Re-Imagining Liberal Education in the 21st Century
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Welcome

It is my great pleasure to welcome you to Union College. We thank you for coming to what we hope will be the first of several symposia and conferences on Engineering as a Liberal Art and the role of technology in a liberal education.

I would be remiss if I didn't begin with a word of thanks to the Andrew W. Mellon Foundation. This symposium was made possible by a Presidential Discretionary Award from Mellon. Gene Tobin, now at Mellon and former President of Hamilton College, will be joining us later and I hope we can all thank him and the Foundation for their support when he arrives.

I hope you will enjoy the symposium and your visit to Union. Forgive me for what has become an occupational habit but I must say a word or two about the College, especially as it pertains to our discussions.

Union was founded in 1795, the first college in America to be designed with a campus master plan. The French architect, Joseph Jacques Ramée, drew his plans for Union in 1813 (several years before Jefferson's plans for the University of Virginia) and its then novel design – large central green with central rotunda, surrounded by its core buildings and arcade – aimed at creating a community of learners. It was also carefully placed on a hill perched above the Mohawk Valley and the campus architecture framed a view to the west and the seemingly unbounded possibilities of a new world that awaited the pioneer.

The imaginative ethos embedded in the campus architecture gave license for the young college to explore new ways of education. Union was among the first non-sectarian schools in the country, founded by three religious groups who believed they could have a common educational purpose regardless of their differences. Union was among the first to allow modern languages to meet graduation requirements. The first analytical chemistry lab taught anywhere was offered at Union by Charles Chandler who later founded the American Chemical Society. And, most pertinent to our conversations this weekend, Union was the first college to introduce engineering into the liberal arts curriculum.

Just as the founders of Union thought it was important to set our sights on the challenges and opportunities that lay to the west in the early 19th century, I would like to think that this symposium similarly asks us to look to the possibilities, challenges, and opportunities that lay in re-imagining what it means to be liberally educated in the 21st century.

While our history makes Union a good place to hold this symposium, I will confess that we have a good bit of self-interest in hearing what you all have to say. We recently adopted a new strategic plan that sets forth, in general terms, our vision for the future of engineering at Union. That vision is based on a strong conviction that engineering should be considered an integral component of a liberal arts education.

We have found some effective ways of making that vision real (I and others from Union will share these in our discussions) but we hardly have what might be regarded as a full or final "blueprint"; instead, what we have is a rapidly evolving conversation. And, our selfish hope for this symposium is that you will become partners in this conversation; co-participants in shaping a new imperative for the education of engineers and, more broadly, liberally educated students.

The Academy has seen many exciting recent developments in this area. A lot of these have taken place at the colleges and universities represented here today. One major purpose of this conference, then, is to share visions and share initiatives. It is a chance to hear how each of us imagines the future of engineering and the liberal arts.

I suspect there will be a good deal of "preaching to the choir." But the "choir" still has a capacity to learn new things and the "choir" needs validation at the very least. We decided to keep this conference small so its sessions could be focused and conversational. I am sure that we all have read a lot about each other's programs, but there is no substitute for first-hand discussion, interrogation, and, indeed, occasional argument.

We have a remarkable opportunity to push the conversation about engineering and liberal education forward over the next day and a half. We have gathered an impressive range of individuals, programs, and institutions. With us are delegations from liberal arts colleges with strong engineering programs, universities with strong engineering programs grounded in a commitment to liberal education, and poly-technical institutes that have distinguished themselves by their groundbreaking work in thinking creatively about what it means to educate their students. We have representatives here today from the oldest engineering program in America -- the U.S. Military Academy at West Point -- and from some of the youngest programs. In sum, we have representatives from a good cross-section of institutions offering a wide range of programs and many exciting new approaches to the teaching of engineering.

<u>Making the Case for Engineering as a Liberal Art.</u>

While not wishing to prejudge the nature of our discussions together, I suspect that it will become clear that the time has come for the Academy as a whole to regard engineering as a fully legitimate component of the liberal arts. Although most participants in this conference today might assent to such a proposition, many in the larger Academy would not; and, the burden of proof will be upon us to make the case.

