

October 31, 2017

PROFESSOR GEERT SCHMID-SCHOENBEIN, Chair
Department of Bioengineering

SUBJECT: Undergraduate Program Review for the Department of Bioengineering

Dear Professor Schmid-Schoenbein,

The Undergraduate Council (UGC) discussed the Bioengineering 2017 Undergraduate Program Review. The Council supports the findings and recommendations of the review subcommittee and appreciates the thoughtful and proactive response from the Department. The Council's comments centered on the following:

Courses. The Council would like to echo the subcommittee's suggestion of offering courses, especially BENG 100 *Statistical Reasoning for Bioengineering Applications*, in the summer or multiple times in one academic year. The Council believes that offering courses more than once in an academic year will help improve time-to-degree and alleviate some bottlenecks in registration.

Teaching Assistants (TAs). UGC shares the subcommittee's concern over TAs being inadequately prepared for the hands-on portion of individual courses. The Council is encouraged that the Department recognizes the need for developing strategies to improve the preparation of TAs, and looks forward to learning about the Department's success in implementing those strategies and their effects on TA training.

The Council will conduct its follow-up review of the Department in Spring Quarter 2018. At that time, our goal is to learn about the Department's progress in implementing the recommendations of the program review subcommittee and the Undergraduate Council. The Council extends its thanks to the Department for their engagement in this process and we look forward to the continued discussion.

Sincerely,

Sam Rickless, Chair
Undergraduate Council

Attachment

(1) Undergraduate Program Review Report and Responses for Bioengineering

cc: A. Pisano
J. Eggers
R. Rodriguez
R. Horowitz
J. Moore
M. Sidney

Undergraduate Council UG Program Review
Department of Bioengineering
May 9-10, 2017

The Undergraduate Program Review Committee for the Department of Bioengineering consists of Professor and Program Review Chair, Joseph O'Connor (Chemistry & Biochemistry, UCSD), Professor Massimo Vergassola (Physics, UCSD), and Professor Victor Rodgers (Bioengineering, UCR).

During its review the committee consulted a number of relevant documents supplied by the Associate Vice Chancellor/Dean of Undergraduate Education, including the prior program review (2009), the department self-study, student surveys, teaching statistics, and data on support & TA funds, majors' courses and enrollment, degree and student profiles, and faculty workload. On May 9 and 10, we interviewed Department Chair Geert Schmid-Schoenbein, Vice-Chair of Undergraduate Education David Gough, eight faculty members, three undergraduate students, two teaching assistants, Chief Administrative Officer Irene Jacobo, Undergraduate Advisors Elizabeth Soos, Kelly Thorpe, and Vanessa Hollingsworth, and the Deans of Academic Advising at Revelle (Shannon O'Brien) and Warren (Jacob Lacy) Colleges.

ADMINISTRATIVE STRUCTURE OF THE DEPARTMENT

The Department of Bioengineering was established as an independent department in 1994. By all accounts the department has strong and capable leadership provided by the administration of Chair Geert Schmid-Schoenbein and Vice-Chair of Undergraduate Education David Gough.

Chief Administrative Officer Irene Jacobo oversees the Business office. A staff of 3 undergraduate advisors (2.4 FTE) provides academic advice to new and continuing students. An Intake Advisor handles primary walk-in advising contact.

COMPOSITION OF THE FACULTY

The department currently has 26 faculty distributed among the ranks of full professor (13), associate professor (10) and assistant professor (3). In addition, there are 8 adjunct faculty, 14 affiliated faculty, and 8 professional research staff. There are no LPSOE, LSOE, or Unit-18 faculty members. In the past three years faculty with systems bioengineering expertise have been recruited and additional hires in this area are targeted for the future.

Currently there are 3 women and 3 underrepresented minority ladder rank faculty (11.5% of the faculty in each category). In the past two years, a rubric was developed to assist in a transparent and unbiased evaluation of faculty candidates. This rubric is now being used as a model for other School of Engineering departments.

Of six finalists for the current search, 4 are female and 2 are from underrepresented minority groups. Furthermore, two of the candidates are UC Presidential Fellows. The department is also seeking a target of opportunity hire. Thus, the department is well positioned to increase faculty diversity this year. The department has requested 5 FTE and 2 LSOE positions over the next three years.

