

Investigation of Undergraduate Multidisciplinary Engineering Programs

An Interactive Qualifying Project Report
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by

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1. **Education**
2. **Engineering**
3. **Multidisciplinary**

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ABSTRACT

The constantly growing need for an engineer skilled in multiple engineering disciplines calls for an investigation of new undergraduate engineering degree programs at WPI. Interviews with WPI administrators, faculty, and industry engineers, accompanied by a review of programs at peer institutions, served as the sources of information for the investigation. The result is a set of recommendations prepared for the WPI faculty and administration.

EXECUTIVE SUMMARY

Investigation of Undergraduate Multidisciplinary Engineering Programs

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As we move into a new millennium, the ability to understand, use, and innovate new technologies is becoming a much sought-after skill in the engineering industry. According to *Educating the Engineer of 2020*¹, a work compiled by the National Academy of Engineering (NAE) in 2005, “scientific and engineering knowledge presently doubles every ten years.” As a technological institution in the United States, it is important that WPI recognize trends in undergraduate education and respond to those trends consistently in a timely manner to ensure that its graduates never lack basic skills as engineers and scientists in industry and in academia. WPI needs to address fundamental changes in the engineering process, changes that have materialized due to an increase in the complexity of technology.

There are many multidisciplinary projects in industry and in academic research. A primary goal of this project is to respond to the growth of multidisciplinary projects in both industry and academia by identifying opportunities at WPI to develop new multidisciplinary engineering programs and to promote multidisciplinary activity at the undergraduate level.

To achieve the goals of the project, data are gathered from different sources. The sources represent the different relevant constituencies, such as academia, industry, as well as WPI enrollment and WPI post-graduate placement. The demands and views of these different groups are often in conflict, and the majority of the analysis in this project is based on finding recommendations and formulating conclusions that take into account the inputs of as many groups as possible. The different constituencies from which data was collected are:

- *Educating the Engineer of 2020*, a report by the NAE on trends in engineering education.
- *Retooling*, a work about contemporary engineering by Rosalind Williams, a historian of technology.
- WPI Engineering Department Heads.
- Industry engineers from General Electric, Teradyne, Amphenol, and others.
- WPI Admissions and Enrollment.
- WPI Career Development Center.
- WPI’s Peer Institutions.

¹ National Academy of Engineering (NAE). *The Engineer of 2020: Visions of Engineering in the New Century*. 2004. 13 April 2006. Hereafter referred to *Engineer of 2020*.

Conclusions, in the form of recommendations to the WPI Faculty, are derived from analysis of data collected from the aforementioned sources, and they are broken up into two groups. The *major* recommendations are as follows:

- A new major program should be established at the undergraduate level in the field of Computer Systems Engineering (CSE), a multidisciplinary program at the interface of computer engineering and computer science.
- WPI faculty should be encouraged to develop multidisciplinary MQPs and should simultaneously encourage students to look for MQPs outside their department that are relevant to their interests.
- A one-unit MQP for double-majors should replace the current rule of two separate MQPs. This is provided that both majors are in related technical disciplines with the further stipulation that any such one-unit MQP will incorporate a sufficient amount of technical concepts from both subjects, as defined by WPI and ABET expectations.
- WPI should monitor the undergraduate major program at Purdue University titled ‘Multidisciplinary Engineering’. The Purdue program was created in response to *Educating the Engineer of 2020*. If it is successful at Purdue, the program should be analyzed and the feasibility of a similar program being incorporated into WPI’s academic structure should be investigated.

Along with the main recommendations, there are a few peripheral recommendations that arise directly from the data collected to accomplish the main goals of the project. These recommendations do not necessarily relate to the main project goals but are nevertheless important.

- All WPI students should engage in multiple writing-intensive activities as a graduation requirement. Throughout our interviews, a common motif was that the average engineering graduate is a deficient technical writer. The possession of solid technical writing skills is a clear way for an engineer to distinguish themselves in industry.
- A list of courses in each technical discipline ought to be identified – these courses will be publicized as ones that will help in making a student a more multidisciplinary engineer.
- WPI engineering students should be exposed to computer programming directly in at least one of the courses that they take during their time at WPI. Possessing computer programming skills and having general computer proficiency is a necessity for engineering graduates today. With the ubiquity of computers in today’s engineering workplace, employees are expected to write their own programs for special applications.

“Imagination, diversity, and the capacity to adapt quickly have become essential qualities for both institutions and individuals not only to facilitate research, but also to ensure the immediate and broad-based application of research results related to the environment.”

Educating the Engineer of 2020

INTRODUCTION

As we move into a new millennium, the ability to understand, use, and innovate new technologies is becoming a much sought-after skill in the engineering industry. Worcester Polytechnic Institute needs to address fundamental changes in the engineering process. These changes have materialized due to an increase in the complexity of technology. The car engine is an excellent example; a working engine in today's world cannot be built by a team of mechanical engineers alone. Chemical, electrical, and computer engineers need to be part of the team that constructs a successful prototype.

The car engine is one example of how technological advances have created a need for the "Renaissance Engineer," someone who understands the bigger picture of a given project. Richard Comerford's 1994 quote in the *IEEE Spectrum*, pertaining to engineering education, illustrates this need: "The world of engineering is like an archipelago whose inhabitants are familiar with their own islands but have only a distant view of the others and little communication with them. A comparable near-isolation impedes the productivity of engineers, whether their field is electrical and electronics, mechanical, chemical, civil, or industrial. Yet modern manufacturing systems, as well as the planes, cars, and computers, and myriad other complex products of their making, depend on the harmonious blending of many different technologies."² *There are many multidisciplinary projects in industry and in academic research—this project aims to investigate the dearth of such projects at WPI and to recommend changes to the status quo.*

According to *Educating the Engineer of 2020*, a work compiled by the National Academy of Engineering (NAE) in 2005, "scientific and engineering knowledge presently doubles every ten years." The relevance of this observation to WPI is immense. WPI needs to recognize trends in undergraduate education and respond to those trends consistently in a timely manner to ensure that its graduates never lack basic skills as engineers and scientists in industry and in academia. A main trend that is noted that *Engineer of 2020* is that engineering is becoming more multidisciplinary in nature as a response to the increase in complexity of technology and its applications.

It is important to establish a working definition of the word 'multidisciplinary' for the purposes of this project. There are four kinds of multidisciplinary study that we encountered during this project:

- Traditional: the combination of two or more existing engineering disciplines, such as electro-mechanical engineering. For example, mechatronics is a field devoted to the study of combined electrical-mechanical systems. *This is the definition that will be the focus of the report.*

² Comerford, Richard. "Mecha...what?" *IEEE Spectrum*. August 1994.

- The combination of more distantly related programs of study, i.e. chemical engineering and creative writing. This type of program, for the purposes of this project, is defined as *interdisciplinary* study.
- Programs for students who are undecided when they arrive at college. For example, Cooper Union offers programs that specifically target students who want a general technology-based education.
- Programs that focus on science over design. For example, engineering physics programs that focus on theoretical physics that have some applications in engineering.

The first two definitions are similar enough that it is necessary to distinguish between them. The first type is a melding of multiple engineering or science-based programs. This type of integrated engineering program that combines different engineering disciplines is defined as multidisciplinary engineering. The second definition mixes two different branches of study, such as engineering and liberal arts, and attempts to create a well-rounded engineer or scientist.

The ultimate goal is to help develop programs at WPI that will result in graduates being even more competitive than they are now in future endeavors, such as industry or graduate school. At the end of this report, a set of recommendations, including a specific program proposal for WPI, will be developed for use by the WPI administration. The next section will outline the goals of this project.

GOALS

As presented in the Introduction section, and developed in more detail in the Background section, the current variety of engineering majors seem less relevant to evolving technological capabilities and societal needs. With this in mind, the goals of this project are:

1. *To identify opportunities at WPI to develop new multidisciplinary engineering programs at the undergraduate level that leverage existing resources to provide a distinct product for future WPI students, in light of recent literature on the engineer of the future.*
2. *To develop a set of recommendations, one of which will be a specific major program proposal, for use by the WPI Faculty.*

A primary goal of this project is to respond to the growth of multidisciplinary projects in both industry and academia by identifying opportunities at WPI to develop new multidisciplinary engineering programs at the undergraduate level. Any new programs that are suggested will attempt to leverage existing resources to provide a distinct product for future WPI students. A new engineering program will have to meet two criteria. The first is that the new program will have to be a distinct product although it will be a combination of multiple established engineering disciplines. The second criterion is that any new program cannot strain WPI's resources too much. "Resources" is a broad term used to denote the usual start-up costs for a new degree program – faculty members, labs, classrooms, new classes, etc. In order to find programs which meet these criteria, data is gathered from different sources:

- *Educating the Engineer of 2020*, a report by the NAE on trends in engineering education.
- *Retooling*, a work about contemporary engineering by Rosalind Williams, a historian of technology.
- WPI Engineering Department Heads
- Industry engineers from General Electric, Teradyne, Amphenol, and others.
- WPI Admissions and Enrollment
- WPI Career Development Center
- WPI's Peer Institutions

The main goal is to look at the data gathered from the different sources and then develop a set of recommendations, one of which will be a specific major program proposal that meets the two aforementioned criteria, for use by the WPI Faculty.

