

# **ENGINEERING FOR A BETTER WORLD: THE PRINCETON VISION**

The School of Engineering and Applied Science (SEAS) at Princeton University will set a new standard for excellence in engineering education and research. We will achieve this ambitious goal by instilling our teaching and research with an interdisciplinary perspective and a greater understanding of the impact of technology on society. We will educate leaders and solve pressing problems.

Science and technology permeate nearly every aspect of life, yet engineering traditionally has been a field with a narrow and technical focus. As the pace of innovation accelerates and technology grows ever more complex, science and technology are becoming increasingly interdisciplinary, demanding an approach that spans multiple academic disciplines and includes a broader, non-technical perspective. Society needs leaders who are capable of incorporating both technical and non-technical considerations, whether in academia, business, government or the not-for-profit sector.

SEAS is well positioned to achieve this vision. With our small size and world-renowned faculty and students, SEAS already has set high standards in balancing cutting-edge research and first-rate teaching. Our research focuses not only on explaining fundamental principles but also on solving real-world problems. An uncommonly close connection already exists between SEAS and the larger University, which has deep strengths in the humanities, social sciences, natural sciences and public policy. Our students become leaders, not just in traditional academic disciplines but also in industry, government and many areas of public service.

We begin this plan by outlining two foundational initiatives, which focus on setting a new standard in engineering education and on fostering an environment for high-impact interdisciplinary research. The report then describes a number of focused research initiatives that address societal needs and grow out of the specific strengths of SEAS and the larger University. The plan includes specific objectives and timetables for achieving the vision and concludes by proposing metrics for measuring our success. Implementing this plan will ensure that SEAS is an outstanding competitor for research funding and a magnet for the very best faculty, staff and students. If we are successful, peers will view SEAS as a leader in realizing the full potential of engineering. Princeton's talented students will see in engineering the means for making the world a better place.

## **1. Introduction**

The School of Engineering and Applied Science (SEAS) at Princeton University has outstanding teaching and research capabilities in the core disciplines and well-established interdisciplinary programs. The school is part of a premier liberal arts institution with world-class departments and programs in the natural sciences, social sciences, humanities and public policy. A solid majority of bachelor of arts students at Princeton enroll in SEAS courses that introduce them to technology. Taken together, these strengths enable SEAS to

educate well-rounded students who go on to become leaders not just in traditional engineering fields, but also in many areas of industry, government, finance and public service.

The unprecedented impact of engineering on every facet of life demands, however, a new paradigm for engineering in the modern world. Our vision is to educate leaders -- both within and outside of engineering -- and to conduct interdisciplinary research that truly addresses the world's needs, by providing a substantive understanding of technology and its role in society. SEAS will strengthen its connection with the University as a whole and expand its relationships with government and industry to become the best at placing engineering in its full societal context.

This approach complements and draws strength from the broader mission of Princeton with its informal motto, "In the Nation's Service and in the Service of All Nations." In carrying out this mission, Princeton has a history of fostering teaching and research in emerging areas of inquiry where the most pressing problems cross boundaries between traditional academic departments. For example, the recently established Lewis-Sigler Institute for Integrative Genomics combines molecular biology, physics, chemistry and engineering to make sense of the information from the human genome project. Princeton's Woodrow Wilson School of Public and International Affairs brings together faculty members from economics, politics, sociology, psychology, biology, geosciences and other departments. The University Center for Human Values supports teaching and research regarding ethics and human values across many disciplines.

The bold step of immersing SEAS within the broader enterprise of the University will not only benefit the engineering school, but will greatly enhance the teaching and research opportunities for any Princeton program that seeks a greater understanding of the human condition in an age of technology.

## **2. The Foundational Initiatives**

### **A. Leadership in Engineering Education**

The first foundational initiative of the SEAS strategic plan is to set a new standard for excellence in engineering education. We will expose students to pressing problems with solutions requiring integrative approaches across multiple disciplines. We will challenge students to explore the full societal context of technology and its applications in the real world. We will provide new educational opportunities within the established disciplines to focus on emerging fields that show great promise. And we will retain our commitment to rigor and depth within the core disciplines of engineering. Our vision for engineering education encompasses undergraduate and graduate students, and a wider audience through outreach. Beyond our core mission of educating engineers, we are committed to teaching non-engineers about concepts in engineering and science, instilling in them a solid understanding of technology and how it affects the world.