"Making the case" will not be a trivial exercise. It is not merely a matter of redefining boundaries or simple inclusion. The intellectual traditions and divides forged over centuries cannot be quickly re-imagined. It is, rather, a larger project that not only involves changing the nature of a modern education and what we teach to college students, but also how we think about knowledge and its sources. If the integration of engineering with the sciences, social sciences, and humanities does not take place at the levels of basic conceptualization and intellectual purpose, it will not be sufficiently well grounded to become broadly accepted across the Academy. Some basic paradigm shifts will be necessary before engineering is regarded as fully integral to the liberal arts.

Advancing engineering as integral to the liberal arts is a more ambitious project than simply saying that engineers would profit from taking liberal arts courses or even saying (although somewhat more ambitious) that humanities- or social science-oriented students should study engineering or technological innovation.

I think there is least resistance to the suggestion that engineers should be liberally educated. We have distributed a piece, written by Charles Steinmetz, considered by many to have been one of the top scientists of the 20th century, especially for his work on alternating current. Steinmetz came to Schenectady to work with Thomas Edison's General Electric Company. Beginning in 1902, he taught for 21 years at Union College and established our Electrical Engineering Program. Steinmetz noted in "The Value of the Classics in Engineering Education," that the study of Greek and Latin would help properly educate engineers. According to Steinmetz, "The first condition that the College should try to fulfill is to turn out educated men and not mere trained artisans." Thus, he argued, engineers needed to be broadly educated and study in the classical languages provided such breadth. Steinmetz anticipated by nearly a century the arguments we now hear from the National Academies of Science who, in their report titled *Rising Above the Gathering Storm*, have focused us on the advantages that broadly educated scientists and engineers will enjoy in the now globally interconnected world of the 21st century.

This rationale stands behind the development of "dual-degree" options at many of our nation's liberal arts colleges. Mt. Holyoke's explanation on their website serves as an example of the argument:

> "As a future engineer, you'll be served well by a degree from a rigorous liberal arts college. Engineering professors at first-rate universities say that most graduate school programs in engineering are as interested in strong students with broad-based science backgrounds from excellent liberal arts colleges as they are in students with engineering degrees. Many professors note that students with liberal arts backgrounds bring an awareness of the human dimension of every issue, as well as a technical dimension. And engineering professionals who have attended Mount Holyoke say that the way the College's faculty and students work collaboratively is ideal preparation for the teamwork that is typical of many engineering projects" (http://www.mtholyoke.edu/acad/math/other/engineering/).

While the logical flipside of this argument would, of course, be that humanistic-oriented students should be more broadly educated by studying engineering, this is likely to be seen as more difficult to accomplish. We have seen national calls for strengthening STEM disciplines and recruiting more students into them. We've seen far less conversation about the need to ensure that students in music, the arts, and other humanities and social sciences are fluent in any of these fields and engineering least of all. It can certainly be said, however, that students so equipped would have equally remarkable advantages in this new century. And, this is precisely the goal set out recently in the University of Michigan's Millenium Project report, titled *Engineering for a Changing World*. In that report, the authors argue that engineering, like the natural sciences, social sciences and humanities, should be embedded "in the general education requirements of a college graduate for an increasingly technology-driven and –dependent society of the century ahead" (University of Michigan, Millenium Project Report, *Engineering for a*

Changing World, 2008, p. v, http://milproj.ummu.umich.edu/publications/EngFlex%20report/download/EngFlex%20Report.pdf).

Most challenging of all will be the development of a full-blown conception of engineering **as** a liberal art, not simply as one more offering on a sort of curricular cafeteria line but rather as possessing qualities that are fundamentally compatible with the goals of liberal education. This is, of course, precisely what William Wulf, President of the National Academy of Engineers seems to call for. "What" he has asked, "is it that identifies humans?" "The use of tools" he answers and continues, "For that reason, perhaps engineering is the most human of studies. ... Maybe we should teach engineering as a liberal art, and maybe a piece of every literate person's experience should be to create a useful artifact that improves life..."

