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WISCONSIN
M A D I S O N

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April 7, 1999

TO: Associate Dean Herbert Wang

FROM: Charles P. Casey, Chair

Chuck Casey

SUBJECT: Undergrad Assessment

I'm enclosing several copies of our Assessment of the Undergraduate Chemistry Major and of the Chemistry Curriculum. The first two pages summarize the assessment and the remarks provide more detail. The assessment was carried out by our undergraduate curriculum committee chaired by Professor Judith Burstyn. The committee members were Steven Burke, Robert Corn, Clark Landis, Cathy Middlecamp, Ieva Reich, Matthew Sanders, Edwin Sibert, Paul Treichel, and Arun Yethiraj.

The report will be discussed at our April 13, 1999 Department meeting. I anticipate that changes in our curriculum and interaction with chemistry majors will occur as a result of this assessment.

Assessment of the Chemistry Major and Chemistry Curriculum

Summary of Assessment Activities and Outcomes

Department profile: The Chemistry Department is one of the largest, strongest, and most visible departments in the College of Letters and Sciences. In 1998-9 academic year, there were 36.5 FTE--full time equivalent--faculty and 17 academic staff positions in the department. About 120 half time TAs assist in undergraduate teaching. The graduate program ranks nationally among the top 10 departments in this country. Currently, about 250 students are pursuing graduate degrees in chemistry

Each semester the department teaches over 5,000 students and about 20,000 credit hours, a majority at the freshman and sophomore level. Since 1990, there has been a steady increase in the number of credit hours taught in the department, for the most part without concurrent increases in funding level. Approximately half of the students on campus take one or more courses in chemistry. Only about 35 students graduate each year with a major in chemistry. One facet of the assessment this year has been to determine the factors that lead students to major in the discipline.

The department is widely recognized for excellence in teaching. Nine members of the current faculty have received all-university teaching awards. The department recognizes teaching contributions with faculty and TA awards. Three of the current faculty and two academic staff members have won national awards in chemical education. There is a serious departmental commitment to teaching, pride in teaching well, and numerous examples in which individual faculty have improved their effectiveness as teachers. Chemical education projects in the department, some funded extramurally, have helped to guide curriculum changes of the academic program.

Program Assessment: This assessment, carried out by the Undergraduate Curriculum Committee, has focused primarily on the curriculum for chemistry majors. For this purpose the Committee sought subjective input from faculty and students. About half of the faculty responded to a questionnaire asking about student learning in their own classes, and about the strengths and weaknesses of the chemistry curriculum. Student input was obtained in small group discussions and through a written survey. In addition, students were asked to answer four questions to test subject comprehension. About 20 students (out of 70 majors) voluntarily participated in these exercises. This group had above average GPAs. A majority was currently doing undergraduate research and intended to pursue graduate studies.

A clear and consistent portrait of the department emerged from this multifaceted approach. Students and faculty viewed the chemistry major as a rigorous and demanding program. Most of the faculty are seen as excellent teachers, knowledgeable and interested in the subject matter, and committed to teaching. Courses are well designed and the overall curriculum provides excellent preparation for further study and for careers in chemistry. Undergraduate research was recognized as a very important component of the program.

Faculty and student expressed different concerns. Faculty saw the curriculum as being too crowded with required courses, restricting the ability to modify the curriculum to accommodate new subject matter and new perspectives. They also were concerned about a lack of coordination in course content. There is sentiment that we do not attract the best students, and that students often lacked necessary skills for courses, especially in mathematics. Students commented on a desire for more personal contacts with the faculty and a closer association with the department and with other chemistry majors. Most criticisms from students were about unfavorable experiences with a specific course (and instructor). A few students commented about labs, noting a lack of

organization, the need to further develop lab skills and, in some instances, excessive effort for the credit given.

Both students and faculty expressed general and specific concerns about substandard facilities in the existing building.

The content exam showed that students were well prepared in Organic and Physical Chemistry. In the Analytical area, some students performed very well while others did very poorly. The background in Inorganic Chemistry was weak, exposing a problem that needs to be addressed.

Recommendations: The committee feels that the value of this assessment will be enhanced if we offer several recommendations for consideration by the department. We hope that this will stimulate further discussion in the department and lead to departmental action, if appropriate.

We suggest that attention be directed to further integrating undergraduate chemistry majors in the broader community of faculty, academic staff, and graduate students. The best route to this end is to expand the undergraduate research activities. Efforts should be made to broaden participation and especially to include students at an earlier stage of their academic careers. More faculty need to be involved as research advisors and mentors. Opportunities for summer research would be especially valuable. Methods to appraise students of these opportunities need to be developed. The most effective current recruiting device seems to be Chemistry 346.