BACKGROUND

With the final goal of bringing recommendations forth to the WPI Faculty, it is necessary to develop a solid base of information from which conclusions can be drawn. As a technically-focused academic institution, WPI operates on facts and hard evidence. In order to make a successful presentation on the topic of multidisciplinary engineering, it is essential that all the key issues are reviewed and addressed properly. A major work that is reviewed is *Educating The Engineer of 2020*, a work prepared by the National Academy of Engineering. Another piece of literature that is analyzed is *Retooling: A Historian Confronts Technological Change*, written by Rosalind Williams during her time as Dean for Undergraduate Education and Student Affairs at the Massachusetts Institute of Technology (MIT). Along with these major works, a number of magazine articles are also analyzed; these articles explore many topics in multidisciplinary engineering, whether it is new projects at the interface of different disciplines, or just an opinion on the trends in engineering education. ABET accreditation is also a paramount consideration for any sort of new engineering program at WPI, and that subject is reviewed and explained. During the literature review, a subject that kept coming up was mechatronics. The popularity of mechatronics as well as the feasibility of an undergraduate mechatronics program at WPI is explored. A review of WPI's peer institutions is performed, with special attention given to programs that are ABET accredited and are well-established at the corresponding institutions.

*Educating The Engineer of 2020*³

As mentioned in the Background section, *Engineer of 2020* is a work that was compiled by the National Academy of Engineering in 2005 specifically to address the future of engineering education. According to the authors, the “report is the result of an initiative of the National Academy of Engineering that attempts to prepare for the future of engineering by asking the question, ‘What will or should engineering education be like today, or in the near future, to prepare the next generation of students for effective engagement in the engineering profession in 2020?’ ” *Engineer of 2020* provides a solid foundation of current practices in engineering education and provides ideas as to how engineering education will evolve over the next twenty years. Specifically, the book's primary focus is “undergraduate education,” which is also the focus of this project (1).

The authors of *Engineer of 2020* believe that the undergraduate (B.S.) degree should be considered an engineer-in-training degree and thus undergraduate education should focus on developing proficiency in one area (2). If this is the case, it is even more imperative that engineers take a broad approach to their engineering education. One does not want to come out of undergraduate education with a narrow mindset or else any future success for that person is jeopardized. It cannot be emphasized enough that “change is constant, but, on an absolute basis

³ *Engineer of 2020*. Pagination captured in parenthetical citation.

our world has changed more in the past 100 years than in all those preceding” (7). According to *Engineer of 2020*, “scientific and engineering knowledge presently doubles every ten years” (7). If an individual has basic knowledge of various areas, and has problem-solving ability, then that person will be more able to adapt to the ever-changing demands of a career in engineering. The motivation behind the book is to ask “how to enrich and broaden engineering education so that those technically grounded graduates will be better prepared to work in a constantly changing global economy” (1).

Furthermore, with the continual outsourcing of engineers, it becomes even more imperative for individuals to possess a diverse portfolio of knowledge in engineering in order to appear as a desirable commodity in the eyes of employers. The literature reiterates this point: “For many years to come, engineers in developing economies will be willing and able to do equivalent work for less than U.S. wage. The key to maintaining a robust marketplace for US engineers will be how they can bring additional value to offset this difference” (10). Thus, engineers educated in the United States will continually need to prove how they will bring additional value to the marketplace and what better way to do this than to have a broad undergraduate background. Thus, engineering educators should introduce multidisciplinary learning in the undergraduate curriculum.

Now that the importance of undergraduate engineering has been established, it is important to have a plan for how this education will be utilized. A good example of an area in which a diverse engineering education can be utilized is in the field of assistive technology. Assistive technology is unique in that the engineer must be aware of the physical and mental state of the group of people for which the device is designed. Such technologies will have a large demand in the near future due to the fact that “the populations of developed countries will ‘age’ and engineering can be an agent for developing assistive technologies for aging citizens to help them maintain healthy, productive lifestyles” (8).

In addition, “surveys of precollege students have consistently shown great interest in meaningful career fields tied to ‘helping others’” (27). Assistive technologies are not purely mechanical or electrical in nature, “from biomedical devices to complex manufacturing designs to large systems of networked devices” (10). It is important to have a low-level understanding of all the pieces of the puzzle even if they may not directly to your field.

In the future there is going to be a “growing need to pursue collaborations with multidisciplinary teams of technical experts [...] important attributes include [...] receptiveness to change” (10). A college engineering education will be more valuable if students can learn and perform in projects that span different engineering fields. Exposure to multidisciplinary projects will help individuals grow due to the fact that one’s mind will be receptive to changes in thought processes and engineering concepts.

Another important point the book drives home is the fact that the engineers of 2020 will need a “motivation to think ahead as a community, to step beyond the immediacy of the moment and the challenges of the present to imagine the future” (14). If these challenges are

multidisciplinary in nature, the answer to the question of which engineer is going to be more successful is evident. The main point is that the engineer of 2020 cannot be someone who tries to isolate engineering problems by discipline. The engineer of the future will be someone that will be trained to think at a multidisciplinary level.

At the end of *Engineer of 2020*, the authors make recommendations as to what modifications should be made to engineering education so that the engineers educated today will be prepared for future problems. The recommendations that were most pertinent are listed below:

- “Real-world problems are rarely defined along narrow disciplinary lines. Undergraduate students would benefit from at least cursory learning about the interplay between disciplines embodied in such problems” (55)
- “Engineering schools should introduce interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate programs” (55).

***Retooling: A Historian Confronts Technological Change*⁴**

While *Engineer of 2020* is a work that seeks to specifically address how changes in engineering need to be followed by a change in engineering education, *Retooling* is written to address the ever-changing role of technology, of which ‘engineering’ is a subset, in contemporary life. The author, Rosalind Williams, uses the experience of coming from a family of engineers as well as her experience in the position of Dean for Undergraduate Education and Student Affairs at the Massachusetts Institute of Technology (MIT). In her own words, she is “a cultural historian of technology” and she writes “as a historian trying to figure out contemporary events and trends as part of larger patterns” (Preface, 10). Most of her discussions in *Retooling* take place against the background of constant change at a first-tier technological institution in MIT.

One of the tell-tale signs of the rapid changes taking place in engineering during the 1990s and the 2000s can be seen in the evolution of the engineering departments at MIT. Williams mentions that “to see the expansive disintegration of engineering, one need only look at the list of engineering departments at MIT. Their traditional boundaries are crumbling as departments stretch and reshape themselves to confront a host of problems, varying wildly in scope and character” (31). While it may have been easy until the 1980s to define the roles and academic jurisdictions of different engineering departments, that is certainly not the case anymore. Take the example of Mechanical Engineering, which, according to Williams, is “now a conglomerate of markedly different types of research and teaching...the department’s activities range from fundamental science (for example, cryogenics and nanoscale phenomena) to

⁴ Williams, Rosalind. *Retooling: A Historian Confronts Technological Change*. The MIT Press: Cambridge, MA, 2002. 10 September 2006. Hereafter referred to as *Retooling*. Pagination captured in parenthetical citation.

teamwork-based design” (32-33). The experience of the ME department at MIT is not unique. Institutions for higher education in engineering are going through identity crises as technology begins to take over for the concept of ‘engineering’.

The background that Williams has provided thus far hints at the future of engineering education and practice. As the words ‘technology’, ‘science’, and ‘engineering’ start to become interchangeable, Williams notes that “traditional engineering disciplines are being brought into enormously productive interdisciplinary mixes that merge them in novel ways with one another and with various sciences” (43). Of special relevance to our project and to WPI are her views on electrical engineering and computer science and the interplay between the two disciplines. Williams says, “the dematerialization of engineering is most evident, however, in the Department of Electrical Engineering and Computer Science...the whole enterprise of ‘software engineering’ reorients engineering from the manipulation of matter to the manipulation of symbols, or code. The hardware side of computer science is recognizably engineering, but it is not obvious where to draw the line between a software engineer and a programmer” (48). Considering the comments in *Retooling*, a possible option for a multidisciplinary major program at WPI is Computer Systems Engineering, a combination of the hardware and software aspects of electrical engineering and computer science.

