AC 2007-2905: CATALYZING SYSTEMIC CHANGE TOWARDS A MULTIDISCIPLINARY, PRODUCT INNOVATION FOCUS

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Catalyzing Systemic Change towards a Multidisciplinary, Product Innovation Focus

Abstract

The mission statement of RIT's newly created honors program focuses on product innovation for a global economy. The critical elements of this program emphasize the importance of a multidisciplinary, systems oriented approach to engineering practice with a special focus on customer-driven design. While the curricular goals are to provide value-added experiences for students that go well beyond the scope of a traditional, discipline-centered BS degree program, an additional benefit of the program lies in its ability to transform the perspectives of the college's faculty in regards to the vital role that multidisciplinary, team-based product development will play for engineering graduates who strive to add value to the global economy. Individuals often choose an academic career for the freedom it provides to explore and extend the boundaries of knowledge in a particular sub-discipline for which they have a passion. But this orientation runs counter to the broad-based, customer-oriented perspective needed in product development and project management. The honors program in the Kate Gleason College is structured to give participating faculty members a full appreciation for the dynamics of the team-based, product development process and the numerous issues on the periphery of engineering that are critical for engineers to be aware of in order to successfully commercialize a product in the global economy. Participating faculty members discover how knowledge creation in their discipline ties into "value creation" in society, better equipping them to incorporate these ideas in their own teaching and mentoring of students. Additionally, through their participation in the program, faculty members become much more receptive to the concept of team-based, multidisciplinary design as a model for the capstone design experience and, as a result, will advocate for the beneficial aspects of this approach among their faculty colleagues.

Introduction

Real economic growth occurs through the development of innovative, value added products that uniquely meet customer needs and desires. The conceptualization, development and manufacture of these products are the purview of engineers. It is what the engineering profession is all about. As articulated by the Council on Competitiveness, "Innovation will be the single most important factor in determining America's success through the 21st century."[1] While today's research results provide the technical foundation for new product development, the nation needs engineers who are experts in utilizing the latest research results to create new, value-added products.

Even in its formative years in the early 1900s, the role of the engineering profession was to harness scientific discoveries to create products that address the needs and desires of our society, and in doing so shape and improve our quality of life. Thus, in attempting to imagine what engineering will be like, and what engineers will need to know, as we move more deeply into the 21st century, we only need to reflect upon how our lives are changing, how society is being stressed, and how recent scientific advances may relate to new product concepts that can address these conditions. "Technology has shifted the societal framework by lengthening our life spans, enabling people to communicate in ways unimaginable in the past, and creating wealth and economic growth by bringing the virtues of innovation and enhanced functionality to the economy in ever-shorter product development cycles. Even more remarkable opportunities are fast approaching through new developments in nanotechnology, logistics, biotechnology, and high-performance computing."[2]

The technological challenges are shifting as well, and engineers need to understand the context of these societal problems in order to develop optimal solutions, hopefully before these challenges become crises. Challenges include the deteriorating physical infrastructure of our nation, particularly in urban settings; the need for alternative sources of energy, renewable and clean; the ever-increasing stress on the environment due to population growth and the non-uniform distribution of key resources around the globe; the need to provide a high quality of life for an aging population; and the need to develop technologies that are sustainable, minimizing their environmental footprint. Understanding the social framework for technological innovation will be a key asset of engineering leaders in the future.

With the body of knowledge doubling every ten years[3], it is impossible for an individual to be an expert in everything. Without a doubt, an education that focuses exclusively on the mastery of a body of knowledge runs the risk of developing specialists who know a great deal about an ever-narrower subject area in relative terms. At the same time, the technological challenges are becoming ever-more complex. Indeed, real-life problems do not respect discipline-specific boundaries. Consequently, the engineer of tomorrow will need to be more effective than ever before at working within multidisciplinary teams, and exploiting the unique and diverse capabilities of each individual on the team to develop the most effective solutions to whatever problem is being addressed. It is also critical to realize and take advantage of the unique capabilities of the human brain. Thinking is an integrative activity, synthesizing information enhanced by inference, analogy and extrapolation. Ideally, engineers should be educated to maximize this capability through the use of a systems engineering approach to solving problems. Invariably, the engineer of the future increasingly will be called upon to see the "big picture" and apply structured methodologies to integrate components from various fields to develop total solutions to a real-life problem.