WORK LOAD

The department self-study document states that the average teaching load is 3-4 courses/year, but this number includes freshman seminar courses, and faculty involved in freshman and senior design projects, etc. The average teaching load is closer to 3 standard lecture courses per year. The student faculty ratio has improved from 50 at the time of the previous external review to 27 (updated number provided during the review by Jacobs School of Engineering Dean Albert Pisano). This large decrease in student/faculty ratio is due in part to discontinuation of the premedical track since the last review.

DISTRIBUTION OF TEACHING ACTIVITY

Faculty teaching averages 50% undergraduate courses and 50% graduate courses. New faculty members are provided significant teaching release in the first two years to facilitate establishment of their research programs.

ENROLLMENTS

There are four separate tracks offered by the department: (1) Bioengineering (186 majors), (2) Bioengineering: Biotechnology (220 majors), (3) Bioengineering: Bioinformatics (133 majors), and (4) Bioengineering: BioSystems (90 majors). The last of these is newly established since the previous outside review. The premedical track has been discontinued. The Bioengineering and Bioengineering: Biotechnology tracks are accredited by the Accreditation Board of Engineering and Technology (ABET). The BioSystems track will apply for ABET-accreditation shortly after graduation of its first class in 2017. Accreditation of the Bioinformatics track is under discussion, but no firm plans are in place to apply for accreditation at this time. Enrollment in the bioinformatics track is shared with Computer Science and Engineering and the Division of Biological Sciences.

Enrollment figures for the 3 established tracks have remained steady over the past three years and steady enrollment growth as occurred in the new BioSystems track. All four tracks are now "capped", which restricts enrollment growth, but also helps to maintain the high quality of the programs. The student's GPA in 8-10 screening courses determines acceptance of continuing students into a bioengineering track.

The department has made significant strides in increasing diversity among the student body. The percentage of female bioengineering majors has increased from 35% in FA11 to 45% in FA15. This compares with a campus-wide FA15 female enrollment of 48%. The FA15 Chicano/Latino and African-American/Black enrollments of 9% and <=1%, respectively, compare to campus-wide figures of 16% and 2%, respectively. Engineering is traditionally male-dominated and it might be informative to see the female enrollment figures for the Jacobs School of Engineering for comparison. Additional efforts to improve diversity of the student body are clearly warranted.

A 5-year BS-MS degree typically enrolls 3 – 5 students per year. Bioengineering currently does not offer a Minor.

JOINT PROGRAMS

The bioinformatics track is shared with Computer Science and Engineering and the Division of Biological Sciences. In addition, the department maintains cooperative arrangements with other departments in the Jacob School of Engineering, as well as with the Schools of Medicine and Management.

Faculty supervision of senior design projects has expanded by engaging general campus faculty, health science faculty, and industry partners (BIOCOM). Of particular note, BENG 193 places high performing students in clinical rotations at the medical school.

STRENGTHS AND WEAKNESSES OF THE CURRICULUM

The department has a strong orientation program for new students. A Welcome/Orientation session at the beginning of the academic year provides students with information on the four tracks and introduces them to faculty and advising staff. The Undergraduate Coordinator also offers interactive group advising each Fall term. The department flow charts are informative about the sequence of courses required for each track.

Curriculum weakness noted in the previous outside review has been partially addressed. Student dissatisfaction with split courses led to a dramatic decrease in courses co-taught by two or more faculty, and BENG 1 (Introduction to Bioengineering) has been substantially revamped. However, BENG 1 remains a work in progress. Some students maintain that lectures are often delivered at a higher level than is appropriate for freshman students, and that teaching assistants are sometimes inadequately prepared for the hands-on portion of the course.

The committee notes that the recent UC-mandated decrease in overall units may have led to unintended consequences with respect to remaining course content. More specifically, some students expressed concern that important biology content may now be lacking from the curriculum, and that some professors may assume student exposure to material that has not actually occurred. This is a particularly difficult problem for a highly interdisciplinary program like bioengineering. The committee encourages the department to closely examine course content in the first two years of the curriculum, and to work with other departments involved in core courses (lab and lecture) in order to update and modify content.

Alumni surveys indicate that some students feel that more emphasis on technical writing and oral presentation skills would be beneficial. During the review exit meeting, Dean Pisano re-emphasized the opportunities afforded by the department's annual Bioengineering Day event at which students present their research, including senior design projects. The committee was pleased to note that the theme for the 2017 BE-day is "diversity" with the goals of addressing diversity in the bioengineering field and creating solutions to improve diversity across the field.