As an exercise in imagining a more expansive view of liberal education, it may be helpful to look at the Winter 2008 issue of *Liberal Education*. In that issue, Michael Wicks and Andrew Phillips, both from the University of Wisconsin-Eau Claire, set out a "liberal education scorecard" which graphically portrays the landscape of liberal education. They incorporate affective, cognitive, and skill domains of liberal education, Bloom's "taxonomy of understanding," and learning outcomes prioritized in recent statements from the AAC&U on the nature and goals of college learning. The Wicks and Phillips graphic representation of liberal education begs the question: where does engineering fit into this schematic? Engineering can be argued to add so much to the problem solving, creative thinking, and critical thinking they suggest liberal education promotes. But where would it fall? Is it part of the "cognitive domain?"

Michael Wick and Andrew Phillips, "A Liberal Education Scorecard," *Liberal Education*, Vol. 94, p. 25 (Winter 2008)

Engineers, for their part, have not helped matters by seemingly being torn between being a part of the liberal arts versus being ever more professional. Michigan's Millennium Project, for example, at once wishes engineering to be added to what they call the "liberal arts canon" yet simultaneously laments that it's not fully appreciated as a "learned profession" like medicine or law.

The growth of knowledge during the last half century has laid the groundwork for paradigmatic shifts that make possible dialogue about even the most expansive understanding of both engineering and what it means to be liberally educated. We hope that this conference can contribute to this growing dialogue and to the development of programs that give substance to that ambition. In sum, we view this conference as a first step in what we hope will be a continuing process of mutual exploration and sharing. If engineering is truly to become regarded as a liberal art, it will only happen as a result of a joint effort by all of us and other like-minded institutions.

Beginning the Dialogue: A Balanced Education

So let us begin the conversation. I would like to share with you some of our thinking here at Union about the future of engineering and the liberal arts. Our conversation has intensified in the last two years thanks to a recent strategic planning exercise I mentioned earlier -- an exercise in which we re-examined our own programs in light of what we perceived to be larger trends in education and society-at-large.

As I also mentioned before, Union has a very long engineering tradition, dating back to 1845, and an even longer tradition of curricular reform and innovation. Eliphalet Nott, our fourth president, whose portrait hangs over there and for whom this structure is named, introduced the "modern" undergraduate curriculum with parallel courses in the classics on the one hand, and in modern languages, science, and engineering on the other. As Ennis Pilcher, physicist and historian described it, "Nott foresaw a clear need for better-educated engineers with a stronger background in the liberal arts, science, and mathematics."

Nott's educational influence in his day was nothing short of stunning. This was, in part due to his longevity in the position; Nott still holds the record as the longest serving President of any college or university – 62 years!! Nott's influence also owes to his entrepreneurial attitude and his ambition to make a difference. While continuing to serve as Union's President, Nott simultaneously served as President of Rensselear Polytechnic Institute from 1829-1845. And it owes to the many students he mentored; several dozen of Nott's students at Union became innovative college presidents who spread his educational philosophy throughout the expanding Republic. These included Francis Wayland at Brown; Leonard Woods at Bowdoin; John Williamson Nevin at Franklin and Marshall; Richmond Fisk at St. Lawrence; Maunsell Van Rensselaer at Hobart; Laurenus Clark Seelye at Smith; John Howard Raymond at Brooklyn Polytechnic and later at Vassar; Eliphalet Gilbert at the University of Delaware; Henry Phillip Tappan at the University of Michigan; John Milton Gregory at the University of Illinois, and Horace Morrison Hale at the University of Colorado.

For Nott, clergyman and inventor as well as educator, combining liberal arts and engineering did not pose a particularly problematic dichotomy. As minister, he occupied the pulpit at the First Presbyterian Church in Albany, which counted among its members Alexander Hamilton (as an aside, Nott' eulogy for Hamilton – a treatise on both the ill-affects of dueling and the nature of civic responsibility – was widely read). As inventor, Nott was well-known for his development and refinement of Nott Stoves. This "philosopher of the caloric" (as he was dubbed at the time) developed an anthracite coal burning stove which made possible the use of the harder, cleaner burning coal by introducing convex rotating grates to remove the ashes.

Beyond the fact that he personally integrated philosophy, theology, and engineering, his theological frame for understanding the world made their separation seem arbitrary. Nott, delivering an address on the 50th anniversary of his inauguration and nine years after introducing engineering at Union, argued:

> "No matter what direction or to what extent inquiries after truth are prosecuted, from each the answer returned will be the same. From the strata embedded in the depths of the earth, from the blossoming flowers on its surface, as well as from the suns that burn and the stars that glitter in the firmament above it, a voice, everywhere alike, is heard to say "God is here, and here, and here."