To summarize, there is no question but that the engineering profession is critical to the future of our society and this planet. Furthermore, the practice of engineering in the future will be even more challenging and rewarding than it is today. Indeed, our society needs a new generation of engineers who are more than subject matter experts. They must be effective integrators of technology, with a talent for leveraging the diverse assets of individuals on multidisciplinary teams. They must also understand the social context of the problems that they are solving. To engineer a sustainable world, society needs engineers who understand the social context of their work, and who are willing to embrace a leadership role to shape public opinion in favor of technically sound, socially responsible decisions for the greater good. Finally, it is clear that we live in a global society with a global economy dominated by global industries. To succeed in the 21st century, engineers will require a full understanding of the implications of this observation. Engineers will need to understand issues such as the factors affecting global competitiveness; the importance of green, as well as lean, manufacturing; cultural influences on manufacturing methodologies, management structures and decision-making processes. A key question articulated in "The Engineer of 2020" is "Are the educators of today up to the challenge of adapting and providing the most suitable education for the engineer of tomorrow?" [2] This question is reinforced in the sequel, "Educating the Engineer of 2020:" "If the U.S. is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for this wave of change [in the global economy]. . . Innovation is the key and engineering is essential to this task; but engineering will only contribute to success if it is able to continue to adapt to new trends and provide education … to arm [graduates] with the tools needed for the world it will be, not as it is today."[4]

Strategies and Challenges

Engineering educators are well aware of the need to provide students with an education that extends well beyond the fundamentals and design-oriented, practical embodiments of the students' particular area of specialization. Indeed, the new ABET criteria clearly articulate that "engineering programs must demonstrate that their students attain …

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(f) an understanding of professional and ethical responsibility,
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context, [and]
(j) a knowledge of contemporary issues."[5]

Every ABET-accredited engineering program has its own special way of assuring that these program outcomes are met. However, the full integration of these program outcomes into the fabric of the engineering curriculum is a goal that few programs achieve. For most B.S. degree programs, it is a challenge to include elements within the engineering curriculum that address these ABET-mandated program outcomes in a substantive fashion. Regarding outcome *"c"* for example, students will demonstrate the ability to do a design that is subject to constraints, but typically will not be exposed to the tradeoffs that product developers and engineering managers face in real-life situations that are constrained by most, if not all, of the constraints listed in outcome *"c."* Additionally, consider outcome *"h."* This outcome is closely aligned with outcome *"f,"* but extends beyond the importance of ethical responsibility to embrace the expectation that students will truly see "the big picture," viewing the world from a systems perspective, fully cognizant of the roles and responsibilities that engineers have in society. Typically, engineering programs must look to the elements of their curriculum that are focused on the humanities and social sciences to assure that this particular outcome is achieved.

With respect to outcome *"d,"* virtually every undergraduate engineering program assures that its students get significant experience working in teams, but often these teams are comprised exclusively of fellow students from their own discipline. In such contexts, students do not get the opportunity to learn how to leverage the assets of a team that is comprised of individuals of diverse backgrounds in a concerted effort to solve a problem that is so broad that it cannot be solved by any one person on the team. In this context, it is important to acknowledge the ever-increasing number of engineering programs across the country that are fully embracing the goal of providing a comprehensive team-based, multidisciplinary design experience for their students.

This certainly has become a key priority of the Kate Gleason College of Engineering (KGCOE) at Rochester Institute of Technology (RIT) where almost 90% of the students graduating with the B.S. degree in engineering now participate in the college-level, multidisciplinary, capstone design program. The overarching educational objective of this program is to educate a new generation of engineers who not only are experts in their field but also understand the product development cycle – in other words, how to turn ideas into reality. Additionally, the program is structured to provide engineering graduates with a sophisticated understanding of team-based project management, and the experience of utilizing the diverse collection of specialized skills that are inherent in multidisciplinary teams, to provide optimal solutions to complex, real-world problems. Many of the projects are sponsored by regionally-based companies; while others are either industry-inspired or are tangentially related to research initiatives within the university that have a strong engineering focus. Furthermore, each student team is directed by a senior-level engineering student who is in the college's integrated B.S./Masters of Engineering program and who has received specialized training in design project management. Thus, every student on the team is exposed to the best practices of managing a project. Finally, each team of students is mentored by a multidisciplinary team of faculty members who not only provide the full range of technical expertise needed for the design project but also model the way in which a multidisciplinary team should function. In its fourth year, this multidisciplinary capstone design initiative has expanded to embrace programs in other colleges as well, including programs such as industrial design and business.

