

# **Report of the Ad Hoc Committee To Study Graduate Education In The Natural Sciences And Engineering**

University of California, San Diego  
Office of Graduate Studies and Research

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# **I. Background**

## **A. COSEPUP Report**

In Spring 1995, the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Science, National Academy of Engineering, and Institute of Medicine issued a report, *Reshaping the Graduate Education of Scientists and Engineers*. This report provides a thoughtful analysis of several important issues confronting graduate education and makes a number of constructive recommendations for improving what it recognizes as an already excellent educational system.

A main theme of the COSEPUP report is that, while the U.S. graduate education system remains strong, new Ph.D.s are facing a time of considerable uncertainty. The number of faculty positions in colleges and universities is unlikely to grow significantly over the next several years. Very likely federal funding for research will be severely constrained and may face major reductions as the nation attempts to balance the federal budget. Business and industry is reducing its support of in-house research in order to pare costs to compete in the global marketplace.

These developments have made it increasingly difficult for new Ph.D.s to obtain permanent positions as basic research scientists and engineers. Although it is difficult to make job market projections, the COSEPUP report concluded that "the growth in nonresearch and applied research and development positions is large enough to absorb most graduates" and made several recommendations designed to increase the versatility of Ph.D.s and to improve the career information and guidance provided to graduate students.

## **B. National Dialogue**

The COSEPUP report, along with many other articles and reports written in the past year about science and engineering doctoral education, has stimulated an active dialogue on the future of science and engineering doctoral education. This has stimulated many higher education organizations such as the Association of Graduate Schools and Council of Graduate Schools and their member institutions to consider whether the scale and character of their science and engineering graduate programs are well suited to the changing marketplace that their students will face when they graduate. Several top-ranked research universities have recently decided to reduce science and engineering graduate enrollments, and others are considering curricular and programmatic changes to make their graduates more versatile.

## **C. UCSD Committee**

In January 1996, UCSD Senior Vice Chancellor Robert Dynes and Academic Senate Chair John Wheeler appointed a committee of faculty and graduate students to review graduate education in the natural sciences and engineering at UCSD in light of the national discussion and to consider what actions might be needed, if any, to ensure that UCSD's programs continue to contribute to the advancement of knowledge and also serve the interests of our students and their prospective employers. It is anticipated that a second committee will be appointed in the 1996-97 academic year to review graduate education in the humanities, social sciences, and arts.

In its four meetings, the committee carefully reviewed and extensively discussed the issues raised in the COSEPUP report. Individual committee members discussed the issues with faculty and graduate

students within their own departments, and some also consulted outside their departments. Related reports, articles, and programs were also examined by the committee. The committee reached a number of conclusions which are spelled out in the following sections.

## **D. University of California**

Within the University of California, a subcommittee of the University of California Coordinating Committee on Graduate Affairs is addressing similar issues at the University-wide level.

## **II. The Challenge**

The U.S. system of graduate education in science and engineering is recognized as the best in the world and one of the nation's great strengths. UCSD's doctoral programs rank fourth in the nation in the biological sciences, ninth in physical sciences and mathematics, and ninth in engineering. Our Ph.D. programs do an excellent job of preparing students for careers as research scientists and engineers.

However, it is likely that a substantial fraction of our students (over half in some disciplines) will not obtain permanent positions in basic research. This has long been the case in engineering and chemistry. Further, in a majority of science and engineering fields, Ph.D.s face an uncertain job market outside of academia. We don't know if these difficulties are a short-term aberration or a long-term problem associated with the restructuring of the U.S. economy. How well the economy does over the next few years, how colleges and universities respond to the projected rapid growth in the college age population, how strongly the federal government is committed to vigorous R&D, and how long industry can do with less internally funded R&D, are questions for which no one now has the answers. But the answers to these questions will dramatically influence the job market for Ph.D.s in the coming decade.

Despite the uncertain future, UCSD departments and programs are encouraged to evaluate job market prospects for their graduates and to review and modify their graduate curricula to take into account the reality of the current difficult job market. The challenge is to modify the programs to face this new reality while preserving the essential features that have made them excellent vehicles for education researchers.

## **III. Recommendations**

### **A. First Principle**

The Ph.D. degree is awarded for the creation of new knowledge. As a first principle, we reaffirm the central role of original research as a requirement for the degree. The requirement that a student take charge of a research program and carry it to completion is a broadly useful education, and it will continue to serve well those who pursue basic research careers in academia, industry, and government, and those who follow careers in applied research and development, as well as those who become managers in technology-based industry or policy makers in government agencies.

### **B. Enrollment Planning**

Because the longer-term demand for new science and engineering Ph.D.s is so uncertain, UCSD should not impose central controls on graduate student enrollments in its graduate programs. Market forces (e.g., student choice and availability of funding for student support) may do that for us. Departments should set standards high enough to ensure that all graduates will be competitive in a

difficult job market. Departments may wish to adjust enrollments to the level they judge appropriate to the likely job placement of graduates and available graduate student support, but if the number of applicants declines, they should not reduce standards to generate enrollment levels sufficient to fill research and teaching assistantships.