As Wayne Somers, the author of our college history, has observed: after Nott, in an academic world that rapidly became "disenchanted" and secularized, succeeding Union College presidents have defended engineering at a liberal arts school in far more functional terms, pointing to society's need for engineers and Union's ability to attract them.

Union's engineering curriculum followed closely in the footsteps of Dartmouth graduate, Sylvanus Thayer, who created the modern engineering curriculum while serving as superintendent at West Point from 1817 to 1833. Union produced engineers who were very active in many of the outstanding engineering accomplishments of the 19th century. By way of examples, they included: Solomon Deyo, chief engineer for New York City's first subway system; Edward Payton North, one of the builders of the trans-continental railway and authority on roads; and Jesse Baker Snow, engineer in the construction of several New York City under-water transit tunnels.

Educational historian, Frederick Rudolph (*Curriculum: A History*) has questioned whether or not Union's "balanced curriculum" produced a different kind of engineering student during this time period. While not prepared to argue the point too forcefully and acknowledging the problem of argument based on an "N" of 1, I *would* point to Franklin Giddings. Giddings is considered to be one of the founding figures in American sociology, my own field of study, and held the very first chair in the discipline in the United States at Columbia University. Giddings was educated at Union *as an engineer* and, by combining his interest in philosophical questions that have preoccupied humans for centuries with his engineering background, developed sociology as an empirically grounded discipline. Giddings' interest in small-scale repetitions of personal acts in human interaction, which he believed could be analyzed statistically, his emphasis on the importance of establishing rigorous classifications of human behavior, and his fundamental belief in the evolutionary progress of society all owed, in some part, to his "balanced education" at Union.

Union's balanced education certainly attracted faculty members sympathetic with the approach. Perhaps our most famous faculty member in engineering, the electrical wizard Charles Steinmetz, played a major role in the creation and development of the discipline of electrical engineering. Steinmetz can also be regarded as one of America's all-time leading advocates of a liberal arts education and of engineering taking place in a liberal arts setting. He was a strong believer in the value of a classical education. As he stated a century ago:

> "By dealing exclusively with empirical science and its applications, the engineer is led to forget, or never to realize, that there are other branches of human thought (besides empirical science) equally important as factors in education and intellectual development. An introduction to these other fields is best and most quickly secured by the study of classics, which open to the student worlds entirely different from the present -- the world of art and literature (of Greece), and the world of organization and administration (of Rome) -- and so broaden his horizon and show relative values in their proper proportion and not distorted by the trend of thought of his time."

Steinmetz was not alone. His fellow faculty member in civil engineering, Olin Landreth (himself a Union alumnus), developed a six-year course of study that introduced engineering students to the study of history, sociology, and aesthetics.

Let us not gild Union's history, however. Over the century and a half since Union introduced engineering into the liberal arts curriculum, our faculty and administrations have sometimes argued the futility of over-reaching in the curriculum and even clearly opposed the integration of engineering into the liberal arts course of study. In his discussion of the "balanced curriculum" in our *Encyclopedia*, Wayne Somers himself calls engineering and liberal arts "antipathetic" disciplines. This was certainly the position taken by Classics Professor Sidney Ashmore, a contemporary on the faculty in the time of Steinmetz and Landreth, who argued in our school's newspaper that, "Union College is practically divided into two camps, which if regarded from the standpoint,,,of educational values, are antagonistic, in some degree at least" (Somers, *Encyclopedia of Union College*, p. 86). In fact, Ashmore suggested that engineering should be split off from the undergraduate liberal arts college, just as had been done with the law school and medical school.

Previous administrations at Union have also sometimes shared this ambivalence. One of my predecessors, Dixon Ryan Fox, who served as Union's President from 1934 to 1945 and a Columbia-educated historian, declared near the end of his presidency:

> "We have come to realize that the philosophy that governs one kind of education is almost entirely different from that which governs the other. The engineering course and the special-degree programs in chemistry and physics train man as specialist, and the liberal arts courses educate man as man…We have come to feel that at Union College these two points of view are irreconcilable, and that there is no advantage to allowing each group to needle the other with attempts at conversion. We are content to let each plan an educational program of the highest possible quality, according to its vision…" (Wayne Somers, *Encyclopedia of Union College*, p. 84)

Thus, to be completely honest and in the interest of full disclosure, at times Union's boast of a "balanced education" referred more to parity between irreconcilable paradigms than a radical departure from the educational status quo. And, let us not gild our present either. The assessment of Ashmore and Fox is undoubtedly still held by some faculty members at Union today.