An important consideration as the face of engineering education changes is: how do technological and industrial changes affect the students and the engineers of the future? Technology has made industry more efficient – cost-cutting is the name of the game, and every manager of any company that hopes to survive in today’s market is looking to make his/her operation leaner and more efficient. As Williams notes, “engineers and other technically skilled employees are part of this flexible, impermanent world...no longer is the corporation the rock on which an engineer builds a career” (63). This uncertainty and a decrease in loyalty from corporations demands that the engineers of the future take charge of their own careers and focus on improving their stature because the organization is concerned with greater problems. Indeed, “engineers now depend on themselves to build their professional identity in an organizational landscape dominated by networks rather than by clearly bounded corporate units” (64). At MIT, according to Williams, “students pragmatically shape their educations and their careers to fit current practice. They are more interested in preparing for a technically oriented career than in preparing for an engineering career...they need a broad education so they can navigate the seas of change” (64). Students at all engineering institutions need to broaden their undergraduate education, not only across engineering disciplines but across technological disciplines as well. With the rise of the personal computer as a necessary tool, it is important for students to be conversant in the language of computer programming and writing their own algorithms to solve problems encountered commonly.

Along with the aforementioned specific skills that are quickly becoming required tools for engineering graduates, it is also imperative for those entering industry today to know how their work impacts the world around them. *Retooling* mentions the many ways through which

technology has influenced engineering education and practice, and while the drastic changes have crept up fairly quickly on many of us, it is fair to say that WPI is well-positioned to adapt to any changes in engineers and will continue to produce engineering graduates who are well-equipped to solve the most difficult problems in the world today and tomorrow.

*Association for Integrative Studies*⁵

Just as the National Academy of Engineering strives to further the engineering profession, and *Retooling* aims to address the changes that technology has brought forth in society, the Association for Integrative Studies (AIS), founded in 1979, is a multidisciplinary professional organization that strives to “promote the interchange of ideas among scholars and administrators in all of the arts and sciences on intellectual and organizational issues related to furthering integrative studies.” The goal of the organization is paralleled to the goal of this project that is, “the integration of narrow disciplinary perspectives into a larger, more encompassing perspective.” The organization has a number of publications including *Issues in Integrative Studies* and the *AIS Newsletter*. One of the interesting aspects of the website is that they welcome companies to post multidisciplinary job openings.

The majority of their research is focused on liberal arts multidisciplinary study. At this point in our research, the evidence collected from mechanical and electrical engineering publications has been much stronger than any of the literature we have researched at the AIS website. Next, we look at some engineering magazine articles that discuss the topic of multidisciplinary engineering in both industrial and academic contexts.

Magazine Articles

We have looked at information from three separate sources in *Engineer of 2020*, *Retooling*, and AIS. There is value in looking at the general trends of how people in engineering feel about multidisciplinary engineering – its potential, trends about multidisciplinary projects, etc. It should be noted that although these articles may represent only the opinions of the authors themselves as well as those associated with the editing of the following engineering magazines, it is interesting to realize that engineers are realizing the need for multidisciplinary initiatives.

Title: *Crossing the Lines: Or Should We Just Mind our Own Business?*⁶

Author: Ephraim Suhir

Suhir echoes the argument of this project; that is, today’s engineering problem are much more complex than those a century earlier, or even a decade earlier. Using nanotechnology as

⁵ “AIS: Association for Integrative Studies” <http://www.units.muohio.edu/aisorg>. 15 April 2006.

⁶ Suhir, Ephraim. “Crossing the lines: Or Should We Just Mind our Own Business?” *Mechanical Engineering Magazine*. September 2004.

the primary example, he illustrates the need for engineers who understand the fundamental concepts of not only their field, but also a variety of fields within engineering and science.

Title: *The Agile Engineer*⁷

Author: John G. Falcioni

Falcioni makes the argument that the engineer who has the best understanding of the overall picture is best equipped to take on a leadership role in engineering projects. The author asks: why is the word ‘interdisciplinary’ so taboo in engineering? Why are people uncomfortable with it? He concedes that there will be experts in different fields, but he contends that it is necessary to know about all aspects of engineering and science in order to effectively lead a team.

Title: *Mixing It Up*⁸

Author: John DeGaspari

DeGaspari focuses on microelectromechanical systems, commonly known as MEMS. MEMS is a cutting-edge field that is equal parts mechanical engineering and electrical engineering. The author mentions that the best MEMS projects happen when there are people involved that know the basics of both engineering fields, as they are the ones who have the breadth of knowledge to envision the project from start to end.

Title: *Engineering for Everyone*⁹

Author: Bethany Halford

Halford speaks about the lack of engineering awareness in the general community. There is a course at Princeton University that is hands-on engineering with no disciplinary borders. Students work on engineering problems without paying heed to what branch of engineering the problem deals with. The focus is on problem-solving, and as expected, many of the problems are multidisciplinary and require some basic knowledge of different engineering and scientific fields.

The point the author stresses is that engineering is all about problem-solving and since problems are getting more complex, the solver needs to have an understanding of more basic concepts before being able to successfully tackle a problem.

Title: *Storm Riders*¹⁰

Author: Stephen Budiansky

Budiansky speaks about how engineering students in Florida get real-world practice due to inclement weather conditions in Florida that lead to many hurricanes and storms. The projects

⁷ Falcioni, John G. “The Agile Engineer.” *Mechanical Engineering Magazine*. September 2004.

⁸ DeGaspari, John. “Mixing It Up.” *Mechanical Engineering Magazine*. August 2003.

⁹ Halford, Bethany. “Engineering for Everyone.” *Prism Magazine*. December 2004.

¹⁰ Budiansky, Stephen. “Storm Riders.” *Prism Magazine*. November 2004.

that involve hurricane protection are often multidisciplinary and teach students that much more than the analysis of stresses and forces contributes to making an educated engineering decision on a real-world problem.

Title: *NSF Update: Investing in the Ideal University*¹¹

Author: Mark Marin, National Science Foundation

Marin discusses changes in the process of how university researchers receive funding. He mentions multidisciplinary research as the main area to focus more money toward. The fact is that many members of academia are still skeptical about the word ‘multidisciplinary’ and universities, where change does not happen very quickly, have been too slow to capture the opportunities that multidisciplinary engineering provides them. It is time for WPI to make a commitment to further more cutting-edge fields that stand at the interface of different traditional engineering disciplines.

Title: *Interdisciplinary Team in New York State Devises New Type of Photovoltaic Collector*¹²

Author: Prachi Patel-Predd

This article discusses a new innovation in solar power for residential use that was discovered by a multidisciplinary team consisting of material scientists, civil, mechanical, chemical, and electrical engineers. The technology developed is less expensive than current systems and could revolutionize solar power in the near future. This sort of innovation is the future of engineering work in the world and can only be developed by a multidisciplinary engineering effort.

Title: *The Tiniest Power Plants*¹³

Author: John Carey

Carey discusses the multidisciplinary project of uniting biology and electrical engineering. He is specifically talking about engineers having *Geobacter* microbes turn organic matter into electricity. Organic material falls to the bottom of a river or lake and microbes, like the *Geobacter*, break it into simpler substances. The *Geobacter* microbes then oxidize the simpler substances into carbon dioxide. They do this by transferring extra electrons to an electrode that is placed under the water. These extra electrons become millions when thousands of microbes are oxidizing at once. These electrons are then conveyed to the surface of a river or lake where they are used to power a monitoring device. So, what’s the point? This ingenious idea would not be possible without the bridge between biology and electrical engineering. Thus, there are fascinating projects at the interface of traditional engineering disciplines.

¹¹ Marin, Mark. “NSF Update: Investing in the Ideal University.” *Prism Magazine*. April 1997.

¹² Patel-Predd, Prachi. “Interdisciplinary Team in New York State Devises new Type of Photovoltaic Collector.” *IEEE Spectrum*. October 2005.

¹³ Carey, John. “The Tiniest Power Plants.” *BusinessWeek*. June 2006.

ABET Accreditation

At this point, this report has looked at key works in *Engineer of 2020* and *Retooling*. In addition, magazine articles relating to multidisciplinary engineering have been researched and analyzed. Now that the big picture of multidisciplinary education is becoming clearer, it is time to focus on the mechanisms through which an engineering program can become successful at the undergraduate level. Accreditation by ABET is a major step in sustaining such success. According to the ABET website, “ABET, Inc., the recognized accreditor for college and university programs in applied science, computing, engineering, and technology, is a federation of 28 professional and technical societies representing these fields. Among the most respected accreditation organizations in the U.S., ABET has provided leadership and quality assurance in higher education for over 70 years.”¹⁴

ABET currently accredits over 2,700 programs at over 550 institutions in the United States. On the ABET website, it is mentioned that “there are two types of accreditation: institutional and specialized.