For too long, traditional engineering education has been characterized by narrow, discipline-specific approaches and methods, an inflexible curriculum focused exclusively on educating engineers (as opposed to all students), an emphasis on individual effort rather than team projects, and little appreciation for technology's societal context. Engineering education has not generally emphasized communication and leadership skills, often hampering engineers' effectiveness in applying solutions. Engineering is perceived by the larger community to be specialized and inaccessible, and engineers are often seen as a largely homogenous group, set apart from their classmates in the humanities, social sciences and natural sciences. Given these perceptions, few women and minorities participate in engineering, and non-engineering students are rarely drawn to engineering courses.

Princeton engineering has never particularly conformed to this tradition -- our students and faculty are too well rounded for that -- making SEAS well positioned to lead a transformation of engineering education. We seek to shift the balance from disciplinary to interdisciplinary, from ivory tower to real world, from exclusively for engineers to inclusive of all students, from largely homogenous to broadly diverse and from individualistic to collaborative. By changing our own approach to engineering education, we seek to have an impact on the culture of engineering pedagogy worldwide.

If engineering is to become truly engaged in understanding and solving societal problems, its practitioners must reflect society. Increasing diversity will facilitate new approaches and ways of thinking about engineering, while strengthening the link between technology and society. We seek to create an educational environment that is relevant and appealing to a broad population and to make this education accessible to those from diverse cultural, ethnic and economic backgrounds. Our success in this regard will address the critical shortfall of women and minority graduates in academia, industry and government.

Our plan sets five specific objectives for SEAS in education:

- Achieve top five rankings for all SEAS graduate and undergraduate programs (recognizing that rankings measure excellence in both education and research).
- Increase diversity in the SEAS student body.
- Broaden interdisciplinary opportunities for SEAS students.
- Improve scientific and engineering education for non-engineers.
- Better prepare SEAS graduates for success in their careers.

SEAS will create a new entity to spearhead and focus efforts in establishing a new standard of excellence in engineering education at Princeton. The Princeton Center for Innovation in Engineering Education (CIEE) will support and encourage the development of new courses, pilot educational initiatives and expose students to real world experiences. CIEE will help integrate consideration of the wider societal context into existing curricula, expand opportunities in cross-disciplinary fields and develop student skills in research, policy, communications, leadership and entrepreneurship. CIEE will support faculty in developing and leading new educational initiatives. In carrying out these initiatives, CIEE will partner with the McGraw Center for Teaching and Learning and the Office of Career Services.

Specific steps to be pursued include:

### *Interdisciplinary Education and Societal Context*

- Develop an innovative first-year undergraduate curriculum integrating engineering with math and physics.
- Work with departments to add AB programs as an alternative to the traditional BSE degree. The AB program will have approximately 20 percent fewer course requirements within the discipline, allowing students greater flexibility to take courses outside of SEAS. This is modeled on the successful computer science AB program.
- Create biology “tracks” in the six engineering departments. These new options will build on bio-engineering capabilities that already exist throughout SEAS, with a goal of exposing students to an emerging and important field.
- Establish new courses, programs and teaching labs related to new areas of high-impact interdisciplinary research, supporting faculty members who invest time in developing new educational offerings. One recent example of this type of initiative is PICASSo, an existing center providing interdisciplinary training in computer-aided research and data analysis in areas from computer science to astrophysics to finance.
- Develop additional courses that allow non-engineers to connect engineering to their other courses and everyday life. This work will build on the several highly popular SEAS courses that engage non-scientists in learning about technology.
- Establish the SEAS Strategic Graduate Fellowship Program to enable promising graduate students to pursue interdisciplinary opportunities during their studies at Princeton. Fellowships will enable students to work outside of their adviser’s labs -- perhaps in another engineering or scientific discipline, or exploring the policy, social or cultural aspects and implications of their research. Fellowships will provide one to four years of funding, relieving faculty advisers from pressure to keep the students tied to specific research grants.

### *Diversity*

- Establish a SEAS Engineering Outreach program targeting junior high and high school students to expose all students to science and engineering early in life. The objective is to excite more talented students, particularly women and under-represented minorities, about engineering and encourage them to apply to Princeton.
- Establish closer ties with select four-year colleges and universities having significant populations of women and under-represented minorities. This program will encourage more of these often overlooked students to apply to Princeton’s graduate engineering programs.