As stated above, all accredited engineering programs must meet or exceed expectations regarding the inclusion of these outcomes in their program. The issue isn't "can these outcomes be achieved," but rather "can engineering programs evolve to a state where they fully integrate these elements into the fabric of their curricula?" Returning to a quote from above: "If the U.S. is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for this wave of change [in the global economy]. . . Innovation is the key and engineering is essential to this task; but engineering will only contribute to success if it is able to continue to adapt to new trends and provide education … to arm [graduates] with the tools needed for the world it will be, not as it is today."[4, pg. 4]

A major challenge in achieving this idealistic goal, I believe, is the tension that inevitably exists between these "big picture" educational themes and the natural disposition of the typical engineering professor, who has chosen an academic career precisely because of a passion for a particular element within her/his discipline and the associated desire to commit one's professional career to an in-depth exploration of the intellectual richness of that sub-discipline. A critical element of an engineering education (program outcome *"i"* in the ABET criteria) is attaining in students an appreciation for, and the ability to engage in, life-long learning. What better way to do this but to model the process of life-long learning through the everyday activities of faculty members engaged in the research of a technologically important element of the discipline? Furthermore, as mentioned earlier, the body of knowledge is doubling every ten years (or thereabouts) and thus faculty members are cognizant of the growing challenge of keeping the engineering content in the undergraduate curriculum current. In light of this fact, it is difficult for faculty members to embrace an alternate educational paradigm in which "big picture" issues are mainstreamed into the curriculum. Yet another complication is related to the background of the typical engineering faculty member. Few have actually had the opportunity to work on a multidisciplinary team to develop a product that meets customer needs, and fewer still have had any formal education or experience in the realm of public policy or business where they would have had first-hand knowledge of how engineering is constrained by social, political, and global business issues. Finally, there also may be a significant conflict between these "big picture" educational goals and the current faculty reward structure within universities across the nation. With faculty productivity measured in terms of journal publications and grantsmanship, it is difficult to imagine why faculty members and programs would be willing to invest significant time and resources into an educational model that is focused on product development, a systems focus, and the variety of elements that provide a contextual basis for engineering practice in society.

Creation of an Honors Program at RIT

In 2002, RIT's central administration decided to establish an institute-wide honors program with two primary objectives: to compete more aggressively for the best and brightest high school students and to increase the level of satisfaction of the top students at RIT for its educational programs. For financial reasons, as well as to create a close-knit, nurturing environment between students and faculty, the honors program at RIT is restricted to the top 5% of the students in RIT's applicant pool (based upon academic achievement in high school and SAT scores). Because of the relatively higher quality of the applicants to the Kate Gleason College, the entering class of honors students to RIT has a disproportionately large number of engineering students. Indeed, approximately 30-35 of the 500 freshmen who enroll in the Kate Gleason College each fall are members of the honors program. Of these engineering honors students, approximately 25% are women, which is twice the percentage of the freshmen class overall. Retention in the program is high and financial resources are limited. Nevertheless, each year the College has been able to invite a handful (3-5) of additional students to join the program in the spring term of the first year, the selection being based upon their outstanding performance in coursework and high potential for leadership and co-curricular contributions to campus life.

In the earliest stages of program development, it was generally recognized that merit scholarships alone would not be sufficient to achieve the desired objectives for the program. Indeed, the best and brightest students in RIT's applicant pool are highly sought after by the nation's best universities. Furthermore, these students typically have high expectations for their engineering education and will not select a university based exclusively on net cost. Rather, the program must also appeal to the intellectual aspirations and interests of these students. Because of the broad diversity of programs at RIT, it quickly became clear that a key element of the honors program needed to be college-centric. At the institute level, the focus would be on leadership development, community service projects, and creatively designed general education courses. However, since at least half of a student's program of study is focused on a major within a specific college, the honors program had to have a significant college-level component as well. Rather than attempt to get all the colleges to agree to a "one size fits all" approach to the honors program, each college was given the freedom to structure its portion of the honors program as it saw fit.