The most serious weakness in the curriculum, as noted in the previous outside review, is that no courses are taught more than once per year, as elaborated upon below. Discussions are underway on the possibility of a 2nd BENG 100 offering each year, perhaps in the summer session. A summer offering would need to be taught by either a LSOE or unit-18 lecturer since ladder rank faculty focus on their research programs during the summer months. The committee recommends a thorough review of course prerequisites to determine if any other courses could be offered twice per year in order to improve time-to-degree. This will be especially important as the department begins to introduce summer internships in several of the majors.

An important strength of the curriculum is the capstone design course sequence, which is required for senior level students in three of the tracks. The bioinformatics track will introduce a capstone requirement in the next two years.

OVERALL ACADEMIC QUALITY, AS COMPARED WITH OTHER INSTITUTIONS

The overall academic quality compared to other institutions is impressive. In 2016 *US News and World Report* rated the undergraduate program #6 among all undergraduate bioengineering programs and #2 among public universities. The Bioengineering and Bioengineering: Biotechnology majors were reviewed for ABET accreditation within the last two years and received a full, six-year accreditation.

OPERATION OF THE PROGRAM IN RELATION TO NEEDS OF STUDENTS FORM OTHER DEPARTMENTS AND/OR PROGRAMS

A large number of students from the Department of Nanoengineering enroll in bioengineering courses, as well as more modest enrollments from other departments within the Jacobs School of Engineering.

RELATION TO NEEDS OF GENERAL EDUCATION AND THE COLLEGE SYSTEM AT UCSD

The Department contributes to the mission of UCSD's College System by providing career options that integrate with the educational objectives of the Colleges. The previous review noted that the UCSD college system makes it difficult to complete a Bioengineering major in four years and this has not changed since the previous review. Many bioengineering majors find Warren College attractive due the relatively lower breadth requirements. The department provides notification in the Catalog that some colleges require more than the ten HSS courses indicated in the curriculum tables, so that students in those colleges may take longer to graduate than the four years indicated in the schedule.

HOW WELL DOES THE PROGRAM MEET THE OBJECTIVES OF THE VARIOUS GROUPS ON CAMPUS? HOW EFFECTIVE IS THE DEPARTMENT'S TEACHING FUNCTION IN RELATION TO STUDENTS OF DIVERSE OBJECTIVES?

The bioengineering major is demanding and aimed at top-tier students who are interested in a highly interdisciplinary degree with strong engineering and biology components.

WHAT ARE THE SUPPORTS AND IMPEDIMENTS TO CURRICULUM EFFECTIVENESS?

The major impediment to curriculum effectiveness is the fact that nearly every required course is taught only once per year. Negative impacts of this policy include: 1) time-to-degree is extended for students who miss a course for whatever reason; 2) it is difficult for students to participate in an internship program (BENG 97) that requires a 10-hour per week commitment; 3) it is difficult for students to participate in a study abroad program; and 4) advanced engineering subjects are taught in large class settings (> 50 students) which is a detriment to quality education and impacts the department ranking in national polls. During the review exit meeting, Dean Pisano noted that the School of Engineering did a survey of all courses that have 100 or more students and is now in year three of a seven-year plan to reduce class size.

Student advising appears to be in need of additional staff, even if minor improvements in efficiency are achievable. Staff responsibilities extend beyond direct interactions with undergraduates. These include work related to the undergraduate component of training grants, an expanding internship program and other outreach activities, the ABET accreditation process for three and possibly four majors in the future, general faculty

support efforts, curriculum/course administration, the senior capstone sequence which is now required in three tracks and will be introduced into the bioinformatics track in the next two years, and other responsibilities related to the unique department culture. A School of Engineering plan to increase enrollment in a Master's Degree program will further exacerbate the situation. The administration's current budget model targets a student/advisor ratio of 640, which may be inappropriate for Student Advising in the Bioengineering Department. Some student dissatisfaction with student advising was noted, including the claim by one student that staff encouraged a change of major due to the difficulty of meeting electives.

Faculty members are each assigned 13 – 27 student advisees. This is an admirable program that in reality could be improved. Many students never contact their faculty advisors and most faculty advisors are not proactive in contacting their advisees. A substantial faculty workload makes it difficult for one-on-one interactions with up to 27 advisees; however, it may be possible to hold small social gatherings once or twice a year involving an individual advisor and a group of advisees. It was suggested that the Biomedical Engineering Student Society (BMES) chapter might be interested in coordinating events of this type. An alternative is to have a few hours blocked per quarter for faculty/student meetings and make the meetings mandatory for registration.