### *Real World Experience and Impact*

- Expand SEAS visitor program to expose students to a wide range of scholars, researchers and practitioners from other universities, industry, government and non-profits. This program will draw from Princeton’s many talented alumni.

- Launch the SEAS Student Entrepreneurial Initiative to encourage and facilitate students' exploring and pursuing entrepreneurial activities while at Princeton.
- Create the SEAS Summer Internships Program to help students gain more real-world experience. Expand career advising resources focused on engineering students.
- Develop optional short courses and workshops to help students improve leadership, project management and communication skills.
- Provide seed funding and administrative support for students interested in pursuing internships, fellowships in government, study abroad or field research away from Princeton.

## **B. An Environment for High-Impact Interdisciplinary Research**

The second foundational initiative of the SEAS strategic plan is to create an environment in which high-impact interdisciplinary research germinates and thrives. This is an environment in which engineers and non-engineers -- within and outside the University -- will work together to solve world problems and create new societal and scientific opportunities. We will create a school-wide hiring process for faculty, add critical faculty and staff positions, build major new facilities and seek greatly increased research support -- all strategically targeted toward realizing this vision.

The practice of engineering is changing almost as rapidly as technology itself. The standard paradigm of researchers working in relative isolation and publishing their results in scientific journals is no longer the driving force for innovation. In this era, the most compelling problems require collaborations that cut across traditional academic departments and nearly always involve partnerships with government agencies, industry and the not-for-profit sector. The knowledge and know-how generated by these multidisciplinary collaborations often are disseminated most effectively by direct personal interactions or through the deployment of technology in industrial products and services. These new methods are particularly important for our ambitious new model of research, which draws on a greater variety of perspectives and more fully addresses society's needs.

SEAS has made significant headway in these new directions, but also faces considerable challenges. Our mechanisms for hiring, rewarding and recruiting faculty members are less effective for those who bridge disciplines. We have outgrown current office and lab space, straining the pursuit of excellence in the core disciplines and inhibiting new interdisciplinary endeavors that demand reconfigurable common spaces and costly, specialized facilities. These limitations, in turn, have hampered the ability of SEAS researchers to win major center grants and to be selected as leaders of multi-institutional consortiums.

Our plan sets four specific objectives for SEAS in high-impact research:

- Recruit and retain leading scholars and researchers who bridge traditional engineering disciplines.
- Increase the proportion of women and under-represented minorities among SEAS faculty.

- Double the amount of SEAS sponsored research funding over the next 10 years and win more large center grants.
- Strengthen collaboration with industry and increase commercialization of Princeton technology.

We will pursue strategies that generate an exceptional research environment. The visibility from our high-impact collaborations will attract top students, result in large center grants, entice leading faculty to Princeton and SEAS, and add credence to Princeton's legacy of providing service to the nation and the world.

We will promote this fertile environment with specific programs relative to people, facilities and research support:

### **3. Focused Research Initiatives**

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### **4. Evaluating Success**

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### **5. Conclusion**

The results of engineering research and education are changing our lives and the world around us more profoundly than ever before, bringing great benefits as well as staggering complications. And we are poised for even more dramatic advances. Yet this engine of innovation remains largely isolated from the society it is so fundamentally changing, leaving engineering ill equipped to create solutions that integrate a broad range of expertise and perspectives.

Many leading engineering schools have begun to recognize this problem. They have called for more interdisciplinary research and the education of technology-savvy leaders. They also have acknowledged the need for greater diversity among engineering faculty and students, and for connecting engineering to its societal context. Yet we believe that no other university is as well positioned to realize these goals as Princeton. We are unique in having deep strengths in the humanities, natural sciences, social sciences and public policy as the setting for a premier school of engineering. Our small size mandates and supports a high level of collaboration across departments. We are able to call on a legacy of excellence in both research and teaching and a tradition of educating students who have demonstrated leadership within their chosen sphere of activity. And we have students and alumni who remain committed to SEAS and Princeton many decades past graduation.

We recognize that we have set ambitious goals, but are convinced that we have both the responsibility and opportunity to achieve them. Our vision builds on what is best about Princeton: an uncompromising pursuit of academic excellence; a broad, humanistic view of education; and a tradition of leadership and service.