- *Institutional* accreditation evaluates overall institutional quality. One form of institutional accreditation is regional accreditation of colleges and universities.
- *Specialized* accreditation examines specific programs of study, rather than an institution as a whole. This type of accreditation is granted to specific programs at specific levels. Architecture, nursing, law, medicine, and engineering programs are often evaluated through specialized accreditation.

As stated in the ABET website, accreditation is voluntary for any institution, but it is usually highly recommended as accreditation is a good indicator of whether the program will prepare the student for a future career in either research or industry. It is a useful tool to convince parents, students, employers, and graduate schools that the student will go through a rigorous program and is properly prepared.

Specialized accreditation is of importance in this project, as the goal is to implement specific programs, and it is also a fact that WPI already has ABET-accredited programs. ABET accreditation is an important consideration for any new program as it is necessary to convince incoming students and their parents that a specific program is a worthwhile investment of both the student’s time and the parents’ money.

During the peer assessment stage of this project, ABET accreditation was an important factor to consider because it is an unofficial marker of the quality and the viability of a particular program. It must be noted that the prospect of not being ABET accredited is not a deterrent to

¹⁴ “ABET, Inc. 2005 Criteria for Accrediting Engineering Programs.”
<http://www.Abet.org/Linked%20DocumentsUPDATE/Criteria%20and%20PP/05-06-EAC%20Criteria.pdf>.
 April 2006.

establishing a multidisciplinary program at WPI as there are already a few programs at WPI that are not ABET accredited, specially engineering physics and management engineering.

Mechatronics

ABET, while it has clear guidelines for many of the established engineering fields, such as mechanical, electrical, or civil engineering, is not as structured for newer engineering programs. An engineering program on the rise at many institutions across the country is mechatronics. “Mechatronics is the synergistic combination of mechanical engineering ("mecha" for mechanisms), electronic engineering ("tronics" for electronics), and software engineering. The purpose of this multidisciplinary engineering field is the study of automata from an engineering perspective and serves the purposes of controlling advanced hybrid systems.”

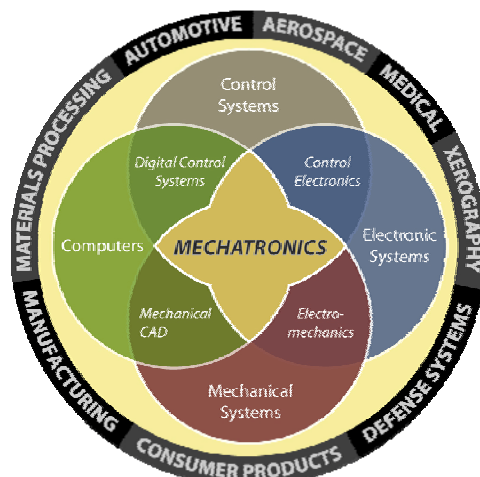


Figure 1 –Explanation of Mechatronics¹⁵

There are very few schools in North America which currently have a mechatronics program of study. Those schools include Sierra College¹⁶, which only offers two-year Associate’s degrees, and the University of Waterloo¹⁷ in Ontario, Canada. There are a couple additional schools worldwide that have a mechatronics program. One interesting feature of Sierra College’s program is that you can study mechatronics online through their website which is referenced below.

Mechatronics would be good for WPI because we would be the pioneers in bringing the subject to undergraduate education. However, due to the introduction of a new major program in Robotics engineering, and due to the various similarities between mechatronics and robotics, we decided not to pursue this area further.

¹⁵ “Explanation of Mechatronics” http://mechatronics.rpi.edu/pictures/logo/logo_gif_800x800.gif. 25 August 2006.

¹⁶ “Mechatronics & Robotics from Sierra College.” <http://www.realskillsrealjobs.com>. 23 April 2006.

¹⁷ UW Mechatronics Homepage.” <http://www.mechatronics.uwaterloo.ca/home.html>. 23 April 2006.

PEER INSTITUTION ASSESSMENT

The idea of establishing multidisciplinary engineering programs is certainly not new. In order to get a fair idea of what the challenges and opportunities are, it is important that a reasonable number of WPI's peer institutions are analyzed in terms of what they have done to promote multidisciplinary programs and how successful those programs have been. The institutions below represent a mixture of those selected from the College Admissions Collaborative Highlighting Engineering and Technology (CACHET), which is a professional organization of engineering colleges around the nation, as well as other engineering colleges that offer the option of multidisciplinary education to undergraduate students.

Schools Assessed:

- | | |
|---|--|
| 1.) California Institute of Technology | 9.) Boston University |
| 2.) Carnegie Mellon University | 10.) Case Western Reserve University |
| 3.) Cooper Union | 11.) Drexel University |
| 4.) Rensselaer Polytechnic Institute | 12.) Harvey Mudd College |
| 5.) Illinois Institute of Technology | 13.) Massachusetts Institute of Technology |
| 6.) Northeastern University | 14.) Rochester Institute of Technology |
| 7.) Rose-Hulman Institute of Technology | 15.) Olin College |
| 8.) Purdue University | 16.) Cornell College of Engineering |
| | 17.) Dartmouth College |

Key Questions:

- 1.) Does an undergraduate multidisciplinary engineering program exist?
- 2.) If yes, is the program ABET accredited? Is the program waiting accreditation?
- 3.) How many students (approximately) are enrolled in the program(s)?
- 4.) How old is the program?
- 5.) What are its features?
- 6.) What are its strengths, weaknesses, opportunities, and threats?

California Institute of Technology¹⁸

Caltech has a host of different multidisciplinary engineering programs, but all of them are at the graduate level. Caltech seems to follow the school of thought that believes that multidisciplinary programs should only be at the graduate level and that students ought to focus on a distinct, traditional branch of engineering at the undergraduate level.

Carnegie-Mellon¹⁹

Carnegie-Mellon does not have a stand-alone undergraduate program in any multidisciplinary fields. The closest offering is a supplementary program in Engineering and Public Policy. According to the website, "the department offers a research-oriented Ph.D.

¹⁸ "California Institute of Technology." <http://www.caltech.edu>. April 2006.

¹⁹ "Carnegie-Mellon." <http://www.epp.cmu.edu>. April 2006.

program and double-major undergraduate B.S. programs with each of the five traditional engineering departments and Computer Science.”

The program *is* ABET accredited at the undergraduate level, but only as a supplement to a core engineering program or Computer Science. This program, although it is an interesting concept, does not fit our needs as it is not a program at the intersection of many different engineering fields; rather, it is a study of the socioeconomic effects of engineering and the future of the profession in an ever-evolving world.

*The Cooper Union*²⁰

Cooper Union is a college that reflects many of the concepts that permeate the WPI Plan, such as a melding of theory and practice, consideration of the “societal and holistic aspects of engineering”, and instilling in undergraduates the fundamental knowledge and theories from which a solid engineering career can be built.

Cooper Union has one general multidisciplinary engineering program; this program is designed “for those students who wish a broad yet sound education in engineering enabling them to work in interdisciplinary areas; or who prefer to delay their specialization in a given area of engineering until after graduation; or who desire a strong broad-based engineering background as preparation for further studies in engineering or in such other professions as medicine, law or business administration.”

Currently, about 40 Cooper Union students are enrolled in this program; that amounts to 10% of all engineering students at Cooper Union. The main strength of the program is that it knows its target audience—students who are not ready or mature enough to commit to a strict engineering program or a concentrated career in just one technical field. The small size of the program also leads to more student-faculty interaction.

A strength of the program is its flexibility—the student is allowed to choose a personalized path of study with the approval of a faculty advisor. Some of the weaknesses of the program include the lack of ABET accreditation and a lack of a clear career path for graduates of this program.

If industry need for multidisciplinary engineering increases, then the opportunity arises for this program to attract a large amount of quality students to Cooper Union. A threat to this program is taking it to the next level in terms of investing resources into more courses and hiring faculty who are passionate about multidisciplinary projects and coursework.

*Rensselaer Polytechnic Institute*²¹

RPI, the nation’s oldest technological university (founded in 1824), has traditionally been WPI’s arch-rival in terms of admissions and similarity of programs. Although it has many multidisciplinary programs, almost all of them are in science. Offerings include programs in

²⁰ “Cooper Union.” <http://www.cooper.edu>. April 2006.

²¹ “Rensselaer Polytechnic Institute.” <http://www.rpi.edu>. April 2006.

biochemistry and biophysics, multidisciplinary science, bioinformatics, and applied science. The website makes no mention of multidisciplinary *engineering* programs.

