The Challenge of Spreading Innovation in Teaching and Learning: Why Is It So Hard and What Can Be Done About It?

By
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Executive Summary. The need for improvement in both the content and pedagogy of STEM[1] education in general—and engineering education in particular—is widely recognized. A number of excellent examples of innovation in this field have been noted at different institutions in the last half century. However, their effects on the mainstream of engineering education have been limited and relatively little change has been observed. History shows that many attempts have been made to facilitate the needed improvements, including large federal programs and smaller and more comprehensive institutional examples. This paper outlines some of the challenges involved in efforts to spread innovation in teaching and learning, and focuses on the potential for Olin College to play a significant role in this important process.

Historical Context. Universities are among the most important and respected institutions in the world. Every developing nation wants a "world class university" to thrust it into the knowledge-based economy and to improve its image in the international community. Historically, universities have maintained a three-fold mission: preserving knowledge, transmitting knowledge, and—more recently—creating new knowledge. Except for the relatively new emphasis on research, universities largely play the role of preserving the best of what we have learned from the past—a fundamentally conservative role. This implicitly involves deciding what constitutes fundamental and critical knowledge for the next generation, and, by default, eliminating what has become perhaps less essential. As a result, academic culture has, in general, been very careful about embracing major new ideas and sweeping changes that inevitably displace the traditions of the past. This protects society from prematurely abandoning ideas and traditions (including teaching methods) that have served us well. But it also creates internal cultural barriers to the rapid acceptance of major innovations.

In a recent study of the history of higher education in America, Jon Marcus[2] concluded that many of the historical sweeping innovations in higher education that we take for granted today—such as the inclusion of the study of "modern languages" like French and German; the inclusion of the study of the natural sciences on an equal basis with philosophy and languages; or even the inclusion of students from working class families through the establishment of Land Grant Universities—were changes that did not originate within universities of the time, but instead required the founding of entirely new institutions in order to introduce them. In fact, faculty at some of the most respected universities resisted these innovations in some cases for decades after they were established.

The Evolution of Engineering Education[3]. The history and evolution of engineering education in the past 60 years is particularly relevant to Olin College. Before 1950, relatively few faculty members in colleges of engineering had Ph.D. degrees, but many had personal experience in leading engineering projects in industry. The level of mathematics involved in engineering instruction rarely extended beyond elementary calculus, and code-based design procedures were common. However, after World War II, an

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[1] Science, Technology, Engineering and Mathematics

[2] Marcus, Jon, "*Old School: Four Hundred Years of Resistance to Change*," presented at Reinventing the American University: The Promise of Innovation in Higher Education, American Enterprise Institute, Washington, DC, June 3, 2010.

[3] This account of the evolution of engineering education is based on several sources, including recent personal conversations with Dr. John W. Prados (former President of ABET; Chair of the Engineering Accreditation Commission; Senior Associate in the NSF Engineering Directorate; editor of the *Journal of Engineering Education;* and Dean of Engineering and Vice President for Academic Affairs at the University of Tennessee System) and with Dr. Joseph Bordogna (former Deputy Director and Chief Operating Officer of NSF and former Dean of Engineering at the University of Pennsylvania). A particularly useful overview of this history is provided in the following paper: Prados, John W., *"Quality and Innovation in Engineering Education: 1991-92 ABET President's Report*."

influential report in 1945 to President Truman by Vannevar Bush, entitled Science: The Endless Frontier, resulted in a major shift in thinking about the relationship between engineering and science. In this report, Bush noted that "*New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science!*" He felt that basic research is the pacemaker of technological progress and his report eventually led to the establishment of the National Science Foundation (NSF) in 1950.

It is difficult to overemphasize the importance of this development for engineering education. In the next decade, engineering education began a major paradigm shift. Engineering curricula nationally shifted away from practice-oriented design and toward applied science. Basic sciences and advanced mathematics became central to the curricular requirement in most engineering schools, and new faculty hiring focused on new graduates with Ph.D. degrees and research strength, rather than practical experience. NSF and mission oriented agencies such as NASA and the Department of Defense made available for the first time significant federal funds to support research in engineering and applied science in universities. The availability of such funds significantly changed the attitudes and priorities of engineering deans and senior university administrators.