ANY TRENDS OBSERVED WITH RESPECT TO THE DEMAND FOR DEPARTMENT MAJORS AND/OR MINORS, SERVICE TEACHING

Student demand for the bioengineering major is greater than can be accommodated. There are many highly qualified students who would like to major in bioengineering but are not admitted because of the "capped" status of all bioengineering majors. Capped status is a consequence of limited faculty FTEs and limited undergraduate laboratory course offerings. A majority of students participate in independent research with a faculty member for their Technical Elective credit (BENG 199).

The department offers no service teaching. It is unlikely that a service course will be created until faculty numbers have increased considerably. There are no minors in the Department of Bioengineering.

METHODS OF INSTRUCTION, SUPERVISION AND TRAINING OF TEACHING ASSISTANTS AND TEMPORARY INSTRUCTORS

In the recent past, Ph.D. students have been required to TA for 4 quarters at 25% time. This requirement has been reduced to 3 quarters going forward. TA training is provided by the Bioengineering Department and UCSD's Center for Teaching Development. Some students felt that TAs need additional instruction on specific experiments to be performed during the hands-on portion of individual courses.

The two TAs who met with the review committee believed that the undergraduates would benefit if the TAs were able to commit more time to teaching and less time to grading. They did note that it would be difficult to involve undergraduate graders for some courses due to the nature of the exams. The department previously experimented with split grader positions from TAs but found the arrangement to be less than optimal.

GRADING POLICIES

Between the 2011/12 - 2015/16 academic years, the mean GPA varied between 3.29 – 3.36

freshmen enrollments. This is slightly higher than the mean GPA of 3.19 – 3.23 over the same period for freshmen campus enrollments.

Between the 2011/12 - 2015/16 academic years, the mean GPA varied between 3.22 – 3.42 for transfer enrollments. This is higher than the 3.09 – 3.14 mean GPA for freshmen campus enrollments.

EVALUATION OF COURSES AND TEACHING

The committee notes that the Course and Professor Evaluations (CAPE) Scatterplot has significant scatter. Roughly 20 course offerings between Fall 2012 and Spring 2016 failed to achieve a "Recommend Instructor Percentage" of > 60%. The Chair and Vice Chair, with input from CAP, have been proactive in addressing teaching issues. The Chair discusses teaching concerns with individual faculty and provides teaching advice to junior faculty. Through these efforts, a number of the teaching issues appear to be resolved. The committee anticipates improvements at the next external review.

ARE ACADEMIC LEARNING OBJECTIVES AND ASSESSMENT PROCESSES CLEARLY DEFINED FOR EACH MAJOR? ARE METHODS IN PLACE FOR CONVEYING LEARNING OBJECTIVES TO STUDENTS?

Actual student learning is assessed in selected courses by both direct and indirect measures, as discussed in the department self-study.

Student learning outcomes are defined through ABET and The Western Association of Schools and Colleges (WASC). The WASC Exhibit 7.1 in Appendix K of the department self-study defines educational effectiveness indicators and core competency standards.

HOW DO FACULTY ASSESS THEIR OWN PROGRAM'S STRENGTHS AND WEAKNESSES?

Regular assessment of the program's strengths and weaknesses is provided by an extensive feedback structure that includes dialogue with representatives from industry (the *Industrial Advisory Board* and the *Board of Trustees*), a senior student exit survey, alumni surveys, and introspective discussions at an annual faculty retreat.

CAMPUS AND UNIVERSITY CONTEXT

The Department of Bioengineering contributes to UCSD's mission of addressing society's needs primarily by contributing human resources and expertise in the medical and bioengineering industries and professions.

Opportunities for community service, spearheaded by the *Biomedical Engineering Student Society* (BMES) chapter, include outreach programs that send undergraduates to local schools in order to introduce high school students to the engineering field. BMES also introduced the highly successful Bioengineering Day (vide infra). The *Engineering World Health* (EWH) student organization provides a mechanism for students to work in cooperation with the UCSD School of Medicine in an effort to provide medical technology for developing nations. The student chapter of the *International Society of Pharmaceutical Engineers* (ISPE) focuses on professional development events for students. The *Women in Bioengineering* student organization focuses on helping women in the field. The *Bioinformatics Club* organizes events related to the field of Bioinformatics.