*Illinois Institute of Technology*²²

IIT makes no mention of multidisciplinary programs on its website. Its programs are very similar to WPI's offerings; apart from the traditional engineering majors, IIT also offers majors in biomedical engineering, aerospace engineering, as well as computer engineering. However, there are no multidisciplinary offerings in place, nor does there seem to be a mechanism for an individually-designed multidisciplinary program if a student wished to pursue such a path. IIT seems to believe firmly that the undergraduate experience should be relegated to only the primary engineering programs.

*Northeastern University*²³

Northeastern's co-operative education program ensures that its engineering graduates leave the school with industry experience. Aside from the co-operative program Northeastern does not have any multidisciplinary engineering programs.

*Rose-Hulman Institute of Technology*²⁴

Rose-Hulman has been ranked #1 in the U.S. News and World Report "as the nation's best college or university that offers the bachelor's or master's degree as its highest degree in engineering." While it differs from WPI in the sense that we offer Ph.D degrees as well, there are many similarities between the two schools, such as a focus on undergraduate teaching and research, and a significant amount of contact between faculty and students. Due to their small size, Rose-Hulman is only able to focus on the core engineering programs and multidisciplinary education is not a focus of the school.

*Purdue University*²⁵

Of all the schools researched, Purdue University seems to have the most cohesive multidisciplinary program. According to the program website, "the Interdisciplinary Engineering Program (IDE) is for the student whose interests and abilities lie at the interface between engineering disciplines, or between engineering and other disciplines, and who is unable to accommodate his/her total range of interests and abilities satisfactorily in one of the traditional engineering disciplines."

The program is composed of pre-planned programs of study in areas like acoustical engineering, engineering mathematics, and a special program called *multidisciplinary*

²² "Illinois Institute of Technology." <http://www.iit.edu>. April 2006.

²³ "Northeastern University." <http://www.coe.neu.edu/Depts/SET/set/index.html>. April 2006.

²⁴ "Rose-Hulman University of Technology." <http://www.rose-hulman.edu>. April 2006.

²⁵ "Purdue University." <http://www.purdue.edu>." April 2006.

engineering. According to the website, Purdue's program in multidisciplinary engineering is "intended for the student whose interests and abilities would be best served by a course of study that builds on several new and existing engineering and science disciplines, rather than focuses on one of the traditional disciplines." The program was developed specifically in response to *Engineer of 2020*. In fact the program was supported by a \$1 million grant from the National Science Foundation who authored the book. The program will be reviewed for Accreditation in the fall of 2007.

The program integrates multiple engineering disciplines. From looking at the four-year plan of study a graduate of this program will have exposure to classes in writing, chemistry, mathematics, engineering science, biology, and some basic electrical engineering. One aspect of this program that was very interesting was that the mathematics was spread out over four years of undergraduate education.

A problem at WPI lies in the fact that most students are done with their math requirements early in sophomore year and it can be argued that many have forgotten the basic concepts learned in those math courses by the time that take upper level courses. Another intriguing part of the Purdue programs are that they expect to be ABET accredited in the near future. Their prospects of obtaining this accreditation will be investigated as any such WPI program will face a similar challenge.

This program should be watched closely as the first class will graduate in the spring of 2008. If the program is successful, meaning graduates are competitive for job in industry or a position in grad school, then WPI should consider implementing such a program. For the time being it will be interesting to see if the program is accepted in academia. See Appendix E for a four-year plan of study for the Multidisciplinary Engineering program.

*Boston University*²⁶

The size of Boston University results in it being divided into schools and colleges. The Mission of the College of Engineering in part is to "to prepare graduates to lead fulfilling professional lives, participate in lifelong learning, and [...] become highly qualified engineers and the technology leaders of tomorrow."

Boston University offers four undergraduate engineering degrees, one of which is the Aerospace and Mechanical degree. 9.3% of the students in the College of Engineering are enrolled in this program. The department of Aerospace and Mechanical Engineering (AME) provides their students with the fundamentals of engineering as well as some exposure to "interdisciplinary frontiers" in nanotechnology, mechatronic systems, and intelligent machines. The AME program seems to be very similar to the WPI Aerospace Concentration within the Mechanical Engineering department.

²⁶ "Boston University." <http://www.bu.edu/bulletins/und/item19g2.html#anchor10>. April 2006.

The College of Engineering fact sheet notes a Multidisciplinary/Undecided area although there is no formal program of study for these students. Students in this category have not yet chosen one of the four key departments of the College. Out of all the students enrolled in the college of engineering program, 13.5% (165) are in the Multidisciplinary/Undecided area.

One of BU's most interesting programs is its degree program in Computer Systems Engineering. According to the program website, "To work in the constantly evolving discipline of computer systems engineering, the computer systems engineer must acquire competence in both digital computer hardware and the fundamentals of software engineering. The Computer Systems Engineering Program provides training in these critical areas of technology." The sample program of study focuses on teaching students basic problem-solving and writing skills through initial classes in calculus, differential equations, and linear algebra, as well as a steady dose of writing and communication classes.

The next step in the program is to give students a strong background in both the electronics and the computer science sides of the major program. This program is ABET accredited. Further research will have to be done to gain more information about how the program works, what its graduates have done so far in the workforce and in academia. The concept of computer systems engineering is very promising, as computers continue to be a very attractive market for recent college graduates. This subject would also translate well to the WPI system, as WPI already has infrastructure in place in terms of classes offered and number of faculty members who focus on computer systems.

*Case Western Reserve University*²⁷

Case Western Reserve University is also divided into schools and colleges. The Case School of Engineering "cultivates a multidisciplinary perspective of the increasingly intersecting fields of science, engineering, business, medicine, and law."

Although the description of the colleges tosses around the word "multidisciplinary," Case Western Reserve does not offer a program in multidisciplinary engineering. The departments of the Case School of Engineering are Biomedical, Chemical, Civil, Electrical & Computer, Macromolecular, Materials Science, and Mechanical & Aerospace. Although Biomedical and Electrical & Computer can be seen as multidisciplinary-type programs, the focus of this peer school assessment is to identify schools that have multidisciplinary programs that are fundamentally different from those at WPI.

*Drexel University*²⁸

Drexel University's College of Engineering is the largest private engineering college in the country. The college enrolls over 3,500 students in six different departments. Drexel's College of Engineering is segregated into departments and programs.

²⁷ "Case Western Reserve University." <http://www.cwru.edu>. April 2006.

²⁸ "Drexel University." <http://www.drexel.edu>. April 2006.

Drexel offers a program in Engineering Management which is very similar to WPI's Management Information Systems program in that both departments strive to integrate the study of management within the context of engineering. Drexel offers programs in Biomedical Engineering, Chemical and Biological Engineering (similar to WPI's Chemical Engineering department), Civil & Environmental Engineering, and Electrical and Computer Engineering. Drexel seems to have many departments and programs in common with WPI but does not offer a specific undergraduate multidisciplinary program.

*Harvey Mudd College*²⁹

Harvey Mudd College offers a number of interdepartmental & special majors which are multidisciplinary in nature. Like WPI, Harvey Mudd offers undergraduates the opportunity to create their own program of study.

One of these programs is the Biology/Chemistry joint major. Harvey Mudd adopted this new program in the spring of 2004 due to the fact that the disciplines of biology and chemistry are "undergoing remarkable and converging transformations." The major prepares students for careers at the interface between the two disciplines. The program seems similar to WPI's Biochemistry major.

Another special program is the Joint Major in Computer Science and Mathematics. This joint major is overseen by the computer science and mathematics departments. The joint major requires more courses than either the computer science or mathematics departments leading to a program that is more structured.

The last of the interdepartmental and special majors is the Mathematical Biology Major. The reason for the creation of this field is that the current century has been "predicted to be the century of biology." With that, the department believes that the quantitative methods to biological science will become increasingly more important in the future.

Due to Harvey Mudd College's size, the school offers a degree in Engineering which attempts to balance theory with a "hands-on" approach to engineering. The school believes that its broad engineering program is "most likely to produce engineers capable of adapting a changing technology to expanding human needs." A potential weakness of the program is that it is so broad and does not focus on any field of engineering in particular.

*Massachusetts Institute of Technology*³⁰

The closest program that MIT has to an undergraduate multidisciplinary program is its Engineering Systems Division (ESD). The degrees you can get in this area are only masters and doctorates. The program "creates and shares multidisciplinary knowledge about complex engineering systems."

²⁹ "Harvey Mudd College." <http://www.hmc.edu>. April 2006.

³⁰ "Massachusetts Institute of Technology." <http://www.mit.edu>. April 2006.

One of the missions of this program is to “transform engineering education and practice.” Their course listing for this department can be found at: <http://student.mit.edu/@2674560.12401/catalog/mESDa.html>.

From MIT’s website it does not seem that they are making any initiative to create an ESD field of study at the undergraduate level. This is perhaps an area that should be further investigated to see if it is indeed feasible to implement this type of study on the undergraduate level. It is also possible that MIT subscribes to the school of thought that believes that broader programs should be restricted to the graduate level.