Given this autonomy, the leadership team of the Kate Gleason College seized the opportunity to shape the college-centric portion of the honors program to address in a comprehensive way the "big picture" educational themes that are reflected in ABET criteria *c, d, f, h,* and *j*. Specifically, the curricular elements of the KGCOE honors program are intended to address the challenges raised in the introduction to this paper.

The mission statement of the KGCOE honors program is "product innovation in a global economy." The goal is to create a carefully crafted set of learning experiences for engineering honors students that promotes a paradigm shift in the students' perspectives about engineering and their engineering education, emphasizing issues such as customer-driven engineering design, commercialization, manufacturing leadership and ethical behavior. The curricular component is comprised of four one-credit courses delivered during the first two years of academic study. Each class meets once per week for two hours for ten weeks. (RIT is on a quarter system.) Students are clustered by year but not by major. Indeed, every effort is made to encourage interdisciplinary perspectives, and all hands-on learning activities are done in multidisciplinary teams. A detailed description of the curriculum for these four courses is provided in the appendix to this paper.

A key educational outcome for the student's first year of study is for students to attain a full appreciation of the product development cycle, from concept to realization; namely how products are conceived, how decisions are made at the corporate level to pursue certain products and not others, and how product concepts are refined, engineered, and then manufactured for the marketplace. A key strategy to achieve this goal is to have students work in multidisciplinary teams to reverse engineer a toy. The process begins by visiting Fisher Price's toy development center in East Aurora, NY to learn first-hand how engineers work with industrial designers and child psychologists to develop product concepts, assess the receptiveness of children to these concepts, develop robust designs for the most promising concepts, and then transfer the design to a remote manufacturing facility. Student teams then choose a toy that is available commercially and, over a period of weeks, reverse engineer the toy while learning in parallel about design methodologies that focus on manufacturability, assembly, safety and reliability. In addition, the first year culminates in a team-based design challenge, with a competition held during the last week of the spring term. Student teams are given an open-ended design statement that describes a device that the team must design and build, with only outcomes and constraints explicitly articulated. The exercise emphasizes the importance of creativity, teamwork, concept generation & development, and prototyping.

The focus in the second year is on a full spectrum of issues that typically are outside the realm of engineering education but which are critical to the successful commercialization of a product and, by association, the success of a company. In particular, the fall term course addresses issues relating to manufacturing leadership and globalization. Specific topics include supply chain management, lean manufacturing, and the business case for outsourcing. The students read the book "The World is Flat" and discuss historical trends in the business world that have led up to the global business environment that exists today. In the fourth and final course in the core curriculum, the focus is on leadership at the corporate level. The students read "Good to Great," and discuss the leadership qualities that maximize the success of an organization. Additionally, issues relating to technology management, ethics, and ethical leadership are discussed. Finally, a few weeks are devoted to the concept of sustainability, the engineers' role in creating a sustainable future, and when it makes good business sense to embrace the concept of sustainability.

At the end of this four-course sequence, students report that they have a much clearer understanding of the context within which engineering innovations take place. They praise the course sequence for its attention to customers, the importance of authentically assessing customer needs, and the role of engineers in creating products and services that are customer-focused. The consensus opinion of the students in the program is that the curriculum has a significant positive impact on their ability to market themselves to companies and to function more effectively in their earliest co-operative education assignments. Students also give the course sequence high praise for exposing them to business-related issues of which they were totally unaware, and providing meaningful perspectives on these issues. Students also give high praise for a signature element of the honors curriculum: the week-long domestic and international "field trips" that the class takes with their faculty mentors. The integration of these trips into the curriculum is illustrated in the following table.

Table 1. Curricular structure of the college-centric elements of the honors program for the honors students in the Kate Gleason College.