### **C. Career Information, Advising, and Placement Assistance**

Accurate and up-to-date information is needed by graduate students and faculty to assist students in planning their graduate programs and making informed career choices. Efforts are under way at the national level to provide this information. Two World Wide Web sites—"Science's Next Wave" and COSEPUP's "Career Planning Center for Beginning Scientists and Engineers"—are now offering career services, information, job listings, and interactive fora. In addition, COSEPUP has recently published a useful new S&E career planning guide. Also, UCSD's Career Services Center and Office of Graduate Studies and Research (OGSR) can offer helpful career information and services.

Departments, however, should be the principal loci of career information and guidance. They should provide students with early and realistic career advising at each stage of their doctoral program. This should include information on the employment of recent graduates from each sub-discipline. The first and second years are not too early to begin critical thinking about students' career options in order to plan and optimize the use of their time at UCSD. Individual faculty should project an attitude that nonacademic jobs can be as challenging, worthwhile, and satisfying as academic jobs and should play a more active role in helping graduate students make rational career choices. Departments and students' advisers should provide vigorous assistance in students' first placement and at later times throughout the early years of graduates' careers.

A practical difficulty with achieving consistently good career advising and placement assistance is that many faculty members are not very knowledgeable about nonacademic career opportunities. For this reason, we recommend that each department assign responsibility to one faculty member for coordinating these functions within the department and that OGSR and Career Services consult with departments about how they can provide better advising and placement.

During the course of the committee's work, many excellent ideas were suggested for improving career advising and placement. These ideas are listed in the appendix. Departments, deans, OGSR, and Career Services are encouraged to study these ideas and implement them as appropriate to their unit and as part of an integrated career advising and placement strategy.

### **D. Curricular Breadth and Professional Skills**

UCSD has developed exceptionally strong graduate programs in the sciences and engineering, and the paramount purpose of our Ph.D. programs must continue to be the education of students to carry out independent original research of high quality. At the same time, recognizing that many of our students will choose nonacademic or nonresearch career paths, we should provide opportunities for our students to acquire (a) breadth within the discipline, (b) breadth across disciplines, and (c) professional skills.

The committee endorses the COSEPUP recommendation that "students should be grounded in the broad fundamentals of their fields and be familiar with several subfields." Such breadth is important not only for students planning nonresearch careers, but also for students aiming for research careers who will require the flexibility to recognize emerging areas of research and work at the interfaces of disciplines where much of the most exciting research is being conducted. One of UCSD's greatest strengths is our interfacial research programs, the permeability of departmental walls, and our many interdisciplinary programs. The committee encourages departments to build on these strengths and to

provide students with opportunities to broaden their knowledge of subfields and related fields, by developing strong minors or by taking more courses and participating in more seminars within and outside their departments. At the dissertation stage, students might want to take one or two courses a year to maintain breadth and flexibility.

Departments are also encouraged to consider establishing innovative interdisciplinary master's programs. These could be offered jointly by two or more departments, or existing master's programs could be expanded with course offerings from other departments. Such programs could be available to Ph.D. students who want to broaden their training and earn an interdisciplinary master's degree along the way to the Ph.D., to doctoral students who decide not to go on for a Ph.D., to new students who intend to study only for a master's degree, and to bachelor's/master's degree students. Examples that were suggested during our discussions include an M.S. in engineering physics (broader than the current AMES degree) with Physics, AMES, and ECE course offerings; biological science students taking bioengineering courses to have a broader M.S. degree; a master's degree in complexity theory, combining nonlinear science, econometrics, and computer science.

Finally, the committee encourages departments to provide students with opportunities to develop professional skills. Important among these are communication skills and the ability to work well in teams. At all stages of their studies, students should be provided with a multitude of opportunities to write up and orally present their work to their own lab groups, subfield group meetings, journal clubs, department faculty/graduate student seminars, and local, regional, national, and international scientific meetings. To develop the ability to communicate complex ideas to nonspecialists, students should be provided with enhanced teacher training, including the experience of teaching their own class. This will better prepare them for both the academic and the nonacademic job market.

Although higher education has long promoted independent thought and activity as a virtue, science and engineering research has become a more collective enterprise. While independence of thought should continue to be emphasized, students should also be encouraged to develop the ability to work well in teams. Such ability will be increasingly important in any career as science Ph.D.s work with people in industry and government in the areas of management, planning, services delivery, marketing, financing, and sales.

Students should have access to opportunities to develop other professional skills in areas such as business and computing. Students could take courses in these areas through other campus departments and through University Extension. Also, departments could develop non-credit courses covering practical career skills similar to ones being developed at several universities around the country.