In addition, students will benefit by becoming more involved in department activities such as the seminar programs. Participation of undergraduates on the Student-Faculty Liaison Committee and/or Undergraduate Curriculum Committee was suggested. Poster sessions for students to present their research should be continued. A commons area, or a "majors room", part of the early planning for the building but not in the final plans, would be of value.

Finally, we suggest that overall curriculum needs further scrutiny. It is important to coordinate the content of courses and to find ways to alleviate limitations to curriculum change. There is a need both to include more inorganic chemistry and to gain additional flexibility so that material from emerging areas such as materials chemistry and biochemistry can be introduced into the curriculum. Dealing with these issues will be challenging, but the potential rewards, such as the ability to attract more and stronger students to become chemistry majors, provides a compelling reason for action.

Future Assessment Plans: The members of the Undergraduate Curriculum Committee are satisfied with the results of these assessment activities but also recognize that we can improve on our efforts. During the next several years, we would like to implement routine exit interviews with all graduating seniors to probe the issues raised here. The broader exercise of the type just completed will be repeated once every five years. We propose to broaden our assessment activities in the coming years to include graduates of the department and client departments. We plan to use the contacts we have with our alumni to survey graduates to assess how well the undergraduate program at UW-Madison prepared them for professional careers. We will also assess our large service courses. As a first step, we will contact other departments that require chemistry to determine whether the chemistry background we provide meets their needs.

A full report on the assessment is available from the Chemistry Department.

Undergraduate Curriculum Committee: Judith Burstyn (Chair), Steve Burke, Gery Essenmacher, Rob Corn, Clark Landis, Cathy Middlecamp, Ieva Reich, Matt Sanders, Ned Sibert, Paul Treichel, Arun Yethiraj

April 2, 1999

Report of Undergraduate Major Assessment Activities
UW-Madison Department of Chemistry
March 1999

Overview of Assessment Activities 1998-9

The Undergraduate Curriculum committee has undertaken an evaluation of the undergraduate chemistry curriculum from both the student and faculty perspectives. In January 1998 we surveyed the Chemistry faculty asking them to reflect on how students were learning in their classes and what they saw as the strengths and weaknesses of our undergraduate major program. To guide our thinking about the undergraduate curriculum the committee independently prepared a statement of Goals for the Chemistry Major. In response to the faculty survey, we prepared a summary of faculty concerns and a list of goals to address those concerns.

In the early spring of 1999, we conducted an assessment of the major from the student perspective. We conducted two surveys of the junior and senior chemistry majors and held a guided interview in which four or five students reported on their undergraduate chemistry experience to one committee member. One survey was on the educational background and experiences of our chemistry majors. The second survey was a test of basic chemical knowledge in the four general areas of chemistry. In addition we collected GPA information on our entire cohort of junior and senior chemistry majors.

Summary of Faculty Survey Responses

We received responses from 22 faculty (51% of the department). The faculty were unanimous in their support of undergraduate research as a strength of our program. They agreed that the faculty was committed to excellence in teaching chemistry and that we have a strong undergraduate major that provides solid training to committed students. However, the faculty were as a group dissatisfied with how students were learning in the undergraduate courses they teach. There was concern that students were not retaining as much material as the faculty would like, and that the students were not mastering problem solving skills needed to solve real world problems. It was noted that the curriculum is too crowded with required courses and that there is poor coordination between the courses. There was a sense that we were not attracting the best students into the chemistry major. Of interest with respect to this observation is the fact that of the current 69 chemistry majors, the average GPA is 3.24 and 52 of the 69 students have a GPA over 3.0.

Summary of Student Questionnaire Responses

The questionnaire profiles the students who provided input to this evaluation. We had 24 responses, 33% of the 73 students contacted. The respondents included 17 men, 7 women, slightly weighed in favor of men relative to statistics for all majors (45 M, 24 F). The overall GPA and the GPA in chemistry for the respondents were 3.5 compared to GPA values for all majors of 3.24. Four of the respondents had graduated within the last year; 9 expected to graduate in 1999, 11 expected to graduate in 2000. Sixteen students out of 24 were planning to continue toward advanced degree in chemistry or were considering this as one option (five listed graduate school in chemistry as one option being considered); five were headed for advanced degrees in other areas, while three intended to enter the job market after receiving their degree.

Of the group, 19 expected to graduate (or had graduated) in 4 years or 4 years plus a summer. Thirteen held scholarships, 7 receiving scholarship aid covering more than 50% of their total costs. Ten students received 10% or less of their support from parents. Four had taken out significant loans (covering 30, 40, 60 and 60% of their total costs.)

