

## ***Reaching Outside the Oval:*** **Strategies for Catalyzing Change in Engineering Education**

by

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**Executive Summary.** One of Olin College's key aspirations is to influence the course of engineering education. Currently the College is devoting substantial effort to try to achieve this goal. We regularly host visitors from across the globe who wish to learn about the school; our faculty and administration are widely engaged with other institutions; and recently we have begun to engage in strategic partnerships with other institutions to catalyze change in engineering education. The lessons we have learned – from how to start a school from scratch, to how to combine entrepreneurship and engineering in the classroom, to how to build a learning culture – are attracting great interest from a variety of other institutions. In this white paper you, the reader, are asked to think about how Olin College should best continue to pursue its goal of contributing to engineering education nationally and internationally.

**Context.** Olin College has firmly established itself as an important and vibrant college, attracting superb students and regularly appearing on lists of campuses to watch. Once a set of rough sketches and big dreams, with its first admissions policy literally written on the back of an envelope, Olin is now a reality and a place of which we can be justifiably proud. In the two years since receiving final accreditation, Olin has made a transition from startup to something that begins to resemble a mature and sustainable organization committed to continuous improvement in engineering education.

In previous white papers<sup>4</sup>, we have asked members of the President's Council and others to assist us in identifying key issues that confronted the College; in establishing institutional priorities and balancing tradeoffs; in setting strategic directions; and in identifying those aspects of Olin that make it the unique institution that it is. Comments and suggestions from our extended community have been very influential in helping us to attain our current status.

Together with feedback from the wider audience of engineering educators and professionals, academics, prospective students, and the popular press, we have been repeatedly told that Olin College is valuable, exciting, innovative, and badly needed. Among the attributes of Olin that have been identified are our culture of learning and the learning continuum; our emphasis on design and entrepreneurial thinking; our risk-taking, innovation, teamwork, communication, and problem-solving. A brief summary of the distinctive features of the Olin learning model is provided in the attached appendix entitled ***Olin at a Glance***. We have been told many times that we educate students who are poised for transformative contributions and that we are producing the next generation of engineering innovators who will be prepared to lead in many different contexts.

While we are proud of what has been accomplished so far, Distinguished Olin Partner Woodie Flowers<sup>5</sup> observed a number of years ago that "*if Olin only succeeds in producing 80 exceptional graduates yearly, it will have failed*" [to achieve its full potential and its original purpose].

**Working for Change.** Olin College was founded in response to the many calls for change in engineering education. According to the College's Founding Precepts<sup>6</sup>,

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*“The National Science Foundation and other credible voices from engineering schools and industry have advocated changes in how engineers are educated. Some of the major themes of the changes advocated include interdisciplinary and integrated teaching, hands-on learning and research opportunities for students, improved communication skills, students working as members of teams (the way that engineers in industry work), exposure to other cultures or an international experience, and a better understanding of business and management practices... The Foundation’s decision to establish the College was based in large part on a determination that the need to reform engineering education could be accomplished more easily at a new institution that is not burdened with people and existing programs resistant to change.”*

The founding precepts also lay out a clear imperative for Olin College to influence engineering education outside of Olin’s walls:

*“Olin College is intended to be different - not for the mere sake of being different - but to be an important and constant contributor to the advancement of engineering education in America and throughout the world...”*

Over the last ten years, Olin College has rapidly grown from an aspiration to a full-fledged and internationally recognized small institution. We are engaged, both nationally and internationally, in catalyzing change in engineering education. However, the need for widespread transformation – in content, in delivery, and in learning culture – remains urgent. Recent National Academy of Engineering reports such as *The Engineer 2020*<sup>7</sup> and *Rising Above the Gathering Storm*<sup>8</sup> outline problems similar to those identified in the 1990s. Olin College was created to play a role in addressing this pressing problem. This has been a consistent refrain in Olin’s strategic planning processes. The Olin College community and members of the President’s Council are of one voice in agreeing that this remains a critical part of Olin’s core mission. As one President’s Council member advised the college in April 2007, Olin’s cost can only be justified if it provides “a meaningful transference of some of its ‘specialness’ to other undergraduate schools that provide, over time, improved education/development for a relatively large number of graduates across the country.” Other members of the President’s Council have given similar advice.