The Electrical Engineering and Computer Science (EECS) department at MIT provides an interesting case study because its programs are dually accredited by ABET. The EECS major is approved under the Computing as well as under the Engineering section by ABET³¹. Students have the option to major in EECS as a whole, or in Electrical Engineering or Computer Science separately. Each major is distinct and offers unique opportunities. The setup of having one department that houses both EE and CS works because the two subjects are so inter-connected. The capstone design project for a student in the EECS major can either be done in Electrical Engineering or in Computer Science.

*Rochester Institute of Technology*³²

RIT has one undergraduate multidisciplinary engineering program as well as a couple others that at first glance seem to be multidisciplinary in nature.

- *Industrial and Systems Engineering*: At a first glance this looks similar to the program offered at MIT. This program is very similar to the Industrial Engineering program at WPI.
- *Engineering Science*: This program was developed out of an increasing number of students wanting to study engineering while maintaining full-time employment. This program prepares graduates to transfer into the third-year level of ABET-accredited engineering programs.
- *Electrical/Mechanical Engineering Technology*: It must be noted that “engineering technology” is much different from standard “engineering”. Simply put, engineering technology strives to produce graduates who understand machinery, not graduates who have the skills to create machinery. The electrical/mechanical engineering technology program identifies the merger of mechanical and electrical aspects of design and strives to develop professionals who have a strong foundation in electrical, mechanical, and manufacturing disciplines. The program creates graduates who can “effectively bridge the gap between coworkers with more specialized backgrounds.” This program is accredited by the Technology Accreditation Commission of the Accreditation Board for

³¹ Accreditation Board for Engineering and Technology (ABET). <http://www.abet.org/schools.asp>. 14 September 2006.

³² “Rochester Institute of Technology.” <http://www.rit.edu>. April 2006.

Engineering and Technology. More information about the course curriculum can be found at: http://www.rit.edu/~932www/ugrad_bulletin/colleges/cast/emetech.html.

*Olin College*³³

This college is unique in that it is attempting to fundamentally change engineering education. The school opened in 2002 and currently has 286 students enrolled—the first class graduated in May of 2006. The curriculum of the school is based on the “Olin Triangle” which is a combination of “rigorous science and engineering fundamentals, entrepreneurship and the liberal arts.”

A unique feature of the school which is similar to the MQP is that seniors engage in the Senior Consulting Program for Engineering (SCOPE) which is a year-long project for an actual client. They have a unique academic program which spreads basic math and science over the four years of study. A block diagram of the four years of study can be found at: http://www.olin.edu/academics/pdf/CurriculumYrs1_41.pdf. The college is currently unaccredited and has not graduated its first class. Olin is currently working with ABET to accredit its programs. Olin College does offer a degree in Engineering Systems which focuses on integrating the fields of ECE + ME into the design of products. Page 21 of the course catalog has requirements for this field of study: http://olin.edu/academics/pdf/course_catalog_05_06.pdf. *The Wall Street Journal* wrote an article on this new school, which can be found at <http://webreprints.djreprints.com/1373220600138.html>. This school may be beneficial to visit in order to investigate the “new” approach to engineering they are taking. It will be important to note the success of the graduating class in the job market.

*Cornell University College of Engineering*³⁴

Cornell does not have any multidisciplinary engineering options—the only option they have is the Independent Engineering major possibility, which is very similar to our current Individual-Designed major option. The website states clearly that “because no single standardized curriculum exists, the independent major is not accredited. Engineering students who intend to seek legal licensing as a Professional Engineer should be aware that this non-accredited degree program will require additional education, work, and/or experience to qualify for eligibility to take the Fundamentals of Engineering examination.”

*Dartmouth College*³⁵

Dartmouth offers three degree programs in the Thayer School of Engineering. The Bachelor of Arts is a four-year program of study that “integrates multiple areas of engineering”

³³ “Olin College.” <http://www.olin.edu>. April 2006.

³⁴ “Cornell University College of Engineering.” <http://www.engineering.cornell.edu>. April 2006.

³⁵ “Thayer School – Undergraduate Study.”

<http://engineering.dartmouth.edu/thayer/academicsadmissions/undergrad-study.html>. September 2006.

where “students learn how to use engineering skills in service to society.” The Bachelor of Arts programs are not accredited by ABET. To receive a degree that is ABET accredited an undergraduate must pursue a Bachelor of Engineering which is a five-year program of study. Dartmouth offers one accredited program of study, namely a B.S. in Engineering. The third program that Dartmouth offers is a Dual Degree Program whereby students from other colleges and universities have the opportunity to combine a Bachelor of Arts degree from their school with a Bachelor of Engineering degree from Dartmouth.

ANALYSIS

Information that is pertinent to this project has been collected from a variety of sources in order to answer one underlying question, which is: Should WPI encourage more multidisciplinary engineering programs for undergraduates?

To address this question, many different facets were explored; these included:

- How can we identify areas in which WPI currently fosters multidisciplinary activity? Analyze those areas and look at ways in which they can be improved.
- Are there comparable programs at other schools? Are they successful?
- If there are existing, viable programs, then how do we translate their success to the WPI academic system?
- What are the human and monetary costs associated with providing this option in the future?
- Is there a need for these programs in industry?
- How do we garner interest in incoming WPI students for such programs?
- What recommendations can be developed based on analysis and feedback received from various sources?

Identify areas in which WPI currently fosters multidisciplinary activity. Analyze those areas and look at ways in which they can be improved.

A critical step in achieving the thesis question is to identify current multidisciplinary programs at WPI and examine their success. These areas are important to examine due to the fact that WPI already has a lot of the infrastructure in place.

- 1.) A new major in Robotics Engineering (RBE) will be presented to the faculty in the fall of 2006.
- 2.) The Mechanical Engineering, Computer Science, *and* Electrical and Computer Engineering departments each offer a Robotics concentration.
- 3.) The Interactive Media and Game Development major has been designed, approved and implemented.
- 4.) A Bachelor of Arts degree in Liberal Arts and Engineering is being investigated.
- 5.) A program of study in Environmental Studies will be brought to the faculty this year.
- 6.) A new program of study in Bioinformatics is being developed.

Are there comparable programs at other schools? Are they successful?

Among engineering schools, Purdue University seems to have the most cohesive multidisciplinary program. According to the program website, “the Interdisciplinary Engineering Program (IDE) is for the student whose interests and abilities lie at the interface

between engineering disciplines, or between engineering and other disciplines, and who is unable to accommodate his/her total range of interests and abilities satisfactorily in one of the traditional engineering disciplines.”³⁶

The program is composed of pre-planned programs of study in areas like acoustical engineering, engineering mathematics, and a special program called *multi-disciplinary engineering*. According to the website, multi-disciplinary engineering is “intended for the student whose interests and abilities would be best served by a course of study that builds on several new and existing engineering and science disciplines, rather than focuses on one of the traditional disciplines.” A sample four-year academic study plan consists primarily of courses in mechanical and electrical engineering supplemented by rigorous study of computer programming, mathematics, and both verbal and written communication.

One aspect of this program that was very interesting was that the mathematics was spread out over four years of undergraduate education. Another intriguing part of the Purdue programs are that they expect to be ABET accredited in the near future. Their prospects of obtaining this accreditation will be investigated as any such WPI program will face a similar challenge.

If there are existing, viable programs, then how do we translate their success to the WPI academic system?

If in fact other universities across the nation offer successful multidisciplinary programs of study, does this mean that they will necessarily be able to be incorporated into the academic structure of WPI? Any program that is recommended to be adopted by the WPI Faculty must be able to fit into the current academic structure of WPI.

Is there a need for these programs in industry?

There is no point in developing recommendations for the WPI administration if the students are not going to be more competitive in the job market or for graduate study upon graduation. An important part of the project was developing a set of focused questions that we will ask companies that frequently hire WPI undergraduates. Through interviews with representatives from various companies that tend to hire WPI students, we are able to deduce the feasibility of specific recommendations, and this will put us in a better position to decide how to build a case for a certain program.

How do we garner interest in incoming WPI students for such programs?

Once the proposed programs have past all of the above tests, they must be sold to the WPI students. What is meant by this is that the students must also be convinced that the program the school is implementing is worth while. This will have to be done by holding seminars on the various new programs. This could be streamlined into the Major Selection Program, run by the

³⁶ “Purdue University.” <http://www.purdue.edu>.” April 2006.

Career Development Center, as well as into the literature in the Admissions Office, as well as other services WPI provides to inform new students of the resources available at this institution.

How do we make sure that the recommendations developed from this endeavor can withstand opposition?