Forces Propelling Us Toward An Integrated Curriculum

I offer these glimpses at Union's history because our story is representative of the hopes, tensions, and challenges that all of us interested in engineering's relationship with liberal education have witnessed. For us at Union, just as I suspect for the rest of you here today, there are really two narratives, each of which provides a lens through which to see our curricular development. One narrative seems suggest a prophetic vision from which a fully integrated curriculum could spring; the other narrative portrays at best parallel curricula operating within a pluralistic educational environment. There are partisans on both sides and a fair number who stand on the curricular sidelines.

Regardless of narrative or partisanship, there is little question that a variety of factors force us to re-examine the place of engineering within the liberal arts today. First of all, over the last century, and especially the last half-century, there has been a geometric acceleration of knowledge, including, importantly, technical knowledge. Second, this growth of technical knowledge has led to, among other things, the creation of technologies that have enabled us to occupy virtual worlds with both energizing and troubling consequences. These technologies have also shrunk our globe. The near instant access to vast reservoirs of information from around the world has, in turn, led to many structural changes within and between the old academic disciplines. Plain and simply: there is a lot more to study, and there are ever-changing methods by which to do so.

Additionally, much of cutting-edge discovery and innovation is taking place at the "intersection" of disciplines. There have been serious breakdowns in the boundaries between disciplines, including breakdowns in the boundaries between science and engineering, with the growth of interdisciplinary scholarship, the use of shared instrumentation, and even the emergence of new disciplines at those boundaries, such as nanotechnology, neuroscience, and bioengineering. Evidence of this change can be found everywhere, ranging from the way in which we design space on our campuses to foundation funding priorities.

More broadly, we have seen a breakdown in the ancient division between the "theoretical" and the "practical" in many disciplines. In the social sciences, the once controversial notion of "praxis" has given way to a general appreciation of the importance of theory and research for policy and social action. In the humanities, perhaps most notably in the area of ethics but also in the contextual study of writers, readers, and texts, the old divides have become blurred. It may go without saying but the same is true for knowledge in the sciences. In this fast-changing world, knowledge for knowledge's sake is indeed still prized but the division between the theoretical and the practical -- a division historically used as a rationale for separating engineering from the liberal arts -- can no longer be regarded as a fundamental differentiator.

And, from the other side of the equation, there is ever increasing appreciation of the fact that engineers employ the paradigms and practices of theoretical science. A good case can be made that what engineers do in their laboratories today and what scientists do in theirs have come to resemble each other far more than ever in the past, and collaborations between the two have become much more frequent. At Union, the joint effort of mechanical engineering and chemistry in our Aerogel Labs offers an example. Faculty and students who study there are hard pressed to say where the purview of one field begins and the other ends.

Thus, I believe that we are seeing a true convergence between the paradigms and practices of scholars and teachers from engineering and those from the liberal arts and this convergence enables us to envision a dissolution of the traditional boundaries. And, just as the development of the liberal arts throughout the ages sought to make the natural environment less mysterious to those who inhabited it, so now there is an increasing imperative to make the engineered – or what Mary Roth from Lafayette urges us to call the "built" -- environment less mysterious to its new inhabitants. And there can be few better equipped to understand this new environment than those who helped to create it.

And finally, this acceleration of new knowledge and the new realities of our ever-changing environment make it very important for present and future citizens of a democracy to be able to make informed choices about the directions in which they want that society to move. If one of the long-standing ideals of a liberal arts education is to help create better citizens, then such an education today must embrace an understanding of technology. In this regard, we all recognize the awesome illiteracy among countless students regarding many fundamental things that shape their lives and about which they, as emerging citizens, should be prepared to make informed choices. Many students today are as ignorant of the whys and wherefores of the engineered environment into which they were born as our ancestors of 1,000 years ago were of the whys and wherefores of the natural environment into which they were born. In short, there is an enormous need to bring the divergent intellectual cultures even closer together for the purpose of understanding and acting.