**High External Interest.** There is a high level of external interest in what Olin College is doing and in how the lessons learned at Olin might apply to other educational institutions. Large numbers of external visitors seek out the College and visit to learn about Olin first hand. Last year the College hosted about 20 different delegations from institutions around the globe. These visits often include extensive one-on-one conversations and interviews with students, faculty, staff, and administration. Visitors are consistently impressed with what we have accomplished at Olin, and leave our campus excited about the possibility of translating some of our experiences to their own environments.

Similarly, members of the Olin College faculty and administration are in high demand as conduits and consultants. Schools ranging from the University of Santiago (Chile) to Washington University (St. Louis) to Gwang Ju Institute of Science and Technology (Korea) to the University of Massachusetts at Lowell have invited Olin’s faculty members and leadership team to visit and consult on curricular, cultural, and administrative matters. Members of the Olin community regularly give invited talks about Olin in national and international venues, including educational and professional conferences and public forums. Finally, many members of the Olin faculty and administration serve in a formal advisory capacity to different educational institutions, ranging from Hope College (Montana) to the University of Southern Florida to Harvard University and the Massachusetts Institute of Technology.

In the last year, Olin College has also begun to forge strategic partnerships with a variety of other engineering schools. Recently the University of Illinois at Urbana-Champaign (Illinois) approached Olin College to collaborate, and in September of this year, Olin and Illinois signed a memorandum of

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<sup>6</sup> The **Founding Precepts of Olin College** are available on the College’s website at [www.olin.edu](http://www.olin.edu); from the front page, choose the “About Olin” tab, then the “Overview” tab, then the “key speeches and documents” link. The link to the *Founding Precepts* is approximately mid-way down the list of speeches and documents.

<sup>7</sup> *The Engineer of 2020: Visions of Engineering in the New Century*, National Academies Press, Washington, DC (2004).

<sup>8</sup> *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academies Press, Washington, DC (2007).

understanding creating the Olin-Illinois Partnership (OIP). The partnership will join efforts of the two schools “to improve engineering education in matters such as content, curriculum, pedagogy, and organizational change.” Since the document was signed, multiple Olin faculty members have visited Illinois to deliver talks and seminars on aspects of the Olin curriculum; further plans are underway for a national conference to be held on April 1, 2009, at Olin College on Transformation of Engineering Education. Similarly, in March of 2009, Olin College, Duke University, and the University of Southern California are co-sponsoring a national summit on the National Academy of Engineering’s Grand Challenges<sup>9</sup> with a focus on educational outreach.

**Special Aspects of Olin.** There are many different aspects of Olin College’s experience that are proving helpful to other institutions. At the highest level, the very process of **starting an institution from scratch** is of enormous interest. For example, the Republic of Kazakhstan is currently in the process of creating a new national university; at the request of the World Bank, President Miller will visit Kazakhstan in December 2008 to share the *Invention 2000*<sup>10</sup> process that Olin used to identify best practices in engineering education, and to use those practices in designing a new institution. Every year an increasing number of new institutions approach Olin to discuss this startup process.

Olin College’s experience in **curriculum design processes** can also provide significant value to others. In the last two years, several faculty members have gone on developmental leaves to assist other schools (e.g., Harvard University, Delft University of Technology in the Netherlands, and California Polytechnic State University in San Luis Obispo, California) with curriculum revision. These kinds of longer-term engagements with other institutions are mutually beneficial: working side by side to produce customized and contextually appropriate solutions, Olin’s faculty members learn from and contribute to the activities of their institutional hosts. Olin faculty members run workshops, lead discussions, and provide model activities for consideration by the host institution. Host faculty members frequently find that Olin’s attitudes, questions, and approaches—even more than its specific curriculum—are most directly informative and transferable.

