Memorandum

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From: The Department of Chemical Engineering Program Review Committee
James B. Callis, Department of Chemistry, Committee Chair
Jane Q. Konig, Department of Environmental Health
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John G. Ekerdt, Department of Chemical Engineering, University of Texas at Austin
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Re: A Review of the Department of Chemical Engineering Degree Programs

The Department of Chemical Engineering Program Review Committee met with Chair J. W. Rogers, faculty members, staff and students of the Department on January 24 - 25, 1999. For the purposes of this review, the members of the Committee were provided with the Department's self-study document and the report of the previous review undertaken in the spring of 1986. At the outset, the Committee was somewhat hampered in its deliberations because the self-study document was prepared by the previous Chair and does not closely reflect the present Chair's program and priorities. The only written document provided by the present Chair was his letter of application for the position. Nevertheless, this letter contained an excellent outline of the present status of the department and a vision for the future.

The Committee is very impressed with the new Chair's vision and perspicacity in assessment of the present condition of the Department. We are pleased that our report's recommendations are in excellent agreement with the Chair's assessment.

We have organized our report around the four major programs: (a) undergraduate degree program, (b) graduate degree program, (c) faculty scholarly activity and (d) infrastructure and administration. We have analyzed these programs in terms of their strengths, weaknesses, opportunities and threats. At the end of each section we provide our recommendations for that program.

Overall, we find that the Chemical Engineering Department is in excellent health and its current degree programs should be continued and even expanded.

I. Undergraduate Degree Program.

Strengths. This is one of the strongest undergraduate degree programs in chemical engineering in the nation. Many factors contribute to the excellence. The commitment of the faculty to the enterprise is exceptional; their dedication to a rigorous coverage of the fundamental aspects of the field is admirable. A large number of undergraduates are involved in research in the department. The experiential content of the curriculum is particularly commendable, with the senior project course constituting a true capstone to the degree program. There is a considerable body of independent validation of the quality of the course of study. The University of Washington students are widely sought by industry. The most recent ABET accreditation yielded an excellent rating. The Chemical Engineering program attracts some of the best students in the College.

A strong indication of the Department's concern for the welfare of the undergraduates is that an accountability plan has already been developed for ABET 2000 well ahead of schedule.

We particularly commend two specific courses for their innovation. First is the senior design course under the direction of Professor Sefaris. Here undergraduates collaborate with graduate students to solve an engineering problem brought to them by industrial scientists. This course is an outstanding example of the experiential/collaborative approach. The second is the process control course taught by Professors Holt and Ricker. Here the theoretical exposition is tightly coupled to experiment through the process of computer simulation. The interplay of theory and experiment can be readily appreciated.

The committee also visited two laboratories in session. It is clear that the students were fully engaged, and at the same time greatly enjoying the learning process. It was gratifying to note that nearly one-half of the students were women. Clearly, this is a department that fosters diversity.

The committee interviewed four of the undergraduate students. Their satisfaction with the program was quite evident. They praised the faculty for their intellectual attainments and devotion to their interests. They were most grateful to Ms. Madrona, the undergraduate advisor for advice and attention to satisfying the requirements of the program. Among the faculty advisors, Professor Schwartz was singled out for praise.

Weaknesses. These are relatively minor. Access to computers is not sufficient. Students could benefit from a staffed computer laboratory which is available for general use, independent of courses. The current PowerPCs are a major drawback as these are of declining use in professional practice. Indeed, one of the major programs used in course work, MATLAB is no longer supported on this platform and another piece of key software, Aspen runs very poorly on the Macs.

The unit operations lab could be improved. It relies mainly on 1950s era equipment, which frequently breaks down. A plan to maintain and upgrade the lab should be developed and perhaps include better integration of the labs into the engineering science courses. The Committee urges that the experiments be carefully considered; too much automation can reduce student engagement. The trial use of a permanently assigned faculty member may provide a solution to continuity problems experienced in this lab in the past. Finally, this lab requires dedicated, well-trained TAs for success. Insufficient attention is paid to training the TAs. A TA manual is highly desired.