The Leadership Imperative.

These developments have created enormous challenges for our society and for higher education. While some might argue that we haven't moved quickly enough to respond to the forces changing our world, higher education has indeed responded. Frankly, awareness of some of the innovative programs and expansive conceptualizations of both engineering and liberal education dictated the invitation list to this symposium.

Many of you represented here today have hosted your own internal conversations about the nature of "literacy" among the students you teach and form. Many of you have questioned what it means to "liberally educate." Many of you have participated in conversations about the impact of technology on society and now study and teach about the phenomenon. Many of you have advanced the need for engineering students to have a broad-based education and thereby better contextualize what they learn and what they do. As the *Swarthmore Catalogue* puts it, "A responsibly educated engineer ... must have a thorough understanding of social and economic influences and an abiding appreciation for cultural and humanistic traditions." ABET, the national accrediting agency for engineering departments now supports this view in the accreditation process. Domenico Grasso, formerly of Smith, now of the University of Vermont, is a nationally-recognized advocate of this position and he will speak to us about this today.

Moreover, we have seen innovative General Education programs come to require an engineering, technology, or design component. Princeton University has been prominent in this development. I hope that Catherine Peters, here at this conference, will tell us more about Princeton's experiences tomorrow.

We have also seen the development of imaginative courses integrating engineering and the liberal arts, and we have seen the development of interdisciplinary projects with students from engineering teamed with students from other fields, often in a problem-solving mode or context. Tufts, which is represented here today, is but one example of a university, committed to the liberal arts, which has created a truly imaginative set of integrative course offerings. Dartmouth's Joseph Helble and William Lotko, Lafayette's Mary Roth, and Smith's Linda Jones will also be describing some exciting course and curricular innovations at their institutions when they present tomorrow.

The ethical implications of scientific and technological discoveries and their uses have long been recognized as important areas of teaching and scholarship in which insights from the humanities can be very important to engineers. We hope to hear tomorrow from Mark Doorley, about Villanova's course on ethics and engineering.

Interdisciplinary programs have proliferated in recent decades and now enthusiastically embrace and welcome engineering faculty. Fields such as environmental studies, energy engineering, digital arts, nanotechnology, and bioinformatics and but examples. Tomorrow, we will hear West Point's Christopher Conley and Union's Jeff Corbin discuss sustainable development - one of the most important of these contemporary interdisciplinary topics.

We also see a strong trend to bring international perspectives to engineering -- concurrent with the movement in liberal arts to expand its perspectives and to increase student awareness of the global society. WPI made pioneering efforts in this area and my friend Lance Schachterle will be speaking to us this afternoon and will also be discussing global undergraduate projects tomorrow.

To meet the challenges of the future, the Academy is making a major effort to increase the number of future engineers by broadening the base from which they are recruited. In this regard, we have seen very serious efforts, again consistent with modern developments in the liberal arts, for engineering programs to reach out to include women and under-represented groups in far greater numbers than they traditionally enrolled. Trinity, Sweet Briar, and Smith have all launched vigorous new initiatives to make engineering more attractive to women and students of color, and have thereby expanded the diversity of engineering students which will change the engineering workforce and perhaps even our conception of engineering.

Here at Union, we have tried to approach many of these same issues through a variety of initiatives. While remaining committed to maintaining our fully accredited program in engineering, we have tried to find way to ensure our students – all of our students – are broadly educated. We too have tried to welcome an increasing array of people to the educational table. We have tried to foster interdisciplinarity within courses and in collaborative programs. Let me quickly mention six initiatives.

1) First, we are experimenting with the use of modules where faculty from one discipline lead one or more class sessions of a course in a different discipline. In this way there can be a degree of cross-fertilization between divisions. One example of this is adding modules taught by engineers to our Introduction to Environmental Studies course. We have also had modules demonstrating how telecommunications systems work in an interdisciplinary course on Technology, Society, and Culture.

2) Second, to bring expertise to bear on important topics that cross disciplinary lines, we have developed full team-taught courses with faculty from engineering and other parts of the College. For example, we recently offered a very successful course entitled "The New Great Wall" on the Three Gorges Dam project in China taught jointly by an engineering professor and a professor of Chinese language and culture. They examined both the engineering dimensions of the project, including its many structural and geological risk factors, and the economic, social and cultural dimensions of the dam in terms of its impact on countless thousands of lives.