	Fall Quarter	**Winter Quarter**	**Spring Break**	**Spring Quarter**
1st Yr	**0 credit:** Community Building, Social Events	**1 credit:** Product development process, Design for "X", reverse engineering	**Break**	**1 credit:** Creativity, team building, meeting customer needs
2nd Yr	**1 credit:** Manufacturing & Globalization	**0 credit:** Preparation for trip, research companies	**Domestic Trip**	**1 credit:** Ethics, Leadership, & Sustainability
3rd Yr			**International Trip**	*International Coop Assistance*

The expressed purpose of the field trips is to observe first-hand the strategies that corporations, large and small, employ to develop new products for the domestic and the global marketplace. The students take the domestic trip during spring break of their second year, and the international trip during spring break of their third year of study at RIT. Locations are selected based upon the robustness of corporate relationships in the region and our perception that the region will yield an itinerary of companies of various sizes where students can be exposed to the practice of all the core engineering disciplines. It is important, in this regard, to emphasize that all engineering majors are represented in each group of honors students.

Each corporate visit is scheduled for a half-day. In addition to hearing about the corporate philosophy and getting a "cook's tour" of the facilities (including a manufacturing line, if possible), the students meet with engineers and technology decision-makers to learn about how the corporation assesses customer needs, develops ideas for new products, makes the business decision to pursue certain product concepts and not others, and develops a cost-effective plan to bring these products to the marketplace. Typically six different companies are visited during each trip. For both the domestic trip and the international trip, every effort is made to orchestrate a diverse set of experiences for the students by visiting companies that span the full spectrum of size and industry sector. Additionally, every effort is made to include a boutique industrial design company in the itinerary.

To date, domestic trips have been taken to San Francisco (Silicon Valley), Seattle, Austin, Orlando, and Guadalajara (broadly classified as "domestic" due to NAFTA). The international trips have been to Paris/Rennes (France), Milan, Munich and Barcelona. In 2008, the plan is to return to Seattle for the domestic trip and go to Ireland for the international experience.

The honors program at RIT and the particular focus of the college-centric elements of this honors program within the Kate Gleason College are not unique in higher education. Rather, there are a significant number of excellent programs with similar goals and perspectives across the nation, emphasizing the broader view of engineers in society particularly from a business, leadership and global perspective. Some fine examples of honors programs that integrate with and complement a traditional B.S. degree in engineering in this manner include ones at the Ohio State University, the University of Michigan and Duke University. At Ohio State, the objectives of the engineering honors program are extraordinarily well aligned with those of the program at RIT. In particular, the honors engineering program at Ohio State focuses on issues that relate to the changing needs of a technological and diverse society and the ways that engineers can contribute to meet those needs through wise development and application of technology. Emphasis is on expanding the impact of innovations, embracing and fulfilling the aspirations of a diverse student body, and meeting the needs of the engineering enterprise and society.

The Engineering Global Leadership Honors Program (EGL) at Michigan combines a traditional engineering undergraduate curriculum with a core of courses in the Ross School of Business and a cultural core in the College of Literature, Science and Arts. The EGL Honors Program leads to a Bachelor's and Master's degree in engineering. EGL students are also required to complete a synthesis team project that provides them an opportunity to place their learning in an industry context, apply their technical knowledge in the field, and develop their teamwork skills.

The Pratt School of Engineering at Duke University has instituted an International Honors Program (IHP) to address the increasing need for engineers and technologists with proficiency in foreign languages and a sound understanding of foreign cultures. The objective is to encourage undergraduate engineering students to study or work abroad in order to acquire a greater understanding of the international arena in which engineering and technological solutions to global problems are being applied. The International Honors Program is a certificate program which consists of six to eight semester courses, depending on the initial foreign language proficiency level of the student. All of the IHP course requirements may fulfill humanities, social sciences and/or approved elective requirements in the school's accredited engineering programs.

All the above programs attempt to address the "big picture" issues through a complementary set of courses that can be integrated into a traditional B.S. engineering degree. The honors program in engineering at Lehigh University takes a different approach: It offers a joint degree program for honors students, leading to the B.S. degree in Business and Engineering sponsored jointly by their College of Business and Economics and their P.C. Rossin College of Engineering and Applied Science. This program is distinct from the honors program at RIT in that it is a stand-alone degree program which is independent of any traditional engineering discipline. Specifically, it requires 137 semester credit hours of coursework of which 30 credits are engineering core, 33 credits are business core, and 15 credits are electives in either business or engineering (based upon the focus of the major).