In 1955, the Grinter Report[4] was published by ASEE which called for comprehensive national changes to the process of education of engineering students. To accommodate the rapidly growing importance of scientific research, the report recommended that a dual track of engineering education be established, one that led to advanced research and development in applied science, and the other to more applied engineering and the art and practice of engineering design. When a majority of engineering deans resisted the dual track concept, the shift toward applied science and research gained further momentum. An emphasis on differential equations replaced code-based design and project management. The Sputnik event in 1957 accelerated the pace of this change and added a degree of urgency.

As a consequence, the culture within engineering faculties became much more closely aligned with that among mainstream science and mathematics faculties on university campuses. For example, success in engineering faculty careers shifted away from a record of achievement in professional engineering practice and toward the publication of research papers in peer-reviewed journals. In addition, counting journal articles seemed more objective and rigorous than judging the quality and significance of real engineering projects. The notion of the engineering process as one of experimentation and continuous improvement, team effort and project management, and empirical refinement became much less respected in favor of the notion of engineering as a body of knowledge of basic and applied science. A fundamental identity shift for the field of engineering was initiated.

By the early 1990s, this paradigm shift had become widespread. The large majority of all engineering faculty members had Ph.D. degrees by 1990, and competition for research funding was frequently expected for career success. Institutional reputation and national rankings became more firmly based on the level of total research expenditures, reinforcing the shift in faculty interests toward research. By this time, engineering schools in the U.S. were producing graduates who were very well prepared in engineering science but lacking in other important abilities, such as teamwork, design, leadership, communication, creativity, and economic/social/political awareness. In the 1950s, training in these skills was sometimes provided by large corporations that employed engineers—where engineering graduates often spent their entire careers. However, by the late 1990s, this was no longer the case. Many engineers now worked for small firms and employers no longer could afford to provide formal training in these areas. As a result, many technical corporate leaders consistently requested significant changes in the educational process for engineers. For example, the corporate advisory boards for many engineering schools as well as for ABET (the former Accreditation Board for Engineering and Technology) frequently complained of the need for broadening the skills of new engineering graduates.

During the period from 1950 - 2000, this shift was accompanied by a parallel change in ABET accreditation standards. The general requirements for an ABET accredited engineering degree during

[4] Grinter, L.E., et al., *Summary of the Report on Evaluation of Engineering Education*, Journal of Engineering Education, September, 1955, pp. 25-60.

this period grew rapidly more explicit and oriented toward course credits in engineering science. For example, before 1955, the ABET general requirements were described on less than one page. By 1967, these same requirements had grown to 1.5 pages, and by 1977, to 4 pages. However, this trend continued and accelerated: by 1987 the same requirements took 16.5 pages and by 1999 they required nearly 20 pages (of smaller type). The result was that the accreditation requirements became so demanding and explicit that faculties had almost no flexibility or room in the curriculum to address any considerations other than engineering science and math. Engineering design would have disappeared altogether had there not been sufficient industry influence in ABET to assure that some design experience was required as part of the engineering curriculum.

The situation had generated such concern that in 1989, Dr. Erich Bloch (former Vice President at IBM and then Director of NSF) convened a special meeting[5] to consider ways that NSF might help provoke systemic change across all of engineering education to address this need. NSF's Engineering Directorate, with Program Officer Dr. Edward W. Ernst at the helm, subsequently took the lead in establishing a national Engineering Education Coalitions Program (EECP) in which substantial federal grants were awarded to coalitions of small numbers of universities to develop systemic changes to engineering education that could spread widely across the nation. This EECP program was funded by NSF at the level of tens of millions of dollars through much of the 1990s, but with success that was concentrated in the coalition universities that received the grants. Some important changes initiated by EECP persist today, but primarily within the coalition member schools, and primarily within the first and second years of the curriculum. Change in the junior and senior year—when most of the core engineering science subjects are taught—was limited. An assessment of the EECP program was performed and published by SRI International in May 2000[6]. The SRI review concluded that while some important progress was made, in general the results fell short of the hopes for systemic change. Excerpts from this review provided here provide a sense of the findings:

> *"…The Coalitions Program has had many important impacts during the first five years, but these cannot be said to be 'the comprehensive and systemic new models for engineering education reform' anticipated. Most impacts had been intra-institutional, indeed, intra-disciplinary…*
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> *…Dissemination is nominal at this stage: there have been many conference presentations and much exchange of information, but the Dean survey showed very limited evidence of actual adoption outside participating institutions, and there remains resistance within even those, ranging from the resistance of conservative faculty to the 'not invented here' syndrome. Participating faculty are enthusiastic and generate a wide variety of innovations, but are not temperamentally suited, nor professionally motivated, to generate the follow-on documentation that aids in adaptation or adoption at other institutions. Coalition products generally get good reviews, but primary interaction between the innovators and the rest of the community is fleeting, documentation limited, and adaptability widely questioned. Costs in terms of faculty effort, equipment, and customized classroom configurations are high. Coalition courses add to student workloads at a time when there is pressure to reduce the number of credit hours needed for an engineering degree…*
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> *…The complexity of the task of 'comprehensive curriculum restructuring' is perceived by Program participants as being greater and more difficult than envisaged in the time-frame imposed on the original Program…"*

Not long after the SRI report was published, NSF funding for the EECP program ended. NSF has made several other attempts since then to promote systemic change in engineering education, aimed instead at influencing the attitudes of faculty members rather than creating new educational models. For example, national award programs identifying the most promising young engineering faculty members (Presidential

[5] Belmont Conference on Imperatives in Engineering Education
[6] Coward, H. Roberts, Ailes, Catherine P., and Bardon, Roland, "*Progress of the Engineering Education Coalitions*," SRI International, Arlington, VA, May 2000.

Young Investigator Awards, Early Career Development Awards, etc.)[7] were modified to include an emphasis on teaching and education, not just research. These award programs require that the winners include a plan to integrate education and research in an effort to develop a cadre of future leaders among the faculty who are more holistic engineering professors. Obviously, this is a long-term strategy.

Simultaneous with the EECP program at NSF, ABET undertook to completely change the approach to accreditation of engineering programs. Instead of criteria based on the number of credit hours required of students in various subjects, the new ABET Criteria 2000 required a clear statement of the specific mission of the engineering program. A diversity of missions among different engineering schools was allowed and encouraged. Then to obtain ABET accreditation, each school was required to develop its own set of metrics to demonstrate that it was monitoring its progress toward meeting its mission, while continuously making changes to the program to improve the outcomes of students. The intent was to allow for greater diversity among engineering programs. This new accreditation approach was launched in 2001 in a comprehensive effort to reduce the barriers to innovation in engineering education.

Innovative Educational Programs in Engineering. While most of the engineering programs in the U.S. shifted the curriculum toward applied science in the last half the 20th century, some notable exceptions established remarkably innovative educational models that addressed the need to retain engineering design and teamwork. These programs deliberately chose to swim against the tide and create integrative programs that attempted to retain a better balance between design, teamwork, and communication on one hand and advanced mathematics and applied science on the other. Some examples of these include Harvey Mudd College (HMC) that established a wonderful capstone design requirement (The Clinic) for all its engineering graduates, while maintaining a thorough and rigorous core program in mathematics and natural science. It is also remarkable that this program was established in the early 1960s, and therefore persisted in defiance of the shift away from design at most larger institutions during this period. The HMC program remains a beacon for other institutions in the area of design, and has been visited by many other institutions over the years. There is no question that HMC has long been influential in the thinking of engineering faculty members at many other universities about the value of realistic engineering design projects and what is possible in an undergraduate environment. However, it is unfortunate that the impact of this great example on the models for engineering education at major universities has not been more widespread[8].

Another remarkably innovative learning model in engineering was developed at the Worcester Polytechnic Institute (WPI) in the early 1970s. Their original program ("*The Plan*") eliminated courses as degree requirements in favor of demonstrated competencies requiring the completion of substantial projects in engineering, social science and the humanities. The program was radical in many respects, requiring integration of knowledge across disciplines and academic years as well as demonstration of competence in applying integrated concepts to solve complex problems. However, the increasing accreditation requirements for engineering science credit hours and the costs associated with operating this model provided major challenges. Over the years the WPI model has evolved significantly and it is currently more consistent with the approach at other universities, even though it retains many distinctive features. While the WPI model has influenced the thinking of faculty members at many other schools, it is unfortunate that not many other universities have attempted to emulate this integrative approach to engineering education over the years.