Specific aspects of Olin College’s curriculum are also of interest to others. One area of particular enthusiasm is the interplay between **entrepreneurship and engineering**. The Entrepreneurship Education Division is the most recent and fastest growing division of the American Society for Engineering Education; other engineering schools are rapidly recognizing the importance of this dimension to engineering education, but are concerned that their faculty are not prepared to teach it. They seek models of success to emulate and learn from. Olin College, as one of the early successes in this area, has partnered with neighboring Babson College—the top-ranked business entrepreneurship program in the nation—to create the *Symposium for Engineering Entrepreneurship Educators* (SyE<sup>3</sup>), a yearly, week-long program aimed at educating engineering educators about how to teach and apply entrepreneurship theory and practice as an integral part of engineering education. The program includes hands-on experiences with unique aspects of the Olin curriculum. In its first few years, SyE<sup>3</sup> has already drawn faculty from schools across the nation, and has drawn strong reviews from participants (e.g., “*The SyE<sup>3</sup> program is a must for any engineering faculty member who is interested in infusing entrepreneurship into the engineering curriculum.*”)

Other institutions also want to learn about **individual courses** at Olin College. Many are interested in potentially adopting or adapting particular pieces of the Olin curriculum, from courses in the first year of the curriculum up to and including the SCOPE program<sup>11</sup>. For example, professors Gill Pratt and Brian Storey have collaborated with Wellesley College to create a version of Olin’s first-year course in *Modeling and Control* at Wellesley. Similarly, last year Olin’s Professor Lynn Stein worked with Harvard University to adapt Olin’s course in *Human Factors and Interface Design* to the Harvard environment. The attached

<sup>9</sup> The National Academy of Engineering identified 14 “Grand Challenges” of engineering in February of 2008. A listing of these challenges is available on their web site at [www.nae.edu](http://www.nae.edu).

<sup>10</sup> *Invention 2000* is the first strategic plan developed by Olin College as a blue print for starting a new academic institution. It is available on the Olin College web site at [www.olin.edu](http://www.olin.edu); from the front page, choose the “About Olin” tab, then the “Overview” tab, and then under *The History of Olin* heading choose the link to “key speeches and documents.” The link to *Invention 2000* is at the very bottom of the list of documents.

<sup>11</sup> The SCOPE program is a required year-long capstone design project in the senior year sponsored by a corporation. A detailed description is available in the white paper “*Learning to Be an Engineer: The Senior Consulting Project in Engineering at Olin College*,” November 2005.

case study summarizes her experience in trying to “port” Olin courses to another institution, showing some of the pitfalls and also the possibilities in this approach.

**Olin Culture.** Perhaps the most important aspect of Olin College is the ***culture of the institution***. In September 2007, at the launch of Harvard’s School of Engineering and Applied Sciences, Charles M. Vest, President of the National Academy of Engineering and former President of MIT, said, “*Making universities and engineering schools exciting, creative, adventurous, rigorous, demanding and empowering milieus is more important than specifying curricular details.*” When attempting to help others, the key is to help them focus on this goal, not on the curricular details at Olin.

In our estimation, Olin is succeeding at creating the milieu that Dr. Vest described. Previously, many members of the President’s Council and the Olin community identified Olin’s *culture* and *community* as being particularly special aspects of Olin and, perhaps, the key to understanding Olin’s success thus far. As one President’s Council member wrote,

*“...Olin’s culture of ownership, the campus-wide relationships and the passion, if not compulsion, for all that Olin can be ... are the most important elements of what Olin has become. This culture is driven by people [who all] seem to share the common traits of creativity, collaboration, commitment and the need for a strong sense of community.”*

This culture is particularly reflected by Olin’s high level of ***student engagement***. Indeed, whenever external guests come to Olin, they are consistently impressed by how thoroughly enthusiastic our students are about their work, and by how committed our students are to the institution. Our experience is that the best way to help visitors “*get Olin*” is to simply introduce them to a student.

We believe that student engagement—and the culture that creates it—are the critical ingredients for success in undergraduate education. At Olin this culture has been fostered through a variety of steps, including the involvement of students as partners in the development of the curriculum, the intentional creation of a “feedback and improvement culture”, and the development of courses that allow (and indeed demand) high levels of self-direction from students.