Discussions with the students led the Committee to judge the quality of faculty advising as mixed. For example, many faculty are unaware of or even discourage co-ops. Yet the students see co-ops and internships as key elements in obtaining job offers from industry. Another minor problem is with course scheduling; it could be more optimal if the specialty courses were spread out over the year. Finally, many of the students desire to learn more C++ programming (CSE 143) but are prevented by the lack of credit as an engineering elective option. It is recognized that the curriculum is highly constrained and the Committee is unable to offer another course to eliminate.

Opportunities. The most important opportunity is to expand the undergraduate program. The state has a large pool of well-qualified students with an interest in Chemical Engineering and the demand for its graduates is consistently among the highest of all degree programs. A demonstrated need to expand the program could be used to justify acquisition of new faculty, TAs, support personnel and equipment.

With this excellent undergraduate program, the opportunity to obtain education-related grants, contracts and gifts seems assured. For example, faculty could easily mount a proposal for upgrades to the unit operations lab in view of their successful development of the control course.

Not only could the NSF be solicited, but FIPSE, Dreyfus and Sloan as well. The chair has already put forth a proposal to the University's Tools for Transformation fund. This is a good start.

Threats. Professor Rogers has suggested that the abandonment of the two track course offering system could free up faculty to bolster the course offerings in the graduate program. His claim that the undergraduate students would suffer minimally is disputed. The undergraduates would not like to see wholesale abandonment of the two track. They feel that the schedule is already so tight, that students doing co-ops are already hard-pressed to fulfill all requirements in a timely fashion. The Paper Science students might also be severely disadvantaged. However, unless additional resources are provided, the Department may have to resort to this approach.

The undergraduate students hold their rigorous and thorough training in fundamental Chemical Engineering to be one of the greatest assets of the degree. When they were informed by the Committee that many of the newly hired faculty were without a traditional ChE degree, they expressed concern that the core of their discipline could become eroded. This is not to say that the students are unhappy with the current new faculty. Rather, they urge the Chair to make sure that new hires be both qualified and willing to teach the core courses of the discipline.

Recommendations: (1) Continue to build this fine undergraduate program. It is recognized throughout the chemical engineering community as one of the premier programs in the country. (2) Remedy minor problems with outmoded equipment and computers through outside funding through educational grants from the NSF and other agencies and foundations. (3) Consider any changes to the course sequence and schedule very carefully. Include all stake holders in the decision making process. (4) Use the fine undergraduate program to leverage new faculty, support staff and modern equipment.

II. Graduate Education Program.

Strengths. Professor Stuve does a fine job in the recruitment of students to the graduate program. As a result the Department receives a larger than expected number of highly qualified students, e.g. ones who have received NSF awards in advance of school selection. We note that most of these outstanding students wish to be associated with a biospecialty; this is a credit to the bio-oriented faculty.

The students are all supported as TAs and RAs. They are pleased that the new Chair is sympathetic to their concerns and is working to remedy them.

Weaknesses. The graduate program needs to be well documented and communicated. As a result of attempts at reform in the recent past, changes in the regulations regarding examinations and course offerings have not been clearly communicated to the students and there has been stress and dissatisfaction. For example, the date of the preliminary examination has not been clear, and has resulted in some students not taking fundamental courses needed for the exam in timely fashion. The core graduate courses are in disarray, and there are not enough of them. In contrast, there seem to be sufficient specialty courses, but most of them are too specialized to benefit anyone but the instructor's graduate students.

While the TA experience is mostly a positive experience, for some critical courses, TA training is not provided and this leads to frustration for both TAs and students. The Department should examine how TAs are being used in the courses and ensure the duties and expectations are reasonable. The students are very interested in interdisciplinary research, but they find few of the faculty are willing to co-advise on joint projects. Access to computer facilities is a considerable problem for the first year graduate students, especially before they choose an advisor. They see this as a lack of interest in their well being.

Opportunities. The Department currently enjoys a bumper crop of outstanding graduate students. They will be very helpful in recruiting new students of equal quality. Also, they are anxious to help the Department build up its programs in interdisciplinary work. There are opportunities for faculty effort in textbook writing. This would not only impact positively the existing students but also enhance the reputation of the Department.