Many other innovative learning models at other universities have been developed in the last several decades. The program at Drexel University is a good example. It involves an integrated program in the first two years and it has influenced a number of other larger universities that have adapted the principles involved to their local system. (Drexel was involved in one of the NSF funded Engineering Education Coalitions.)

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[7] Bordogna, Joseph, personal communication, October 2011.

[8] One concern is that faculty at research universities may not see innovations introduced at undergraduate institutions like HMC as relevant to them, due to the difference in institutional mission.

One pattern that emerged as engineering schools attempted to innovate in education is that a small group of faculty members succeeded in obtaining financial support from NSF in order to launch a new program, with internal support from the Dean and Department Head. This NSF funding lasted for several years, and then ended. If the faculty had not embraced the new learning model by the time the funding ended, and if the Dean had not found a way to obtain new funding to continue the added financial support, the innovation was soon abandoned and the learning model reverted largely to the original approach. An excellent example of this was reported at the Illinois Institute of Technology[9].

The Establishment of Olin College. In 1997, after several years of deliberation and consulting with many engineering leaders—including Dr. Bordogna and Dr. Prados, the F.W. Olin Foundation obtained a charter from the Commonwealth of Massachusetts for the Franklin W. Olin College of Engineering. A primary purpose of Olin College was to "*become an important and constant contributor to the advancement of engineering education in America and throughout the world*." By establishing a new paradigm for undergraduate engineering education that simultaneously addressed all of the concerns about needed change, the Foundation hoped to contribute to the broad improvement of engineering education. However, broad improvement requires more than a single example, even a compelling one like Olin. It requires the adoption of new ideas and attitudes broadly across the faculty in the majority of engineering schools across the nation. This spreading of innovation presents a major challenge. Olin will have to address this process of spreading innovation if it intends to have a significant impact.

The Spreading of Innovation in Teaching and Learning. In order to achieve the widespread improvement in undergraduate engineering education that is desired, it is necessary to find effective methods for broad dissemination of successful innovations in education across many institutions. There have been many important innovations in learning models over the years. However, the greater challenge appears to be in developing successful methods for spreading these innovations to other institutions.

As noted in the historical introduction, many attempts have been made to achieve this in the past. These have included both large, federally-funded programs intended to create incentives and rewards for efforts on a large scale in the area of educational reform, and also smaller but more comprehensive innovations within a single institution. Neither approach has proven to be greatly successful. ***Finding ways to spread innovation from one institution to another has proven to be remarkably difficult***.

It is perhaps interesting to draw a contrast here with the corporate world where the opposite seems to be the case. When Apple introduced the iPad or the iPhone, it was not long before competitors introduced their own versions of similar devices. Competition in the corporate marketplace naturally drives rival companies to pay close attention to the ideas and products of competitors in order to beat them to the market. Industrial espionage is a common concern at technology companies, and guests are usually required to sign in at a central reception desk and wear visitor tags while they are escorted through the plant. Visitors often must leave cameras and computers at the reception desk. Companies assume that visitors might steal valuable ideas that will soon be incorporated in a competitor's product.

In contrast, universities have remarkably little interest in the activities and methods of other institutions. No visitor to a university campus is required to sign in at a reception desk. No one requires you to leave your camera or computer in the reception area. Instead of worrying about what the competition is doing in teaching and learning, it is difficult to find ways to motivate the campus community to pay attention to its own efforts in this area. It is not unusual to find faculty members at large universities that have worked there for more than 30 years and have never been inside the building next to the one where their office is located! Perhaps the simplest way to substantially improve teaching and learning on many campuses is to require the faculty to actually visit the classes required for the degree program that their own students must take. Far from being worried about what competitors might take from them, universities are concerned about how to create interest in monitoring their own teaching and learning programs. Because of the rampant resistance to change, even if a faculty member returned from a visit to a competitor with a

[9] Torda, T. Paul, "*An Innovation That Worked—A Useful Reminder*," **Journal of Engineering Education**, January 1999, pp. 7-9.

wonderful new idea, it is extremely unlikely that this idea could ever be implemented at the home institution. Obviously, there is very little concern that other schools will steal their ideas in teaching and learning.