On other campuses, the recipe for student engagement may take very different forms, such as student leaders involved in important campus committees, etc., but the principle of increasing student engagement and treating them as important members of the team is what unlocks the door. The National Survey of Student Engagement is an emerging metric that is now widely used to measure various aspects of student engagement on many university campuses.<sup>12</sup>

**Summary and Questions.** Each of these aspects of Olin College’s experience can be of value to other institutions. As Olin sets strategic directions and marshals resources for the next phase of our institutional life, we seek your advice on ways to most effectively leverage what Olin is and what our community members know, to maximize the benefit of our efforts for the larger engineering and educational communities. At the meeting of the Olin College President’s Council on the morning of November 10, 2008, we seek perspectives from all members of the Olin extended community on the issues raised in this paper. As preparation for this meeting, we ask that you consider the following questions in advance.

1. How should Olin decide what is important to others?
2. In your opinion, what aspects of Olin are particularly important and amenable for sharing with other institutions? In other words, what should Olin be trying to promote?
3. Each of you has dealt with organizational change in one environment or another. Given your experience, what concrete strategies do you suggest for effecting the adaptation and adoption of the features you identified? In other words, how should Olin be trying to achieve this influence, particularly with well established institutions?
4. Effective use of resources requires that we understand the impact of our actions. How should Olin measure its success in influencing others?

<sup>12</sup> The *National Survey of Student Engagement* was initiated at Indiana University at Bloomington in 1998 with a grant from the Pew Charitable Trust. Further details are available at their web site at <http://nsse.iub.edu>.

## OLIN AT A GLANCE

- OLIN COLLEGE has NO ACADEMIC DEPARTMENTS and DOES NOT OFFER TENURE TO ITS FACULTY MEMBERS.** This has resulted in a completely different academic culture that naturally emphasizes interdisciplinary learning of all kinds and an intense focus on educational innovation.
- EVERY STUDENT AT OLIN RECEIVES A FULL 8-SEMESTER TUITION SCHOLARSHIP BASED ON MERIT.** This has attracted a student body of exceptional quality, and provides a reward for merit for those willing to study engineering—an area of national need in a time of increasing global competition. Olin’s selectivity is among the top 10 in the country, and the quality of our students is truly extraordinary. *Newsweek* named Olin College one of the nation’s “New Ivies” even before we were accredited, and about 40% of our students are National Merit Finalists—one of the highest percentages in the nation.
- ADMISSION TO OLIN REQUIRES A WEEKEND OF ON-CAMPUS INTERVIEWS INVOLVING TEAMWORK.** Although test scores and grades are important, they don’t tell the whole story. Olin is trying to develop innovators and leaders who have multiple intelligences and can work well on teams. The best way to measure this is through face-to-face interviews in multiple settings, including team exercises. It’s amazing that other schools don’t do more of this. Corporate employers know that interviews are essential to measuring the most important factors in determining career potential.
- OLIN OFFERS ONLY THREE B.S. DEGREE PROGRAMS, ALL IN ENGINEERING.** By focusing our mission on the best possible preparation of engineers, we are able to organize our program optimally for this one goal. We do not have to compromise the presentation of material to accommodate the different career goals of students majoring science, math, or humanities who may be taking the same required courses. This allows us to provide integrated course blocks involving interdisciplinary material often with several teachers of different disciplines in the classroom at the same time. Students use project-based learning and design—the core process of engineering—as a way of thinking in every semester.
- OLIN’S STUDENT BODY IS NEARLY GENDER BALANCED, VERY RARE IN ENGINEERING.** Women currently comprise less than 20% of the engineering student population nationally. Olin consistently attracts between 40 and 50% women in its first year class. We believe women will make up an increasing fraction of the nation’s engineering workforce in the future, and we believe that learning in a gender balanced environment provides the best preparation for future engineering leaders.
- EVERY OLIN STUDENT MUST START AND RUN A BUSINESS TO GRADUATE.** Olin also requires all students to complete an academic program in fundamentals of business and entrepreneurship. One of Olin’s fundamental goals is to produce innovators, not just engineers. This requires entrepreneurial thinking and is the primary reason why Olin chose to locate its campus adjacent to Babson College—which consistently ranks among the best schools for entrepreneurship studies in the nation. Olin and Babson encourage cross enrollment and combined student teams have won several business plan competitions.
- OLIN REQUIRES ALL STUDENTS TO COMPLETE A YEAR-LONG SENIOR DESIGN PROJECT SPONSORED BY INDUSTRY.** Olin students are assigned to small teams for design projects in every semester, culminating in a capstone project requirement in the senior year. The senior project (which we call SCOPE, for Senior Consulting Project in Engineering) typically involves 4-6 students, a corporate sponsor with about \$50k of support, a faculty advisor and a team of faculty “angels.” ALL design teams are multidisciplinary, often involving an MBA student from Babson and/or a liberal arts student from Wellesley College. The projects are quite professional, often involve non-disclosure agreements, and sometimes produce patents and new products. Companies often use these projects to recruit permanent employees, and students learn what it is like to have a paying customer.
- OLIN REQUIRES ALL STUDENTS TO “STAND AND DELIVER” AT THE END OF EVERY SEMESTER.** To insure that all Olin graduates are effective at communication in a professional setting, every student is required to present some aspect of their academic work in a public setting at the end of every semester. The setting is called the Olin EXPO, spread out over three days it involves either a short lecture or poster presentation to the entire campus community and about 100 corporate and academic visitors who assess the presentations. As a result, the typical Olin graduate has made 8 consecutive EXPO presentations before graduation. The level of poise and confidence in handling technical questions is remarkable and distinguishes Olin’s graduates.
- OLIN STUDENTS MAY CROSS-ENROLL AT NEIGHBORING BABSON COLLEGE, WELLESLEY COLLEGE, OR BRANDEIS UNIVERSITY.** Olin has established partner relations with neighboring colleges and universities which permit Olin students to cross-enroll without charge. Olin students are encouraged to take