CAMPUS AND UNIVERSITY CONTEXT: TRANSFER STUDENTS

The 2-year graduation rate for transfer students declined from 32% in 2011 to 6.5% in 2013. This compares to the total campus figures of 40% in 2011 and 37% in 2013. Thus, very few transfer students graduate in two years. Vice-Chair for Undergraduate Education David Gough and the Student Affairs staff indicate that this is a multi-level issue contributed to by the following:

- 1) Due to courses being offered one time a year, and many courses such as math (differential equations and vector calculus) and lower and upper division Bioengineering courses not being offered at community colleges, it takes transfer students 3 years to graduate. As a consequence, transfer students must be admitted directly into a major in the department and are ineligible to apply through the continuing application process (as this would put them at 4 years to graduate). This is consistent for transfer students across engineering within the Jacobs School.
- 2) In 2011, the department was still graduating transfer students from the Bioengineering: PreMedical track. This track had minimal engineering, was not capped/impacted, and required many courses offered multiple times per year from outside of the department.

CAMPUS AND UNIVERSITY CONTEXT: FUNDING AND PERSONNEL ALLOCATIONS; PHYSICAL FACILITIES, INCLUDING LABORATORIES AND LIBRARIES

Students indicate a desire for a more hands-on bioengineering component early in the curriculum. The prior external review identified limited undergraduate laboratory space as an obstacle to increasing the hands-on component of the program. Currently there is one undergraduate laboratory space (~1600 ft²) and an additional lab of comparable size appears warranted in view of industry demand for students with extensive laboratory experience. The use of simulation software may provide a valuable supplemental laboratory tool but does not replace hands-on experience. The committee recommends the department accelerate planning for an additional undergraduate laboratory facility, perhaps through renovation of basement space in the existing building. An additional solution is to offer labs in the summer and multiple times each year, however this would require additional faculty. A promising recent development is expansion of the EnVision Arts and Engineering Maker Studio at UCSD from 3000 ft² to 6000 ft². This space provides a range of design, fabrication, and prototyping tools for UCSD students.

RECOMMENDATIONS FOR ALLEVIATING ANY SHORTCOMINGS SUGGESTED BY THE DESCRIPTION AND ANALYSIS

The Department of Bioengineering is an excellent world-class department. Committee recommendations are as follows:

- 1) Carefully examine course content in light of recent university-mandated decreases in units. Students seem to desire more biology content. This may require modification of course content in freshman and sophomore level offerings by other departments.
- 2) Offer courses more than once per year, especially BENG 100 and laboratory courses.
- 3) Increase student training in technical writing and oral communication skills throughout the curriculum.

- 4) Improve experiment-specific TA training for individual courses. This may require more faculty-TA interaction with regard to individual experiments to be undertaken in a given course.
- 5) Continue to improve BENG 001. The first exposure to bioengineering should be an outstanding experience for the students.
- 6) Improve the faculty advisor program by introducing social interaction events between individual advisors with groups of advisees, or possible mandatory requirement to student/faculty advising at least once per year.
- 7) Additional undergraduate advisor staff appears fully justified. A uniform advising protocol may be useful, as it appears some students were advised to change majors due to difficulty in meeting elective requirements.
- 8) Recruit additional FTEs from underrepresented minority groups.
- 9) Further develop outreach efforts to increase the percent of majors from underrepresented groups.
- 10) A departmental meeting may facilitate changes to current structure and proposed adjustments.

Many of the key shortcomings will require additional financial support from the administration. Additional staff in Student Affairs is a pressing need, especially in light of the expanding internship program. Additional faculty FTE are required in order to address long-standing problems that result from offering most courses only once per year.

The committee thanks the following for participating in the review process: Associate Vice Chancellor/Dean of Undergraduate Education Barbara Sawrey; Department Chair Geert Schmid-Schoenbein; Vice Chair of Undergraduate Studies David Gough; Department Faculty, including Shu Chien (Prof.), Adam Engler (Assoc. Prof.), Andrew McCulloch (Prof.), Christian Metallo (Asst Prof.), Subramaniam Shankar (Prof.), Yingxiao Wang (Prof.), Pedro Cabrales (Assoc. Prof.), and Bruce Wheeler (Adj. Prof.); Chief Administrative Officer Irene Jacobo; Undergraduate Affairs Staff: Elizabeth Soos, Kelly Thorpe, Vanessa Hollingsworth; undergraduate students and teaching assistants; Shannon O'Brien, Revelle College Dean of Academic Advising; Jacob Lacy, Warren College Dean of Academic Advising; Kathleen Johnson, Asst. Dean Undergraduate Education; and Dean Albert Pisano, Jacobs School of Engineering.