Another striking difference between corporate and university systems is the way in which decisions are made. A decision to change a major product line in a corporation is usually made in the board room, by the CEO and the Directors. An announcement of the decision is usually issued to all employees and the changes are implemented quickly. However, decisions to change the curriculum or teaching and learning model in a university are not made by the board or the president, but instead by the faculty. Such decisions are never made quickly, but usually require months or years of deliberation and discussion to develop a high level of consensus. ***Without consensus, change doesn't usually happen within academia, or it is short lived***. Furthermore, due to the culture of academic freedom[10]—in which faculty members choose which problems to work on and which fields to pursue—they are not usually receptive to directives from the president or the board about academic matters. When this reality is ignored and changes are driven from the top of a university structure, they are almost always resisted. ***Change in the teaching and learning model of a university inherently requires a change in culture and personal belief in, and respect for, the new approach by the majority of the faculty involved***.

Therefore, any attempt to spread innovation in models of teaching and learning in higher education should focus on the real decision makers—the faculty. Of course, administrators are important, too, but they can only encourage and support fundamental change. Strategies that work must involve methods that influence the attitudes and behaviors of faculty members at other institutions.

Examples of the Successful Spread of Innovation. While they may not be common, there are examples of innovations in higher education in fields other than engineering that have successfully spread from one institution to many others. One example is the establishment of the advanced study of Business Administration as an academic discipline separate from Economics (MBA). Apparently, this was initiated by Harvard University with the establishment of the Harvard Business School (HBS) in the early 1900s at a time when many other universities did not yet accept the notion that Business was an appropriate subject for advanced academic pursuit[11]. Perhaps this is understandable if you consider that Business seems inherently focused on applied and practical skills rather than philosophical or academic concepts and ideas. An account of this development is provided in a book that outlines the history of HBS from 1908 until World War II[12].

Perhaps another more recent example is the calculus reform movement. In the 1980s, an organized effort across several universities undertook to generally improve the teaching and learning of calculus. The goals included broadening student understanding of calculus beyond the application of formulas and improving the ability to recognize and use mathematical concepts in unfamiliar contexts. By the year 2000, many universities had adopted new textbooks that made major strides to address these concerns and improved students engagement and learning[13]. Although documentation of the impact is not handy as this paper is written, the establishment in 1982 of the New Pathway in General Medical Education program at Harvard Medical School presents a systemic change in the educational paradigm in medicine

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[10] It is important here to remember that the culture of academic freedom, for all its inefficiencies and inherent frustrations, is also largely responsible for the major rapid advances in understanding in science and innovation in the 20th century. It is through the free exchange of ideas from independent thinkers who challenge assumptions and authority and pursue ideas even when they are unpopular that many of the most important discoveries are often made. Also, American universities—founded solidly on the principles of academic freedom—are among the most globally admired and financially competitive sectors of the U.S. economy.

[11] While the Wharton School at the University of Pennsylvania predated Harvard with an undergraduate program in business, Harvard elevated this to a professional degree with the establishment of the MBA through the Harvard Business School.

[12] Cruikshank, Jeffrey L., A Delicate Experiment: The Harvard Business School, 1908 – 1945, Harvard Business Press: Boston, 1987.

[13] Hallett, Debra Hughes, "Calculus at the Start of the New Millennium," Proc. of the Intl. Conf. on Technology in Mathematics Education, Beirut, Lebanon, July 2000.

that continues today to attract attention from medical educators worldwide[14]. Similarly, the unique integrative educational program in entrepreneurship at Babson College established in the 1990's has also had substantial impact in business education and continues to attract international attention from business educators today. Surely, there are many other examples in other fields. The point here is that it has happened before in other fields, and under the right conditions it must be possible in engineering education, too.

Now Is the Time to Catalyze Change in Engineering Education. While it is certain to be difficult to spread innovation in higher education at any time, there are indications that the opportunities may be better now than they have been in many years. For example, the interest among engineering faculty members in education has never been higher. One indication of this is the increase in membership in the American Society for Engineering Education (ASEE) in the last 20 years. In 1993, the total membership of ASEE was 7,469. By 2001, this number grew to 11,269 (a 51% increase in 8 years). By 2011, the total ASEE membership grew again to 13,063 (another 16% increase). Since the total number of faculty members in engineering schools has not grown significantly in the last 20 years, this indicates approximately a doubling of the number of engineering faculty who care enough about education to monitor advances in teaching and learning.