advantage of these relationships, and as a result about 1/3 of Olin's students are enrolled each semester at a neighboring institution. This provides great enrichment of academic offerings beyond technical subjects.

•**OLIN'S PROGRAM ENABLES ANY STUDENTS TO STUDY ABROAD FOR A SEMESTER AND STILL GRADUATE WITHIN 4 YEARS.** Nationally, fewer than 5% of engineering graduates have had a study abroad experience, due to the high demands of the engineering curriculum. However, about 20% of Olin's graduates have taken advantage of our program which was specifically designed to enable any students to study away from campus for a semester in the junior year, without delaying graduation in most cases.

•**OLIN'S GRADUATES HAVE EXCEPTIONAL CAREER OPPORTUNITIES.** The first three graduating classes at Olin have obtained remarkable career opportunities. About 25% have chosen to continue their education in engineering, science, mathematics, medicine, business, law, and other subjects. Four graduates have received Fulbright Scholarships, and many more have received NSF doctoral fellowships and traineeships to a stellar list of top universities, including Stanford, MIT, Caltech, UC Berkeley, Oxford, Cornell, CMU, UCLA, UCSD, UCSB, Rice, Georgia Tech, and others. Several Olin graduates were admitted to Harvard Business School, Stanford Business School, or Babson College upon graduation, several are in MD-PhD. programs in medical school, and several are studying law at Columbia University, University of Virginia, and others. However, the majority of Olin graduates are working in engineering or science positions in both large and small companies, many with names that are very familiar. In addition, a few have successfully started their own new ventures. Olin seems to have succeeded in infecting its graduates with "entrepreneurial disease."

PRINCETON REVIEW REPORTS THAT OLIN STUDENTS ARE AMONG THE HAPPIEST IN AMERICA. Olin students routinely report to *Princeton Review* and other publications that the quality of life on campus is exceptional. The campus facilities are dazzling and new, residence halls provide campus housing for every student, and each dorm room includes a private bathroom. The campus food service routinely ranks among the best in the country in student satisfaction, the music and drama programs are extraordinary, and the Honor Code has been highly successful in establishing an authentic culture of integrity and respect for others. The Olin "Learning Continuum" extends the opportunities beyond the classroom and includes an extensive co-curricular program that is rare for a campus of this size.