Threats. There seems to be two distinct groups in the Department: (a) the elite top-tier students who are highly motivated, and (b) the less motivated students who are less dedicated to their graduate education. The elite students have considerable ambition and a well-developed work ethic compared with those with less interest in attaining the top ranks of their profession. At present the UW Chemical Engineering Department enjoys a fine reputation as a place where top graduate students can prepare for a career in biologically oriented work. Other departments are gearing up such programs. Competition for top-flight graduate students in this arena is likely to intensify. It is understandable that the elite students feel resentment that those with less ambition are holding the department back.

Recommendations: (1) Continue to improve graduate student quality using conventional recruitment strategies and the existing stellar students to recruit others. (2) Remedy first year course work and exam deficiencies. (3) Publish all requirements for degrees on the web. Insist that faculty advisors fully understand the system. (4) Increase graduate enrollment through increased research funding.

III. Faculty Research Program.

Strengths. The Department exhibits a commendable breadth of research interests which are well aligned with emerging areas in chemical engineering. The faculty conducts a number of high-visibility research programs. The well-established programs of Finlayson and Berg are highly regarded externally, and the work of Davis is well recognized in the particle science community. Together, they constitute a major contribution to the Department's international reputation. The strong program of Ratner and Horbitt through the newly developed UWEB organization is a real plus for the Department, as are the programs of the other faculty in the biological arena, Banyex and Lidstrom. These four constitute the nucleus of a group which is contributing greatly to the Department's research reputation and ability to recruit outstanding students.

The Department enjoys a level of endowment funding that is enviable. This provides a great deal of flexibility in hiring new faculty and recruiting outstanding students.

Weaknesses. There is a clear deficiency of faculty numbers. The correlation between rank and department size is all too obvious. In addition, the Department turns away too many qualified undergraduate students. The research funding from national agencies is too small to sustain a graduate program of the first rank. As a result, there are too few graduate students to build the research program of an ambitious department. Also, there is not enough collaboration among faculty members within or outside the department. Large, multidisciplinary programs are an excellent way to build the capabilities and recognition of the Department.

Finally, there are faculty members who could contribute more to the research mission.

Opportunities. With the nucleus of excellent faculty mentioned in the strengths above, there seems a genuine opportunity to increase the Department's stature. The excellent center in the area of Biotechnology seems especially appropriate. The fortuitous combination of a close tie with Bioengineering and an outstanding medical school less than a couple hundred meters distant is ripe for further exploitation. Biomaterials is a unique niche that is being well exploited. Some thought should be given to building complementary strengths in bioprocessing.

Yet another area of potential growth is in materials science. The Department has the opportunity to impact electronic materials processing and contribute to the regional industry. Other areas such as MEMS (microelectromechanical systems), ceramic processing and sensors should be considered.

The Department has a leadership role in colloidal sciences that might be jeopardized with future retirements. Consideration should be given to hiring in this area as well. Other areas that we might suggest are computational chemistry and bio-informatics.

One of the faculty members is now President of the AIChe. Such a highly visible position could be used to further the Department's reputation.

Threats. The current leadership must recognize how much of the Department's reputation rests on the shoulders of its senior faculty members (as it does in most highly regarded departments). Other faculty members must be groomed to take on the role of senior statesmen. Increased collaboration with other departments must be handled with care to ensure that the unique contributions of the Chemical Engineering faculty are recognized. Otherwise there is a danger that the department will be viewed as an entity that provides no real leadership on campus.

Recommendations. (1) Increase the size of the Department to at least 17 faculty. The demand from the undergraduates alone would seem to justify this move. (2) Insist that all faculty become research active. Establish targets for research productivity. (3) Raise national awareness of the Department: (a) establish an awards committee and nominate faculty regularly for national awards, (b) publish more texts and monographs (c) continue to increase the endowment. Use endowment money for strategic investments, e.g. create named seminars, whereby the Department honors prestigious faculty from the leading departments around the world.

IV. Infrastructure.

Strengths. The office staff, though small, seems remarkably good and efficient. Ms. Blanchette attends to all administrative needs in timely fashion. Both the graduate and undergraduate students universally praise Ms. Madrano, the student advisor. The endowment of this department is enviable. The physical plant is aging, but in good shape and makes a good impression on the visitor.