3) Third, we have experimented with paired courses, one taught by an engineering faculty member, the other from the humanities, sciences, or social sciences. These courses promote intellectual cross-fertilization, with students from each course contributing their expertise to a common project. For example, we have taught several courses pairing music with acoustical engineering. In one, the music students performed in different settings, the engineering students then tried to make the sound of one setting approximate the sound of the other, and then the music students evaluated the results.

4) Fourth, we are creating interdisciplinary programs with an engineering or technology component. These include digital arts, environmental studies, bioengineering, neuroscience, and nanotechnology. Whether these represent true interdisciplinary initiatives, multidisciplinary approaches, or reflect the emergence of wholly new disciplines, our engineering resources have and will play a role in the development of these programs.

5) Fifth, we are utilizing our engineering division as a resource by instituting interdisciplinary research projects with engineering components. These involve both faculty and students, and at times draw on our large summer undergraduate research program. For example, we have a very active ongoing aerogel project in which students and faculty from chemistry and mechanical engineering have received NSF grants and a patent based on their research. We have other interdisciplinary research teams in the areas of bioengineering and environmental studies as well as a seminar in Engineering, Economics, and Entrepreneurship, in which teams of non-engineering students work with senior engineering majors in exploring the potential market for the engineers' capstone design projects.

6) Sixth, faculty from engineering are, in growing numbers, teaching in our first-year Preceptorial and second-year Research Seminar – key components of our General Education curriculum. Seminar topics have included: "Designing as if People Mattered"; "Water and Civilization"; "Impossible Missions Design Team" (which you will hear more about tomorrow); and "Can You Hear Me Now -- The Social and Technical Aspects of Electrical Communication."

All of us have developed innovative programs. All of us represented here have seemed to have carved out an intellectual arena on our campuses within which a conversation between engineering and the arts, humanities, social sciences, and sciences has been nurtured. While David Billington may mistakenly privilege Princeton, the qualities of the intellectual community that he has experienced there *are* critical to moving the conversation forward. He has noted of

his Princeton experience:

> "It would have never occurred to me to make these kinds of connections [between engineering and the liberal arts] if I had not been at Princeton. I don't think it would have been possible at other universities to have such long and fruitful conversations with other disciplines. But I was able to do it here because of the University's relatively small size and because the engineering school is so integral to the university itself." [From the Princeton web site.]

For all of us, a prime objective must be creating an educational and collegial environment within which conversations can be had and connections can be made. This certainly must be a priority for people in my position.

Re-Imagining Liberal Education.

At the end of the day, the value of seeing engineering as integral to our liberal arts course of study will depend on the efficacy of the results. The proof will indeed be in the pudding. I believe we are already seeing the resulting value of broadly educated engineers but I will leave it to Dr. Grasso to address this is greater detail. And what is it scholar/teachers throughout the liberal arts can learn from engineers? Will the students in other fields of study be better prepared by virtue of a reciprocal exposure?

If scholars and students outside of engineering can learn from engineers in ways that will help them in their own disciplines, and add to their intellectual power and depth, then it would be very difficult for anyone to argue that engineering should not be considered part of the liberal arts. There are at least three areas of intellection through which engineers can make very important contributions to understanding in other disciplines and establish their foothold in the liberal arts. These are in conceptualization, creativity, and evaluation.

With respect to **conceptualization**, there are many ways in which the insights of engineers might be useful to teachers and scholars in other disciplines. For example, scholars and students across many disciplines can learn a great deal from engineers about their investigative methods and approach to the arts of design and problem-solving. As another example, and more specifically, the concept of “system,” used by engineers, should well be of interest and of use to biologists, chemists, physicists, computer scientists, political scientists, sociologists, industrial architects, and economists when they employ the concept of a system in their own disciplines. A re-consideration of their own study of systems, informed by the approach taken by engineers, could well lead to expansion and/or refinement of their own thinking. As yet another example, the way in which engineers and computer scientists use the recursive concept of "feedback" should be of interest to political scientists, sociologists, and especially economists (where the "rational expectations" school of economics is partly built around a form of this concept). As a final example, related to problem-solving, most scholars throughout the social sciences stand to learn a good deal from the ways in which engineers use forecasting, predicting, and risk assessment. Might not even scholars from the classics and from literature be interested in expanding their understanding of how those in a different intellectual milieu approach the all-too-human circumstance of confronting the unknown? The point is that a fruitful convergence can and should be possible between the concepts developed and used by engineers and teacher/scholars from other disciplines. After all, intellectual cross-fertilization is

one of the most important aims of the liberal arts and one of its primary contributions to scholarly inquiry.