A similar increase in the number and quality of scholarly publications in the field of engineering education also has occurred in the last 20 years. The ***Journal of Engineering Education*** has rapidly grown in stature to the point that acceptance rates for articles submitted to this journal are now no higher than they are for many of the mainstream technical journals in engineering. This indicates a change in attitudes among engineering faculty and a rapidly growing acceptance of the importance of innovations in this field.

In the last decade the National Academy of Engineering (under the leadership of Bill Wulf, a member of the Olin College President's Council) adopted a change in the membership criteria to allow candidates with a career marked by innovation within engineering education to be considered for the first time. The Academy has begun to induct members for these contributions. This also indicates a significant shift in attitudes among the most respected members of the engineering community to embrace the importance and value of innovation in engineering education.

The Role of Olin College in Catalyzing Change in Engineering Education. While it may be difficult to believe that a very small undergraduate college of engineering could have enough influence to make a significant difference, Olin has already established an enviable reputation for innovation in engineering education and has begun to develop the expertise to influence the attitudes and motivations of faculty members from much larger institutions. As indicated on the attached summary of the Olin College ***Initiative for Innovation in Engineering Education (I2E2),*** we have been visited by more than 100 different institutions from around the globe in the last two years. Our visitors are consistently impressed and very enthusiastic about Olin when they leave. We have already established a partnership with the University of Illinois at Urbana-Champaign that resulted in a major change in its first-year curriculum in engineering for all 1,500 entering freshman this fall. Through the Summer Institute of I2E2 (whose attendance has doubled in the last year) and other programs, our faculty members work closely with dozens of faculty visitors on the process of innovation in teaching and learning, inspiring them to experiment with new methods in their own institution. Olin does not attempt to "transfer" the Olin curriculum to others. Instead, it encourages these faculty visitors to construct their own new approach to education by co-invention of fresh approaches that conform to the unique institutional environment and constraints at the home institution of the visitors. The principles of design-based team learning, entrepreneurial thinking, intrinsic motivation, and empowerment of students to construct their own authentic understanding through experiential learning are themes that permeate the Olin approach. The results so far are encouraging. In less than two years, the Olin I2E2 program has inspired significant change in faculty behavior at nine other universities. Olin has already influenced thought leaders in educational innovation, faculty practice at more than 100 other universities, and the learning experience of several thousand students worldwide. If expanded and sustained for a decade or more, this approach

[14] Tosteson, Daniel C., Adelstein, S. James, and Carver, Susan T., (Eds.), New Pathways to Medical Education, Cambridge, MA: Harvard University Press, 1994.

appears to have the potential to change the beliefs, attitudes, and behaviors of key faculty members at many other universities. The goal is to have an impact on the world by launching a movement that sweeps across engineering schools to improve both content and pedagogy in the study of engineering.

Questions for Discussion. The President's Council meeting will be focused on this need to spread innovation in models of teaching and learning in engineering education. The following questions will be used to guide the discussion.

1. What are the persistent obstacles to collaboration and innovation in teaching and learning?
2. What strategies can Olin College employ to catalyze the needed changes in engineering education at other institutions?
3. What role can corporations, foundations, and others play in this process?

Summary of Status of Olin College's
Initiative for Innovation in Engineering Education (I2E2)
October 2011

The establishment of I2E2 was announced as an initiative of the president on October 24, 2011. Professor Lynn Andrea Stein was appointed as the founding Director of I2E2. She has done an excellent job of creating this program and leading it through its first two years. As stated in the original announcement:

> *"The overall goal of the Initiative is to provide coordination, leadership, and a single point of contact for both internal and external conversations aimed at fostering innovation and change in engineering education. In the near term the Initiative will provide an initial point of contact for potential new collaborators, seek external funding, and plan and execute workshops, meetings and custom programs in response to external requests. In order for this Initiative to succeed it will need the involvement of a number of Olin faculty members, and the programs within the Initiative must contribute to the professional development of the faculty involved.*
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> *In the longer term, the Initiative will aim to arrange personnel exchanges (fellowships, and other visits—to Olin and by Olin community members to other institutions) that will further enrich our own on-campus conversation. In order to achieve our purpose it is important that these activities be better organized and that Olin be better recognized for its efforts to innovate in engineering education."*