One of the major obstacles will be to convince the WPI community to adopt the recommendations made in this report. We will not only have to show all of the above but will also have to anticipate and address opposition to our ideas. These will include but not be limited to:

- 1.) Undergraduate education should be focused in developing a firm foundation in one program of study.
- 2.) ABET accreditation.

In order to better prepare answers to the questions that will arise in the above areas, we interviewed many individuals on campus. Our interview subjects included faculty members who are active in faculty governance, engineering Department Heads, the Provost, as well as various staff members on campus, such as the director of Employer Relations at the Career Development Center and the Vice-President for Enrollment Management, among others. All interview minutes are included in the appendices except for the interview with the Provost. The reason is that the meeting with the Provost was very brief and informal, and the major point of action from that interview was that multiple faculty champions will be needed for a new program proposal, a fact that is reiterated at various times in the report.

RECOMMENDATIONS

Based on data from the variety of sources that have been analyzed, recommendations are made to improve WPI's academic program. The list of *major* recommendations, all of which are elaborated on later, is:

- A new major program should be established at the undergraduate level in the field of Computer Systems Engineering (CSE), a multidisciplinary program at the interface of computer engineering and computer science.
- WPI faculty should be encouraged to develop multidisciplinary MQPs and should simultaneously encourage students to look for MQPs outside their department that are relevant to their interests.
- A one-unit MQP for double-majors should replace the current rule of two separate MQPs. This is provided that both majors are in related technical disciplines with the further stipulation that any such one-unit MQP will incorporate a sufficient amount of technical concepts from both subjects, as defined by WPI and ABET expectations.
- WPI should monitor the undergraduate major program at Purdue University titled 'Multidisciplinary Engineering'. The Purdue program was created in response to *Educating the Engineer of 2020*. If it is successful at Purdue, the program should be analyzed and the feasibility of a similar program being incorporated into WPI's academic structure should be investigated.

Along with the main recommendations, there are a few peripheral recommendations that arise directly from the data collected to accomplish the main goals of the project. These recommendations do not necessarily relate to the main project goals but are nevertheless important.

- All WPI students should engage in multiple writing-intensive activities as a graduation requirement. Throughout our interviews, a common motif was that the average engineering graduate is a deficient technical writer. The possession of solid technical writing skills is a clear way for engineers to distinguish themselves in industry.
- A list of courses in each technical major that will be especially useful for students outside that major should be identified – these courses will be publicized as ones that will help in making a student a more multidisciplinary engineer.
- WPI engineering students should be exposed to computer programming directly in at least one of the courses that they take during their time at WPI. Possessing computer programming skills and having general computer proficiency is a necessity for engineering graduates today. With the ubiquity of computers in today's engineering workplace, employees are expected to write their own programs for special applications.

Now that we have listed the recommendations, we will elaborate on them. The first recommendation we will look at in detail is the introduction of a Computer Systems Engineering (CSE) major at WPI.

Computer Systems Engineering (CSE)

The primary goal of this project is to identify opportunities at WPI to develop new multidisciplinary engineering programs at the undergraduate level that leverage existing resources to provide a distinct program for future WPI students. The two most important criteria for the development of a successful new program are resources and marketability. Electrical and Computer Engineering Department Head Prof. Looft reiterated this point, “the program can only be implemented if it does not require the addition of significant number of faculty and courses.” The program must also be marketable to prospective students, employers, and graduate schools. With these considerations, it is recommended that the WPI faculty adopt a new program in Computer Systems Engineering (CSE), a combination of Computer Engineering and Computer Science.

The development of a program in CSE can be justified by the recognition that there is a need for a change in engineering education at the undergraduate level due to an increase in the complexity of technology. The ability to understand the bigger picture of a project is essential for engineering graduates and therefore should be realized by a multidisciplinary program of study at the undergraduate level. One of the recommendations in *Engineer of 2020* is that undergraduate engineering needs to “enrich and broaden engineering education so that those technically grounded graduates will be better prepared to work in a constantly changing global economy” (1).

This recommendation was reiterated in the interview with Andrew Solitro (WPI '99, EE) who has been working at Teradyne, a \$2 billion semiconductor test company, for the past seven years. Solitro works in a customer service department for Teradyne. He entered Teradyne when the semiconductor test market was booming. In the past seven years, over 2/3 of his department has been laid off. The customer service department is now based in the Philippines and Solitro trains Filipinos to do the job that was once done in North Reading, MA. Solitro says that “the jobs that involved specific and narrow tasks are the ones that are being outsourced.”

Engineer of 2020 reiterates the point that “for many years to come, engineers in developing economies will be willing and able to do equivalent work for less than U.S. wage. The key to maintaining a robust marketplace for US engineers will be how they can bring additional value to offset this difference” (10). *Retooling* also identifies with Solitro in the need that engineering students “need a broad education so they can navigate the seas of change” (64). These seas of change are not coming in the distant future – they are here now. A program in CSE would develop an undergraduate who has a diverse portfolio of knowledge in two

interconnected fields of engineering and will be well-equipped to adapt to the changes of the engineering industry.

The recognition of the need for a change in engineering education goes hand-in-hand with ensuring that a new program in multidisciplinary engineering provides a WPI graduate with the ability to show competence in at least one engineering discipline. There is one point that almost every interview subject mentioned: *all graduates need to have a solid understanding of the fundamentals of their field*. The development of a multidisciplinary engineering program must be done carefully so as not to result in a student who does not know enough in order to market themselves to companies in industry or graduate school. A program in CSE is broad but at the same time will provide a student with the opportunity to achieve a solid grasp of the fundamentals in four years. The delicate balance of breadth and depth in a multidisciplinary major is extremely important in ensuring its success. Brad Robbins, Vice President and General Manager of Teradyne, echoed this view:

“A broad degree in engineering can be valuable for a particular subset of students. Let me clarify this point. On the west coast we hire a number of graduates from Harvey Mudd. These students graduate with a degree in Engineering. We only look to hire the top students with the general Engineering degree at Harvey Mudd. It is valuable to have a student that can demonstrate competence in one specific field and it is tough enough finding those graduates as it is. So what I’m saying is that if you are the cream of your crop, no matter how broad your field is, I’m going to hire you. If you’re not, you are better off in focusing in one specific field and being able to come to the table with one degree on your belt.”

A potential problem with the CSE program is that the depth of knowledge in CE or CS will be less than that of a student who pursued a degree in either of the two fields. Urszula Tasto, a Computer Systems Engineer at Teradyne, describes the market for CSE jobs as a Venn diagram. The intersection between the CE and CS fields is where CSE majors will find jobs. If Microsoft is looking for a candidate with a strong knowledge of software, they will choose the CS major over the CSE major. While this may be discouraging, the big picture is that job outlook for CSE majors is very good in the near future. The Bureau of Labor notes that the job outlook for computer systems engineers is stellar, “although they are employed in most industries, the largest concentration of computer software engineers—almost 30 percent—are in computer systems design and related services.”³⁷ This means that the subset of computer software engineers that are involved in systems engineering represents a robust percentage, and job opportunities for them are just as promising. As long as the market for students that have knowledge of CE and CS remains strong, a program of study in CSE would serve WPI well. The fact that the Bureau of Labor provides statistical data on Computer Systems Engineering

³⁷ Bureau of Labor, "Computer Software Engineers," Web, <http://www.bls.gov/oco/ocos267.htm>.

indicates that the field is well-established and is marketable. Sharon Johnson, Director of the Industrial Engineering program at WPI, noted this in her interview: “Computer Systems Engineering has an advantage in that it is already well-established as a technical major, and it won’t scare employers away.”

The marketability of a program to graduate schools and employers only satisfies those students that have completed their education at WPI. An arguably even more important population to satisfy is those students that are looking to come to WPI. ABET accreditation is seen as an indicator of the program’s ability to prepare a student for a future career. The introduction of an accredited multidisciplinary program is difficult due to accreditation requirements. For example, to introduce a degree at WPI in Electro-Mechanical Engineering a student would need to fulfill ABET requirements for Electrical Engineering *and* Mechanical Engineering. Another strength of introducing CSE into WPI’s curriculum is that the program has the potential to be accredited in the future. CSE is accredited at four institutions across the country: Arizona State University, Boston University, University of Houston – Clear Lake, and University of Massachusetts – Amherst. A program in CSE at WPI may attract students to WPI who choose other local schools like BU and UMass Amherst because of their degree in CSE. Although the WPI CSE program may end up being distinct from these current programs, they represent a useful comparison if nothing else.