Catalyzing Systemic Change

In the descriptions above of the engineering honors program at RIT and elsewhere, the focus is on the goals, objectives and learning outcomes from a student perspective. The greatest long term benefit of the program in the Kate Gleason College, however, may be the ways in which the honors program systemically changes the perspectives of the engineering faculty regarding the role of engineers in society and the importance of reshaping the undergraduate curriculum to better address the evolving relationship between engineers and society. The implementation strategy is the key to optimizing the potential for achieving such collateral benefits. The relevant elements of the implementation strategy and the ways in which each element contributes to catalyzing a paradigm shift in the college are as follows:

- The honors curriculum is actively managed by a relatively large team of faculty advocates. In particular, there is at least one faculty member from each engineering department on the team at all times. Currently, there are eight faculty advocates for the program, with 30-35 students entering the program each year.

- The faculty advocates are jointly responsible for the delivery of the curriculum to the students. This means that every faculty member is intellectually engaged in all aspects of the curriculum. Because most of the topics in the curriculum are outside of any traditional engineering discipline, every faculty member is actively engaged in the learning process, becoming better educated about the "big picture" issues relating to engineers and their role in society.

- A significant part of the curriculum is presented to the students by subject-matter experts from within other colleges at RIT. Engaging these individuals in the instructional process educates the faculty members as well as the students on the interrelationships between seemingly disconnected disciplines and colleges within the institute. Additionally, it helps to establish relevant relationships between engineering faculty members and faculty from programs outside of engineering.

- All administrative issues, such as logistics and required representation at institute-level meeting, are managed by the assistant dean for undergraduate programs. This liberates the faculty advocates to focus exclusively on course content and intellectual impact of the program.

- The team of faculty advocates is not static; rather, the team is renewed at a regular (although not programmed) rate. Consequently, over time, an ever-increasing percentage of the engineering faculty become intimately familiar with the "big picture" issues and take ownership for the relevance of these issues to undergraduate engineering education.

- The dean and the associate dean for undergraduate programs are permanent members of the honors faculty team, thereby conveying a strong sense of the importance of this program to the college.

- All faculty advocates are "rewarded" with a week-long trip each year at spring break. Half of the faculty advocates accompany the second year students on the domestic trip and the other half of the faculty advocates accompany the third year students on the international trip. The value of the camaraderie that develops from these trips cannot be overstated. The faculty members, all from different departments within the college, get to know one another extraordinarily well. Interconnections between the various disciplines become much clearer in everyone's minds and the nucleus for future collaborations between disciplines materializes.

- On each trip, the faculty advocates are exposed to engineering managers, innovators and leaders, and learn first-hand about the challenges that industries face in being globally competitive and the role that engineers need to play in making a company successful. Thus, the faculty advocates learn from their "customers" just how important it is to include these "big picture" issues in a progressive undergraduate engineering program.

Conclusion

The engineering component of the honors program at RIT has been structured to address subject areas that, while outside the explicit domain of engineering science and design, are nevertheless critical to the future of the engineering profession and the increasingly important role that engineers will need to play in our society. As stated in the introduction, our society needs a new generation of engineers who are more than subject matter experts. They must be effective integrators of technology, with a talent for leveraging the diverse assets of individuals on multidisciplinary teams. They must also understand the social context of the problems that they are solving. Engineers also need to understand issues such as the factors affecting global competitiveness; the importance of green, as well as lean, manufacturing; cultural influences on manufacturing methodologies, management structures and decision-making processes.

To fully achieve these educational goals, engineering colleges need to find ways to integrate these ideas into the mainstream curriculum. Accomplishing this goal is a major challenge because programs cannot afford to sacrifice aspects of the students' technical education in order to find room for courses that address these "big picture" issues. The honors program achieves its goals by introducing additional coursework, which is acceptable and practical for honors students because most, if not all, come to the university with significant advanced placement credit and an inherent ability to handle an intense workload. But these conditions are not met by the typical student in the engineering programs. Furthermore, signature elements of the honors program are the domestic trip and the international trip. Frankly, it is impractical to consider offering such opportunities for every student in the engineering programs.