Since its inception, I2E2 has grown rapidly in size, effectiveness, and influence. Olin is on the short list of "must see" institutions for educational innovators from all over the world. I2E2 arranges and hosts these many visits and the visitors are consistently impressed and very enthusiastic about Olin when they leave. Through these contacts and others, Olin influences international thinking; our graduates motivate change; our faculty members lead conferences, workshops, and training sessions; we advise academic start-ups; and our influence has grown substantially. Through I2E2, Olin faculty members conduct 12 – 15 short educational workshops each year and host 50+ campus visits. The Summer Institute (a week-long program for educational innovators from all over the world) has grown from 15 participants in 2010 to 40 in 2011, with many more expected in 2012.

At this point, Olin-influenced curriculum or pedagogy is in operation at nine other universities:

> Cal Poly San Luis Obispo (Materials Engineering);
> Creighton University (Energy Technology);
> Harvard University (Engineering and Applied Sciences and Computer Science);
> Iron Range Engineering, Minnesota
> National University of Singapore (Design Summer School)
> Technical University of Delft (Aerospace Engineering)
> University of Chile, Santiago
> University of Illinois at Urbana-Champaign (iFoundry)
> University of Massachusetts at Amherst (iCons)

At the University of Illinois, this fall all 1,500 entering first-year engineering students are enrolled in an Olin-inspired engineering program. In addition, I2E2 has received multi-year commitments for substantial financial support from US corporations. Furthermore, it also receives substantial financial support from universities that request special workshops and consulting support. The program is financially self-supporting and was recently integrated into the core budget of the Academic Affairs program at Olin.

Through I2E2 and the College's faculty and leadership, Olin's culture has shaped the Engineer of the Future conference series, NAE's Grand Challenge Summit series, and the NAE's Grand Challenge Scholars Program. In addition, Olin has already influenced thought leaders in educational innovation, faculty practice at more than 100 other schools, and the learning experience of more than 10,000 students worldwide.

Perhaps the best way to grasp the scope and breadth of I2E2 that has developed in just two years is the following list of institutions whose visits to Olin have been hosted by I2E2. Many of the 104 institutions listed sent more than one faculty member or administrator to visit our campus. The typical visit is several hours in length and includes meeting students, staff, a few faculty members and often a member of the leadership team.

There appears to be an increasing demand for Olin's influence in catalyzing the innovation in engineering education in the US and throughout the world. I2E2 will play an important part in the growth and development of Olin's influence for the foreseeable future.

Olin, through I2E2, has received representatives from the following academic institutions. Interactions may include on-campus visits or workshops.

Aalborg University	Denmark
Bakrie University *	Indonesia
California State University/Bakersfield	Bakersfield, CA
Centre d'Innovation et de Recherche en Pédagogie de Paris	France
Chalmers University of Technology	Sweden
Ciputra University in Surabaya*	Indonesia
Creighton University	Omaha, NB
Daejeon University	Korea
Dana Hall School	Wellesley, MA
Delft University of Technology	Netherlands
Ecole Supérieure de Commerce de Paris	France
Engineering Academy of Japan	Japan
Engineers Without Borders, Australia	Australia
Escuela Superior Politécnica del Litoral**	Ecuador
Ewing Marion Kauffman Foundation	Kansas City, MO
Group T University	Belgium
Habib University Foundation	Pakistan
Harvard University	Cambridge, MA
Harvey Mudd College	Claremont, CA
Indian Institute of Technology at Gandhinagar (IIT)	India
Indian Institute of Technology at Mandi (IIT)	India
Indian Institute of Technology at Madras (IIT)	India
Insper	Brazil
Khalifa University of Science, Technology, and Research (KUSTAR)	UAE
King Saud University	Saudi Arabia
Korea University of Technology and Education (KUT)	Korea
KTH Royal Institute of Technology	Sweden
Lawrence Technological University	Southfield, MI
Louisiana Tech University	Ruston, LA
Maastricht University	Netherlands
Malaysian Ministry of Higher Education	Malaysia
Manipal International University	Malaysia
Massachusetts Institute of Technology (MIT)	Cambridge, MA
Ministry of Knowledge Economy	Korea
Nagoya University	Japan