## A Case Study in the Export of an Olin Course<sup>13</sup>

Venkatesh Narayanamurti, Dean of the School of Engineering and Applied Sciences at Harvard University (H-SEAS) and member of Olin's President's Council, invited Olin's Professor Lynn Stein to spend her sabbatical year helping to catalyze new educational initiatives at H-SEAS. During the year, Stein ran workshops for faculty, served on several curricular committees, and taught an exported Olin course. The course was chosen to illustrate what an Olin-style educational experience might look like when adapted to the Harvard context. The experience of importing this activity highlights both the opportunities for and the obstacles to transfer.

Olin's *ENGR 3220 Human Factors and Interface Design* is a studio-based design course in which multidisciplinary student teams take a software-driven product from initial idea to functional prototype. Past projects include a hand-held device for travelers, a novel online music player, and an online marketplace.

At Harvard, the course was rebranded as *CS179 The Design of Usable Systems*. Harvard courses traditionally sit within a single department and may receive concentration, credit in one or two neighboring disciplines. To attract an interdisciplinary student body, CS179 was approved as a concentration elective by the undergraduate committees in Computer Science, and Engineering, in Psychology, Sociology, and Anthropology, and in Visual and Environmental Studies (which includes Harvard's studio art program). Actual enrollment reflected this distribution: each four-person team included at least one person with a technical background, at least one person with a human subjects research background, and at least one person with a studio art or studio design background.

Finding a suitable classroom space proved a challenge. Harvard's classroom stock is dominated by lecture halls – with capacities ranging from two dozen to several hundred – and seminar rooms. In contrast, studio pedagogy leverages persistent “owned” workspaces to create a shared culture of living within one's work. For the spring semester, 2008, CS179 occupied the atrium of Harvard's 60 Oxford St. laboratory. While this nontraditional teaching space posed certain obstacles, it also created an opportunity for the Harvard community – including visitors to the research lab and attendees of seminars held in an adjacent auditorium – to follow the progress of the course.



Student comments at the end of the semester reflect the extent to which course objectives were met: Students built teamwork, contextual understanding, communication, and design skills. The same comments highlight the differences between the culture of the CS179 classroom and other experiences at Harvard.

*I realized that I have the ability to recognize when certain tradeoffs should be made, especially in terms of balancing the practical and the conceptual.*

*I learned how and when to take on responsibility within a team without necessarily waiting for it to be assigned.*

*I've started to look at the world from a designer's point of view, looking for ways to make things easier to use.*

<sup>13</sup> This case study was written by Professor Lynn Andrea Stein and is based on her experiences during the 2007-08 academic year while on leave from Olin College at the School of Engineering and Applied Sciences at Harvard University.

*I felt more comfortable asking for help contributing to my own work, and doing the same for others, and was far more likely to give important feedback on other people's work at the end of the semester.*

As of fall 2008, the atrium at 60 Oxford Street has been returned to its pre-CS179 condition; the studio has been packed up and stored for a future offering of the course. Initially, a Harvard faculty member was slated to teach CS179 in the spring of 2009, but he has since been tapped for an administrative post and consequent reduced teaching responsibilities. While there is interest in continuing CS179, this cannot happen until another faculty member is prepared to take on this style of pedagogy.

At the same time, efforts are currently underway to create a studio teaching space in a new educational facility coming on line in the next year, and the CS179 experience will likely inform planned renovation of other teaching spaces. Several aspects of CS179 are under consideration for inclusion in a revised junior design experience in Harvard's Engineering Science program.

The style of learning practiced in CS179 is novel to many Harvard students. At mid-semester, one student commented that he spent as much time on teamwork as on the content of the course. At Olin, we sometimes take this for granted, living as we do in a culture that values the contextual as well as content aspects of learning. Supporting this style of education requires a gradual transition but can have profound effects on an institution.

CS179 proved what is possible. Teaching CS179 at Harvard was an attempt to transplant a particular piece of Olin curriculum and culture. It is now clear that a cross-disciplinary team-based hands-on project experience can be viable (and even valued) within Harvard College. Curriculum was driven by learning outcomes rather than a content list; students achieved the desired knowledge, skills, and attitudes. Further, student experience in CS179 replicated important characteristics of Olin culture in a way that is consistent with Harvard's own undergraduate experience.