Needless to say, one way to provide all engineering students with the educational benefits of the honors program is to create a paradigm shift in the way the engineering faculty view these "big picture" issues and embrace them as a priority. If a significant subset of the faculty develop a comprehensive understanding of these "big picture" issues, it becomes possible to develop strategies to integrate these issues into the intellectual (and thus educational) fabric of the college. This is indeed occurring within the Kate Gleason College. All the faculty who have been associated with the honors program since its inception five years ago have become better educated with respect to these "big picture" issues, they have identified resources and established relationships with faculty in other disciplines and colleges which make it possible for them to efficiently integrate these topics into their mainstream courses, and they are encouraging others to do the same. Within individual departments, seminar topics and guest speakers are being sought that address these issues. Topics discussed in the honors sequence of courses are starting to be integrated into the core undergraduate curriculum through seminars, local field trips, and special projects.

The number of free electives in each engineering program has been increased significantly, and students are using this increased curricular flexibility to pursue a broader program of study, many times seeking educational opportunities aligned with the honors program. The latest curricular outcomes include the creation of a minor in sustainable engineering (partnership between industrial & systems engineering and mechanical engineering) and the formulation of an integrated bachelors/master of science program between engineering and public policy. Finally, the College's efforts to transform the traditional discipline-specific, capstone design course into a college-level, team based, customer focused, multidisciplinary design program for all students really has taken hold. Indeed, the key drivers behind the recent comprehensive assessment and curricular redesign of this program can be traced to the experiences of the honors program and the perspectives gained by the faculty members who have participated in this program.

In conclusion, in a relatively short span of time, significant changes have taken place within the Kate Gleason College leading to a broader perspective regarding the goals, objectives and desired educational outcomes for its students. Furthermore, a process is evolving which is leading to the integration of "big picture" issues into the core curriculum. The new honors program in the Kate Gleason College has played a significant role in catalyzing this process of change, has provided the leadership for these changes, and will continue to motivate these changes into the future.

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Appendix: The Core Curriculum for Engineering Honors in the KGCOE

Honors Course #1: First-Year, Winter Quarter

Course Objectives

- *Product development principles*
- *Designing subject to constraints: designing for "X" (manufacturability, safety, test)*
- *Reverse engineering*
- *Effective communication*

Course Details

- Meet weekly
- students divided into teams of 3 or 4
- hands-on, experiential learning activities
- course structure includes guest presentations and culminating design analysis project

Course Expectations & Assessment

- Portfolio Entries (6) – General issues: 30%
- Portfolio Entries (3) – Design for "X": 30%
- "Design for X" exercise – group presentations: 25%
- Reflective essay (individual): 15%

Course Lesson Plan

Week 1 Guest lecture: Product development – Toys
Read materials on Fisher Price
Basic principles of a SWOT analysis

Week 2 Field trip to Fisher Price
How are toys conceptualized, designed and manufactured?

Week 3 Introduce team project: reverse engineer a toy of choice
Consider in particular "design for manufacturability" and "design for safety"

Week 4 Reverse engineering: principles and strategies

Week 5 Design for manufacture and assembly

Week 6 Design for safety

Week 7 Assess team-selected toy with respect to reverse engineering concepts, design for manufacturing, and design for safety

Week 8 Continuation of week 7

Week 9 Guest lecture: Elements of an effective presentation

Week 10 Group presentations

<u>Toy Selection Criteria for Team Analysis Project</u>

- Each team will have a budget of $15 for the purchase of a toy to be used for reverse engineering
- DFX analysis. This analysis will mirror the hands-on exercises done in class. Criteria for toy selection criteria are provided below.
    1. Complexity: 10 to 40 parts as a guideline (use your judgment when selecting the toy)
    2. Electronics: Purely electronic toys are excluded (e.g. handheld video games). However, electro-mechanical toys are desirable.
    3. Packaging: The toy must be purchased in a package. Packaging is part of analysis.

<u>Honors Course #2</u>: First-Year, Spring Quarter

<u>Course Objectives</u>

- *Team Building*
- *Creativity*
- *Product development methodology: voice of customer; ideation to prototype development*

<u>Course Details</u>

- Meet weekly
- students divided into teams of 3 or 4
- course structure includes guest presentations and culminating design experience

<u>Course Expectations & Assessment</u>

- Portfolio Entries (6): 37.5%
- Term Project:
    - Design Problem Report: 37.5%
    - Design Problem Competition (team grade): 25%

<u>Course Lesson Plan</u>

Week 1 Value and limitations of teamwork: Airplane Crash Survival Scenario

Portfolio assignment:
- describe yourself
- explain relevance of honors program curriculum to personal goals, aspirations and experiences
- Using Myers-Briggs test explain personality type and how it might impact ability to succeed in a team

Week 2 Team-building: create diverse teams based on Myers-Briggs, gender, and major
Guest Speaker: Team dynamics and conflict management

Week 3 Overview of product development process
Discussion of relative effectiveness of various products to meet customer needs

Week 4 Voice of the customer

Week 5 Creation and ideation

Week 6 Provide overview of design process and show how customer requirements lead to concepts and eventually lead to final product. Review those elements of the design process which will be highlighted in student design competition.