Nanyang Technological University	Singapore
National University of Singapore (NUS)	Singapore
Needham High School	Needham, MA
Ngee Ann Polytechnic	Singapore
Normandale Community College	Minneapolis, MN
Nueva School	Hillsboro, CA
Pacific Lutheran University	Seattle, WA
Petroleum Institute	UAE
Qiming College of Huazhong University of Science and Technology	China
Rensselaer Polytechnic Institute (RPI)	Troy, NY
Rice Center for Engineering Leadership	Houston, TX
Royal Melbourne Institute of Technology (RMIT) Health Innovations Institute	Australia
Roger Van Overstraeten [RVO] Society	Belgium
Rotterdam School of Management, Erasmus University	Belgium
Sahmyook University	Korea
Shikshantar: The Peoples' Institute for Rethinking Education & Development	India
Singapore Polytechnic	Singapore
Singapore University of Technology and Design (SUTD)	Singapore
St. Cloud State University	St. Cloud, MN
St. Louis University	St. Louis, MO
St. Thomas More High School	Milwaukee, WI
Stanford University	Palo Alto, CA
TECSUP	Peru
Telecom Paris Tech	France
Tennessee State University	Nashville, TN
Tillväxtanalys/Swedish Agency for Growth Policy Analysis	Sweden
Toyota Technological Institute	Japan
Universidad Adolfo Ibanez	Chile
Universidad Autónoma de Santo Domingo**	Dominican Republic
Universidad Catolica de Valparaiso	Chile
Universidad de Caldas**	Colombia
Universidad de Chile**	Chile
Universidad de Costa Rica	Costa Rica
Universidad de El Salvador**	El Salvador
Universidad de los Andes**	Colombia
Universidad del Norte	Colombia
Universidad Diego Portales	Chile
Universidad Iberoamericana**	Dominican Republic
Universidad Icesi**	Colombia
Universidad Juárez Autónoma de Tabasco**	Mexico
Universidad Nacional Agraria La Molina**	Peru
Universidad Nuestra Señora de La Paz**	Bolivia

Universidad Pedagógica Nacional Francisco Morazán**	Honduras
Universidad San Carlos de Guatemala**	Guatemala
Universidad Tecnológica de Bolívar**	Colombia
Universidad Tecnológica de Pereira**	Colombia
Universidade Federal de Minas Gerais	Brazil
University of Illinois at Urbana Champaign	Urbana, IL
University of Leuven	Belgium
University of Limerick	Ireland
University of Maine	Orono, ME
University of Massachusetts at Amherst	Amherst, MA
University of Massachusetts at Lowell	Lowell, MA
University of Missouri	Columbia, MO
University of New Haven	New Haven, CT
University of New South Wales	Australia
University of Queensland	Australia
University of Technology, Jamaica**	Jamaica
University of the West Indies, St. Augustine**	Trinidad & Tobago
University of Tsukuba	Japan
University of Utrecht	Netherlands
Van Hall Larenstein University of Applied Sciences	Holland
Virginia Commonwealth University (VCU)	Richmond, VA
Vrije Universiteit Amsterdam	Netherlands
Wayne State University	Detroit, MI
Western New England College	Springfield, MA
Wichita State University	Wichita, KS
Worcester Polytechnic Institute (WPI)	Worcester, MA

[*] Visitors from these institutions came to Olin as a part of the Global Faculty Visitors/ Global Fellows Program of the Ewing Marion Kauffman Foundation, Kansas City.

[**] Visitors from these institutions came to Olin as a part of the Fulbright Program on Effective Teaching in STEM Fields, sponsored by the U.S. Department of State's Bureau of Educational and Cultural Affairs. Each program participant was resident at one of the following US Universities: Colorado State University, North Carolina State University, North Dakota State University, Purdue University, Texas Tech University, University at Buffalo, University of Arizona, University of Arkansas at Fayetteville, University of California at Davis, University of Connecticut, University of Georgia, University of Illinois at Chicago, University of Illinois at Urbana-Champaign, University of Iowa, University of Kansas, University of South Carolina at Columbia, University of North Texas, and the University of South Florida.