Off-campus internships in industry and government might be useful to assist students in developing the full range of professional skills. For those students interested in doing an internship, it would be important to fit the internship into the Ph.D. program without it becoming disruptive or increasing time to degree. The summer before beginning graduate study or the summer between the first and second years might work well for some students in some disciplines.

## **E. Specialization and Time to Degree**

A corollary to the recommendation to increase the breadth of doctoral students' education is the recommendation to discourage students from overspecializing. Some students become so essential to their advisers' research programs that completion of their degree programs can be delayed. Advisers should take responsibility for ensuring that a dissertation topic is a realistic project that can be accomplished in a reasonable amount of time. Although for all students the dissertation should

represent a substantial accomplishment, specialization and development of a reputation as an expert in a specialized research niche should be done at the postdoctoral level.

Departments and faculty could be given incentives to encourage timely degree completion and discourage overspecialization. Two suggestions that the Vice Chancellor-Academic Affairs might consider are recognizing postdoctoral instruction in departmental instructional workload statistics, such as student/faculty ratios and the Penner Parameter, and modifying the faculty review system so that faculty are rewarded as much for supervising postdocs as they are for supervising graduate students.

In the implementation of the above recommendations, it is important that time to degree not be increased. Indeed, departments are encouraged to search for appropriate, academically sound ways to reduce time to degree.

## **F. Placement Tracking and Alumni Contact**

Accurate information about the placement and career paths of our new Ph.D.s and postdocs is important to our ability to recruit outstanding graduate students and postdocs to our programs, to provide accurate career advising, to assist them in securing challenging career positions, and to assist the University in keeping our graduate programs vital and among the top-rated programs in the country.

Since 1972, departments and the Office of Graduate Studies and Research have been collecting and analyzing information on first placement after award of the Ph.D. Some records after first placement are maintained by a few departments, particularly those with training grants that require placement reporting. These records, however, are typically spotty and many are out-of-date. Departments and OGSR should implement a system that tracks placement of graduate students and postdocs throughout their careers. Because the data are necessarily retrospective, current students and postdocs should be cautioned that there are many other important factors to consider when choosing a mentor.

Departments and OGSR are encouraged to use the alumni database as a resource to link our graduates with UCSD. This would provide departments and OGSR with the ability to access up-to-date information on graduates' current jobs, survey our graduates about the quality of their graduate education and solicit suggestions for changes, contact graduates regarding possible internships and advising of current students, and become a recipient of graduates' gift-giving. Departments and OGSR are encouraged to establish regular communications with our graduates through, for example, web pages, electronic discussion groups, newsletters, yearly letters from the chair and/or dean. Such communications could provide graduates with ongoing news about the department and UCSD, placement advice, and information about continuing education options, and would assist graduates in maintaining useful contacts in their discipline.

## **IV. Responsibilities**

Departments review their programs in light of the above and make changes they deem appropriate.

Office of Graduate Studies and Research work with departments to systematically track Ph.D. and postdoc placement and with the Career Services Center to provide consulting services to departments and to explore options for providing better career information, advising, and placement services.

Deans work within their divisions or schools and collectively across divisions and schools to provide opportunities for interdisciplinary study.

Senior Vice Chancellor-Academic Affairs consider incentives to encourage timely degree completion and discourage overspecialization.

Graduate Council and Senior Vice Chancellor-Academic Affairs review the report's recommendations, modify the recommendations where they think appropriate, and monitor departments' and deans' progress in reviewing and implementing the recommendations.

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Science's Next Wave, <http://sci.aaas.org/nextwave/>

## **VI. Appendix**

### **Ideas for Improving Career Advising and Placement Assistance for Graduate Students**

1. OGSR and Career Services could assist departments by providing access to information about nonacademic jobs, conducting workshops that cut across more than one department, organizing a career fair, collecting information about industrial job opportunities in interdisciplinary markets, and consulting with departments about how they can provide better advising and placement.
2. Faculty could describe job opportunities in their field when they describe their research in first-year graduate student seminars.
3. A director or directors of industrial relations could be appointed to facilitate faculty-graduate student-industry interaction and graduate students obtaining industrial jobs. This person might be a former or retired industry executive employed on a part-time or full-time basis by a department or by a divisional dean.
4. Industrial boards could be created with graduate student representation and involvement in organizing board activities.
5. Previous Ph.D. recipients from the department could be brought in to talk about their current work outside academe and advise students who might be interested in careers in their sector.
6. Industry representatives could be invited to talk about job opportunities and serve as career advising mentors to students.
7. Students and industry representatives could be brought together in other formal ways, such as in student poster sessions where students discuss their research.
8. Students could form groups to research job information, evaluate job opportunities, discuss job-getting strategies, advise one another, et cetera. A student or students could also be paid to coordinate these activities.
9. While presenting their research at scientific meetings, students could also arrange structured visits to local universities and industries.