Week 7 Practical implementation of the product development process
Team-based design (week #1)

Week 8 Team-based design (week #2)

Week 9 Team-based design (week #3)

Honors Course #3: Second-year, Fall Quarter
Manufacturing and Globalization

Course Objectives

The goal of the course is to highlight key issues that decision-makers in industry need to be aware of as they shape their companies to be more competitive in a global context. Students will read and discuss "The World is Flat," which helps to provide some idea as to the issues corporate leaders face in moving their organizations forward in a global economy. Specific topics in the course will include an in-depth discussion of the manufacturing supply chain and how the active management of the supply chain can enhance profitability and customer satisfaction. Additionally, the course will address issues such as the shareholder's perspective on corporate management, as well as the impact of government policies and monetary issues on globalization and outsourcing. Specifically, discussions will examine the impact of NAFTA and other such treaties, tariffs, etc on corporate strategies.

Assessment process

60% -- two short essays (no more than 1000 words each)
- Ethics from the perspective of a practicing engineer in a corporate context
- Leadership: the challenges and strategies for effective leadership

40% -- final exam in week #10: short answer and essay questions requiring synthesis and/or elaboration on what was learned in the course.

Bonus credit will be given for quality of in-class participation.

Selected Readings

A. “The World is Flat,” by Thomas L. Friedman
B. Web-based articles from *Business Week* magazine on globalization and outsourcing

Course Lesson Plan

Week 1	Supply chain management and logistics Factors affecting manufacturing costs and profitability: Part I
Week 2	Supply chain management and logistics Factors affecting manufacturing costs and profitability: Part II
Week 3	Limitations on efficiency gains through active management of the supply chain
Week 4	Lean Manufacturing Workshop: hands-on, team-based activity
Week 5	Historical perspective on role of globalization in defining domestic economies
Week 6	“The World is Flat:” critical assessment of key points raised in book
Week 7	Impact of government policies & monetary issues on globalization and outsourcing
Week 8	How Businesses Make Decisions: A shareholder’s perspective
Week 9	Will China & India become the next superpowers? Does the U.S. have anything to fear from the rise of these two nations?

Honors Course #4: Second-Year, Spring Quarter
Ethics, Leadership, and Sustainability

Course Objectives

The goal of the course is to address the challenges of technical leadership. Students will read and discuss "Good to Great," focusing on the leadership qualities that maximize the success of an organization. Additionally, issues relating to technology management, ethics, and ethical leadership will be discussed. Finally, a few weeks will be devoted to the concept of sustainability, the engineers’ role in creating a sustainable future, and when it makes good business sense to embrace the concept of sustainability.

Assessment process

60% -- two short essays (no more than 1000 words each)
- Ethics from the perspective of a practicing engineer in a corporate context
- Leadership: the challenges and strategies for effective leadership

40% -- final exam in week #10: short answer and essay questions requiring synthesis and/or elaboration on what was learned in the course.

Bonus credit will be given for quality of in-class participation.

Selected Readings

A. “Good to Great,” Jim Collins

Course Lesson Plan

Week 1	De-brief of the outcomes of the domestic trip
Week 2	Sustainability issues in engineering design Environmental footprints and life-cycle analysis

Week 3	The business case for sustainability
Week 4	Engineering Ethics: Ethical dilemmas in the corporate sector
Week 5	Case studies of ethical challenges
Week 6	"Good to Great:" critical assessment of key points raised in book
Week 7	How to grow a company: The CEO's perspective Presentation by a CEO discussing leadership style, motivational strategies, and corporate decision-making
Week 8	Can leadership be learned?
Week 9	Open discussion: Reflections on the four-course sequence What do we still need to know and how can we learn it?