Some of our presentations at this symposium will explore this point more explicitly. For example, tomorrow, William Keat from Union will make the case that there are striking parallels between the great pragmatic philosopher John Dewey's analysis of what constitutes "a complete act of thought," (set forth in his famous *How We Think*) and major elements of engineering design methodology.

A second area where scholars in other disciplines might learn from engineers is in the area of **creativity**. Good engineering is creativity *par excellence.* This gives engineering strong intellectual connections to and sympathies with the arts. Understood from this vantage point, engineers can be thought of as artists and artificers. Leonardo is perhaps the patron saint of this convergence -- his locking system for canals has been used for over 500 years. Isn't it possible that the way engineers approach design questions would be of interest not only to those in the fine arts and architecture, but also to those in the social sciences as well? The engineering design process contains many features that speak directly to the concept of creativity, and the desire to encourage creativity is very broad indeed. Scholars from many fields of study can learn from their colleagues in engineering, better distinguishing between aspects of the creative process such as what it means to author, imitate, and replicate. Creativity, of course goes beyond just design, and the way engineers exhibit and employ the creative impulse may be of interest to those interested in creativity right across the liberal arts. David Billington's recent book exploring the sources of creativity among inventors and engineers is but one example.

A third area in which scholars from other disciplines might learn from engineers is that of **evaluation.** For example, we would all benefit from an attempt to tease out the differences between the standards of evaluation and criticism used in engineering, politics, art, music, literature, and the classics. Could not a sophisticated understanding of how engineers assess failure and success be of great interest to scholars in other disciplines? Could not the same be said for how engineers evaluate efficiency -- or make aesthetic evaluations? Perhaps even more importantly, we would all benefit from an extended conversation – between engineers and scholars across the entire academy – about the nature of ethical commitments and professional responsibility. At a time when "assessment" looms so large on the Academy's horizon, shouldn't there be some urgency to this conversation?

My point is not that engineering paradigms and practices should be imported whole into another discipline. That is not to be expected, and would probably be very counter-productive. But an informed understanding of how engineers conceptualize, create, and evaluate could help scholars and teachers in other disciplines expand or refine their own thinking and their own paradigms. It is in this way, I would argue, that engineers can make intellectual contributions to important questions which traditionally have been regarded as the province of the "liberal arts."

It is perhaps because of the potential benefit of this cross-fertilization, along with an emerging sense that an understanding of engineering concepts and principles is essential to being literate in today's world, that educational institutions and their leaders have started to rethink the very meaning of what it means to be liberally educated in this new century.

I am pleased and honored that President Carol Christ of Smith is with us today. She will, I believe, share with us not only some features of Smith's exciting program in engineering, but also share with us, in much more detail than I have, some of the many ways in which these and other developments in higher education are making possible the greater integration of engineering and the liberal arts throughout the Academy -- and the emergence of a new definition of what a liberal education entails.

Before turning things over to President Christ, let me make one final observation. Certainly each of us can play and has played an active and creative role in furthering the integration of engineering and the liberal arts. But, I cannot emphasize enough the notion that the integration of engineering into the liberal arts is no single institution's innovation or mandate. It is a national and even international mandate, important to our collective future. Thus, it is a goal we all share and we will be far more effective if we all work together. I hope that this symposium will make a significant contribution to that goal of sharing ideas and become the basis for shared action.

The sometimes controversial C.P. Snow, speaking at Union College in 1979 said, "I am hopeful that given a bit of good fortune there will be a culture within perhaps two generations far more unified, better informed, and with a deeper sense of life." We can probably all agree that on this point Snow was correct and let us hope that our work together this weekend is a step along the pathway that Snow imagined.

Thank you.

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