Weaknesses. A major lack is high quality space. There are only two lecture rooms, and research space is especially critical if one considers the special needs of the biological faculty. The lack of sufficient computer facilities is leading to frustration on the part of the undergraduate and first-year graduate students. The Department needs a higher level computer support person.

Opportunities. With the excellent alumni support, a campaign could be mounted to put a fourth floor on the building.

Threats. If the Department is to accommodate increased faculty and their graduate students and post docs, then more high quality space is needed. This need might become acute if there is more activity in the bioengineering side.

Recommendations: (1) Mount a campaign to put a fourth floor on the building. (2) Recruit a higher-level computer support person. (3) Devise an infrastructure plan to accommodate the additions of faculty, graduate and undergraduate students.

Summary and Conclusions.

A summary of our findings and analyses is contained in Table I which lists each of the areas considered and their strengths, weaknesses, opportunities and threats. We find the undergraduate program to be among the very best in the nation. We note that the excellent job market has lead to an increased demand for the major. With new faculty lines and infrastructure funding from state and federal agencies, the program could be readily expanded.

The graduate program is very good, but not among the top 5 to 10. There is an elite cadre of highly intelligent and motivated students, but the Department must encourage the small group of mediocre students. Expansion and upgrading of the graduate program will require adding faculty, developing more space, increasing research funding and intensifying graduate student recruiting.

The research and scholarly activities of the faculty are, for the most part commendable. However the visibility of the research program needs to be improved. If the Department is to increase its rank, there must be an increase in faculty to at least 17. Recruitment of high quality junior faculty will be critically dependent on (a) a decent salary and (b) adequate start-up funding.

Finally, the infrastructure of the Department is adequate. But if it is to meet its goal of improving its ranking by hiring more high quality faculty, then infrastructure improvements must be made. The committee recommends the acquisition of the needed space by addition of a fourth floor to the present building.

Summary Recommendations

Develop a strategic plan for the Department, revisit it regularly, and follow it. This strategic plan must include the following elements:

Faculty: Increase the size of the faculty to at least 17. Hire in areas consistent with the strategic plan. Insist that all faculty participate in research.

Research Program: Continue to pursue and expand collaborative research opportunities.

Graduate Program: Complete ongoing review of graduate curriculum, including examinations. Document and communicate the resulting curriculum and policies.

Undergraduate Program: Revitalize computing facilities and improve access. Update outmoded equipment in labs. Maintain excellence in teaching.

Finally, we address the ultimate question posed to us by the Charge Letter of September 14, 1998: should the University reaffirm the continuing states of the Bachelor of Science in Chemical Engineering, (B.S.Ch.E.), Master of Science in Chemical Engineering (M.S.Ch.E.), and Doctor of Philosophy (Ph.D.) degree programs offered by the Department of Chemical Engineering at the University of Washington? *Our answer is a resounding yes.* In fact we believe that everything possible should be done to expand and strengthen this outstanding program.

Table I. SWOT Analysis of Chemical Engineering

	Strengths	Weaknesses	Opportunities	Threats
Undergraduate	Excellent Quality Students, Dedicated Faculty, Rigorous Curriculum, Innovative classes	Faculty Advising, Unit Operations Lab outmoded	Increased outside funding as recognition of outstanding program, and for innovative new thrusts	Wholesale abandonment of two track course scheduling
Graduate	A cadre of highly motivated, outstanding students	Too many weak students, Insufficient computer facilities for first-years students	Recruitment of even more outstanding students using present students	Failure to meet expectations of current cadre of outstanding students
Research	Recognized excellence in such research as bioengineering, colloids, applied math and composites	Too many research inactive faculty. Insufficient funding to support requisite number of graduate students to achieve desired quality of research	Multidisciplinary programs by establishing stronger ties with Bioengineering and Materials science.	Failure to establish a strong and essential presence in collaborative projects.
Infrastructure	Talented, energetic support staff	Insufficient staff numbers to support desired growth path	Leverage loyal alumni to obtain fourth floor for building	Loss of support staff due to inadequate compensation