Ten members of the group switched to chemistry after beginning other majors (from chemical engineering, biochemistry, zoology, pharmacy), the others initially selected chemistry as their major. Eight had joint majors with one or more field. Math was the most common second major (for five students) and biochemistry and chemical engineering were mentioned twice. For those who switched majors, the reasons (when stated) often related to a positive experience in a particular class. Similarly, reasons given for choosing a chemistry major initially were often related to a class.

Twenty out of 24 respondents have done or are doing independent study, senior thesis or honor thesis. Twelve had summer employment in a chemistry related position, two others had summer research appointments at the UW (in chemistry and in biochemistry.)

The students who responded to this questionnaire had favorable views of the department. On a scale of 1 - 5 they rated the academic program in chemistry as very favorable (ave. 4.6) and academic and career advising as favorable (ave. 4.1). They generally gave the faculty quite high marks (ave. 4.4). Almost all would recommend UW to a friend intending to major in chemistry.

Written comments generally supported these opinions. The overall tone was very positive. Adjectives like *dynamic, friendly, helpful, willing to share their time, interested in helping, and always fair* were frequently used. Usually these comments referred to "most of the faculty" and the students implied, and sometimes stated directly, that there were exceptions. The curriculum received fewer comments and these were also generally favorable, *high quality, interesting, and challenging* were adjectives used. Several students spoke favorably about small class size for advanced courses. Most negative comments focused on labs; these included criticisms on the content of lab (not enough problem solving, and too little emphasis on gaining lab skills), on hours spent for minimal credits, and poor planning so that experiments did not require a full period. Several students indicated a desire to have more personal interaction with faculty (and graduate students.)

The students were asked to identify favorite (and least favorite) classes. Invariably, the comments on this question included references to specific faculty members. Excepting for research experiences, which were unanimously given favorable ratings, the responses ranged across the map and were often contradictory. To a great extent, the primary factor in a stated choice (positive and negative) related to the faculty member. Standing out most positively among the favorable comments were several on the honors sections of 343 and 345, and the research experience in 346. The committee readily acknowledges that statistically significant conclusions cannot be drawn from the comments, but feels that two important positive themes should be mentioned: the first is small well taught classes with motivated students and the second is the pipeline to research and independent study. Chemistry 346 stood out in this regard.

In summary, the survey revealed useful information about our students and our undergraduate major program. The students responding were a small sample of our majors (33%). They were self-selected for their interest in chemistry and in communicating with faculty, they were or had participated in undergraduate research, and a high proportion were planning to attend graduate school in chemistry. These students may thus not be representative of all our majors but they do represent our best majors. The student comments revealed that excellent introductory classes and personal contacts (in 346 for example) were important to the recruitment of majors. The department as a whole received very high marks on quality of instruction and on the curriculum generally. The comments about faculty generally were very favorable and specific faculty members were frequently mentioned. Overall the undergraduate research experience and small classes at the upper levels rated high in the students assessments.

Summary of Knowledge Survey Results

Four sets (organic, physical, inorganic and analytical) of three questions designed to probe general knowledge were presented to 15 students. They were instructed to answer one question in each of the four areas during a period of one hour. The questions, prepared by experienced faculty in each of the four traditional areas above, were screened by the Undergraduate Curriculum Committee. They were considered to be sufficiently general that a senior-level student should be able to provide a detailed and comprehensive answer to each one in 15 minutes.

Those students who had not had the appropriate courses for each area were not counted in the summary (organic, 15/15 counted; physical, 14/15; inorganic, 11/15; analytical, 14/15). Grading was based a scale of 3, 2, and 1, where 3 was for a full, complete, and comprehensive answer, 2 was for an acceptable answer, and 1 was for a below par answer. Out of a possible 12 points across the four questions chosen, the range was 4-10 and the average was 6.6/12. The averages on each of the four area questions were organic 2.13/3, physical 2.00/3, inorganic 1.10/3, and analytical 1.71/3. The consensus of the committee members was that the students had performed well on the organic and physical sections of the exam, marginally on the analytical part, and poorly on the inorganic portion. It was noted that the performance of the students was in direct proportion to the amount of coverage the subject area receives in the curriculum.

