, they will be much more likely to use it. The presence of the Answer Garden also could lighten the load somewhat for the instructor, as students have ready access to a whole database of consultation on their course work. Banaszak-Holl speculated that not enough students will be self-motivated to use the garden, and thus make the garden useful, unless some incentive is given. Making Answer Garden participation a graded section of the course is considered critical for its inception.

Workshop participants questioned whether students could generate enough “correct” responses for the Answer Garden to be meaningful. Banaszak-Holl indicated that sources outside of the Web would be listed in the garden and warnings given to the students not to rely exclusively on the garden for “authoritative” conclusions. This only makes sense, but came off somewhat inadequate, as it can be readily assumed that most students will not heed such warnings. Perhaps more back-up systems could be introduced into the garden, but none were suggested by workshop participants. The small college workshop participants found the Answer Garden idea compelling, but felt that their much smaller class sizes would be better served by less ambitious devices, such as a simple electronic bulletin board proposed by Professor Dan Barber for his classes.

As Web resources were initially being introduced by the workshop leaders, participants questioned how test reports were handled on the net and particularly the grading styles of those tests. The discussion soon led to a major digression on test

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making, grading, and strategies for dealing with cheating. Globally, a consensus was reached on most commonly heard topics, such as the inferiority of multiple-choice examinations versus the testing (grading) of very large classes. The organic and general chemistry classes at U of M are both very large, but have retained the written exam to improve student evaluation, even though grading is a grueling experience. Evaluating student performance was also brought up in the context of a “redemption-point” system, a common feature used to reward students who gradually improve their grades over the semester. Other deficiencies in the multiple-choice examination method enumerated were the susceptibility to the “professional test taker” and the temptation to cheat, particularly if such an examination were given a large weight in the overall course grade. David Harpp of McGill University was cited as an authority on how to deal with cheaters. Specifics on grading styles dominated this discourse however.

Banaszak-Holl stated that he had a history of taking and grading tests based on curves and the need to interact with James Penner-Hahn in CH 302 brought him into conflictual contact with the absolute-grading-scale system. He said Penner-Hahn “dragged me kicking and screaming” into an absolute grading system, but now he is convinced that this is the best way to grade students. Workshop participants zeroed in on the benefits to students of one system over the other. Curved grade scales put students into direct competition with each other, although no consensus was reached as to how good such direct competition was. The point was made that industry in particular likes to see personnel trained in cooperative skills making such competition detrimental. Absolute scales also give students a much firmer handle on exactly how they are performing in a course, and if the instructor is relatively consistent in his methods, the students can prepare more efficiently for such examinations. Banaszak-Holl made a final point that, as the years go by, older students frequently tire of such constant competition with each other, and the collective performance of students on a curved grading scale declines with time. A most important point, agreed on by all workshop participants, is that competitive grading systems suppress student interaction. The fear of damaging one’s own competitive edge by helping others is a direct hindrance to peer interaction, especially between those students who are most capable of offering useful help and those who most need help. These concerns all appear to indicate that absolute grading scales are the best. As a direct result of this discussion, both Barber and Tellinghuisen stated that absolute grading scales will be

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implemented in their classes. The main barrier to adopting such a scale, which was only hinted at by workshop participants, is that more burden is placed on the instructor to create "doable" tests.

## Reflections

Workshop participants were in general agreement that the format of this "workshop" was much more like an academic lecture, but with a considerable amount of open discussion. Participants commented specifically on deficiencies in the presentation, such as not being well organized, being too narrowly focused on just one course, and lacking specific components designed to engage the workshop participants. The subject matter was well commented on, though the lack of significant reporting on courses other than inorganic, left participants wondering what was the true overall effect on chemistry at U of M as a result of the course sequence change.

Most participants were from small colleges with a traditional sequence of chemistry courses. All participants could appreciate the changes made at the U of M, and even speak favorably of them, but invariably participants commented that these changes would not be practical on the same scale at their institutions. The impression was that such changes were appropriate only at a big university where the resources for a large and sustainable curriculum shift were possible. No further reasons, however, beyond those of a financial nature, were given as a deterrent for implementing these curricular changes at small schools. The other adoptive changes which participants did respond to have been elaborated on above.

The course Websites for CH 302 and CH 260 can be found at: http://www.umich.edu/`michchem.

Answer Gardens and application of SIFT can be found at: http://www.ics.uci.edu/~vl/.

## Workshop Participants

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