Summary of Group Discussions

All current chemistry majors were invited to an evening program with Chemistry Department faculty and staff and asked to provide their input relative to the chemistry major program. Twenty of the current sixty-nine majors attended and broke into small discussion groups of about 4-5 students with one or two faculty/staff acting as discussion facilitators. The students who chose to attend were predominantly involved with research groups and most were considering continuing on in graduate studies in chemistry or a related field. The students were asked to respond to four questions: 1) why did they become a chemistry major, 2,3) what were the high and low points of their experience as chemistry majors, and 4) what advice would they give to less advanced students of chemistry and to the faculty with regard to the major. The students were also asked what one significant change they would like to see in the chemistry major. Their comments are summarized below. The verbal comments of the students reinforced many of the same themes that emerged in the questionnaire.

The students expressed diverse reasons for choosing chemistry major. Many students were not specifically interested in chemistry before they came to college, however, most had decided on their major within the first year and a half in college. Several students changed to chemistry from original intended majors in chemical engineering, pre-med/biology or pharmacy. The primary reasons for choosing chemistry were interest and positive class experiences.

The most often-mentioned high point was undergraduate research. The students who had worked in research labs saw this experience as the single most important part of their education and wished that they had known about the possibility earlier, as early as their freshman year. Students also mention specific courses as high points including Chem 109, 110, 343, 345, 346, 511, 561 and 562. Many students mentioned specific faculty members in this context. The student felt that courses were generally good and well taught. Many commented specifically on Chem 346 lab; they really liked the greater level of independence required and noted that 346 was the first class where the chemistry majors get to know one another well. The students who joined research labs during 346 and felt that the experience was excellent because it introduced them to a different perspective on chemistry and got them into undergraduate research. Other high points mentioned were Chem 109 and 343 with instructors who were highly demanding but supportive and the students really felt they learned a lot. The oral exams in 346 and 563 were mentioned as challenging but confidence building experiences. The students really liked the one-on-one interaction and the opportunity to develop their skills at oral expression.

The lows mentioned by these students tended to be specific courses with specific instructors where the students did not connect to the instructor. They felt that some faculty did not want to talk to students or to make an effort to teach to their level. A real low for these students was the realization that they had not learned the material covered in those classes. Another low was the lack of adequate advising. The students sensed that the department was much more focussed on the graduate students than the undergraduates and felt there was no place for them to go for help. Other lows were really tough semesters, particularly in the second year with physics and organic chemistry. There was some feeling that faculty simply required too much work, behaving as though the students were taking only their class, and that some classes covered too much, too fast with little connection to the real world.

The students had several pieces of advice for more junior chemistry students and the faculty and staff of the department. Their most often-repeated advice for younger students was to get into the research laboratory, preferably as early as possible. They also suggested finding a peer mentor early on, a junior or senior major who would be able to give advice. A suggestion for the faculty and staff was to facilitate such peer mentoring arrangements. Other advice for younger students was that the curriculum was indeed challenging and that they should be prepared to work hard. The students stressed to the faculty that they wanted a challenging curriculum and that they would like to opportunity to take more advanced courses in chemistry. They regretted that the curriculum was too crowded to allow them to take more advanced courses in their area of interest. They suggested allowing options in the later years instead of so many required courses. Another piece of advice was to include real world applications and teach to smaller groups of students.

A clear message from the students in attendance was a desire for more non-academic contact with the faculty. They suggested having some activity (such as a pizza party) to bring together the chemistry majors with the faculty. They suggested that such activities would help beginning students connect with

juniors and seniors. Such a gathering could also be used to introduce students to research opportunities in the department and attract students to the major. Several students indicated that they wished they could have declared their major earlier and gotten into a research lab right away and said that this would be a way to draw in students like themselves.

Conclusions from the Assessment

In response to the surveys the Undergraduate Curriculum Committee is rethinking the undergraduate chemistry curriculum. In order to guide this process we developed a statements of goals for the major and for the curriculum revision. The goal of the curriculum committee is to revise the undergraduate curriculum to increase flexibility within the chemistry major, provide more opportunities for variation in advanced course work, emphasize the application of chemistry to real world problems, and encourage undergraduate research participation. We anticipate that these changes will create a major program that attracts and retains outstanding students and we will develop strategies to involve the chemistry majors more in the life of the department. We will encourage communication among faculty and staff to disseminate new strategies in teaching, maintain awareness of course coverage in the new curriculum, and promote connections between courses. In collaboration with the College of Letters and Sciences, we hope to design and build a new instructional building with facilities, both laboratory and classroom, appropriate to the new curriculum.

Appendices

The assessment tools and goals statements developed by the Undergraduate Curriculum Committee are provided as appendices to this report. The documents appended are: the faculty survey, the chemistry major questionnaire, the chemistry major evaluation exam, the list of questions used to guide the discussions with the chemistry majors, the statement of goals for the chemistry major, and the executive summary of the concerns from the faculty survey and a list of goals to address those concerns.