The marketability of a new program, while a major consideration in its conception, is not the only one. The program should fill a need at WPI and be able to be implemented with minimal strain on resources. A myWPI poll was run from September 14, 2006 – September 24, 2006. The poll was open to students – the question and responses can be found in Appendix D. 43% of undergraduates responded to the poll, and 47.3% of all respondents indicated that a program in CSE would be beneficial to WPI students. It should be noted that 44.4% of all respondents said that they did not know enough about the fields of Computer Engineering and Computer Science to answer the question, and only 8.3% of respondents said that a CSE program would not be beneficial to WPI students. From this poll, it seems like educating new students about this major will be a major priority when this program is established. Furthermore, Professor Looft, ECE Department Head, stated that approximately 50% of the ECE students decide to pursue the Computer Engineering side of ECE. Among these students there are many CS minors. Due to the fact that the ECE department has an established Computer Engineering set of courses, a program in CSE would be able to employ the existing resources the ECE and CS departments have in place. The reason is that the courses students will be taking to obtain a B.S. in CSE are in WPI’s Electrical and Computer Engineering department as well as the Computer Science department. The need for additional faculty may present itself in the even the major draws a large number of students to the two departments.

Professor Tryggvason, Mechanical Engineering Department Head, stated in his interview that the “increase in computer power has revolutionized all fields in engineering.” Furthermore, the interviews indicated that the combination of Computer Engineering and Computer Science are the most compatible engineering programs.

The aforementioned supporting data does not stand on its own without faculty champions who will support the development of the program. Professor Looft is fully supportive of the integration of a CSE program into the WPI curriculum. The WPI administration and faculty are strongly encouraged to implement a new major program at the undergraduate level in the field of Computer Systems Engineering, a multidisciplinary subject at the interface of computer engineering and computer science with great potential in today’s academic and industrial markets. A sample program chart for CSE is presented in the next section.

Computer Systems Engineering

As mentioned previously, one of the main goals of this project is to develop a major program at the undergraduate level in a multidisciplinary subject. A primary consideration in choosing the right program is that it must be distinct enough to survive past the initial years at WPI. However, it must also be a program that utilizes WPI’s existing departmental and resource strengths as well. In other words, a new major program cannot require too much money or too many faculty members to sustain because that is simply not feasible for WPI. With these constraints in mind, a program in Computer Systems Engineering (CSE) is proposed. Computer systems engineering is a field that requires engineers to have knowledge of the fields of digital computer hardware and software engineering. What follows is a rudimentary program proposal for CSE at WPI.

Program Proposal for Computer Systems Engineering (CSE) at WPI:

Motion

The following motion is for a B.S degree in Computer Systems Engineering (B.S. CSE).

Computer Systems Engineering Degree Requirements

The degree requirements for the B.S. in Computer Systems Engineering are as follows:

The normal period of residency at WPI is 16 terms. In addition to WPI requirements applicable to all students, students wishing to receive the ABET-accredited degree designated “Computer Systems Engineering” must satisfy certain distribution requirements as follows:

<i>Requirements</i>	<i>Minimum Units</i>
1. Mathematics and Basic Science (Note 1)	4
2. Engineering Science and Design (includes MQP) (Note 2)	6

Notes

1. Mathematics and Basic Science
 - a. Must include 8/3 units of mathematics (prefix MA), including differential and integral calculus, differential equations, linear algebra, discrete mathematics, and probability and/or statistics.
 - b. Must include at least 2/3 units of physics (prefix PH).
 - c. Must include an additional 2/3 units of math, physics, or chemistry (prefixes MA, PH, CH).
2. Engineering Science and Design (including the MQP)
 - a. Must include 3 units within the Electrical and Computer Engineering area and 2 units within the Computer Science area.
 - b. The 3 units within the Electrical and Computer Engineering area must include at least 2 units of courses from an approved list of Computer Engineering courses. See list below.
 - c. The 2 units within the Computer Science area must include at least 1 unit of courses. See list below.
 - d. Must include 1 unit of engineering science and design at the 2000 level or above, selected from courses having the prefix BME, CE, CHE, ES, or ME.
 - e. The 3 units within the Electrical and Computer Engineering area and 2 units within the Computer Science area must include 1/3 unit of Capstone Design Experience. (This requirement is typically fulfilled by the MQP.)

Computer Engineering courses satisfying requirement

2b: ECE 2111, ECE 2201, ECE 2311, ECE 2022, ECE 2799, ECE 2801, ECE 3801, ECE 3803, ECE 3810, and ECE 4801

Computer Science courses satisfying requirement

2c: CS 2223, CS 2303, CS 3013, CS 3133, CS 3733, CS 4513, CS 4514, CS 4515

Rationale

Overview

Computers have revolutionized the way work is done today. Computer systems can consist of a single computer or of a complicated network of computing equipment spanning thousands of miles across the globe. Regardless of their size, computer systems are at the heart of many common applications in telecommunications, manufacturing automation, process improvement, medical systems, and of course, in almost every engineering field. Computers are also the portal to the Internet and the World Wide Web. Computer systems engineering is a field that requires engineers to have knowledge of the fields of digital computer hardware and software engineering. The ideal computer systems engineer is a person who has a strong foundation in both hardware and software and is eager to engage in a career that requires continuous learning.

According to the Bureau of Labor, “computer software engineers held about 800,000 jobs in 2004. Approximately 460,000 were computer applications software engineers, and around 340,000 were computer systems software engineers. Although they are employed in most industries, the largest concentration of computer software engineers—almost 30 percent—are in computer systems design in industry and related services.”³⁸ Computer systems engineering is also a still-burgeoning field. The Bureau of Labor notes that the job outlook for computer systems engineers is stellar for the next decade – “Computer software engineers are projected to be one of the fastest-growing occupations from 2004 to 2014. Rapid employment growth in the computer systems design and related services industry, which employs the greatest number of computer software engineers, should result in very good opportunities for those college graduates with at least a bachelor’s degree in computer engineering or computer science and practical experience working with computers.”³⁹

There are currently four ABET-accredited CSE programs in the nation.⁴⁰ They are at:

- Arizona State University
- Boston University
- University of Houston - Clear Lake
- University of Massachusetts Amherst

As demonstrated by the data from the Bureau of Labor, there is ample need for computer engineers in the next decade and for the foreseeable labor, and a large portion of computer

³⁸ Bureau of Labor, "Computer Software Engineers," Web, <http://www.bls.gov/oco/ocos267.htm>.

³⁹ Bureau of Labor, "Computer Software Engineers," Web, <http://www.bls.gov/oco/ocos267.htm>.

⁴⁰ ABET, “ABET,” Web, <http://www.abet.org/schoolareaac.asp>.

systems engineers are especially in demand. Judging by the relative lack of ABET-accredited programs in computer systems engineering, this seems like a great opportunity to WPI to leverage existing resources and faculty to develop a new, exciting undergraduate degree program that comes with an established job market and promise of growth in the future.

Catalog

The following text provides an introduction to Computer Systems Engineering for prospective Computer Systems Engineering majors, suitable for the WPI Course Catalog:

To be determined by a faculty committee

Computer Systems Engineering Program Chart

The following chart would be published in the undergraduate catalog to assist students in formulating their plans of study. It would also be used by the Associated Faculty as an advising tool.

To be determined by a faculty committee

Computer Systems Engineering vs. ECE vs. Computer Science

The similarities between Computer Systems Engineering and the two already established program at WPI in Electrical and Computer Engineering and Computer Science are apparent. CSE is a major consisting of courses from ECE and CS. The differences between the three subjects are not as clear at first sight. It is probably most accurate to say that Computer Systems Engineering takes the most relevant courses from both the established departments and combines them in a cohesive manner so as to provide a graduate with the skills necessary to commence a successful career in computer systems engineering or to go on to graduate school. For example, ECE majors currently only have to take two courses in computer engineering. CSE majors will have to take six courses, all dealing with different topics in computer engineering and computer systems. ECE majors also only have to take one CS course currently – CSE majors will have to take at least 2 units worth of CS courses, which will give them the background necessary on the software/programming side of computer systems engineering. On the CS side, Computer Science majors do not have to take ECE courses unless they choose to for their general science/engineering requirement. CS majors also are only required to take 1/3-unit worth of Systems courses, as opposed to CSE majors, who are required to take at least 1 unit worth of

Systems courses. While it is true that currently there are no plans for courses that will have a prefix of ‘CSE’, the program is significantly more specific to computer systems than either of the current established majors, and as thus is sufficiently distinct. In order to visually display the differences between the three aforementioned programs, a matrix showing the breakdown of courses for each major is displayed.

Course Number	Course Description	ECE w/ CE focus	CS	CSE
ECE 2011	Intro. to ECE	C - ECE	E	C - CSE
ECE 2022	Intro to Digital Circuits and Comp. Eng.	C - ECE	E	C - CSE
ECE 2111	Physical Principles of ECE Applications	C - ECE	E	C - CSE
ECE 2201	Microelectronic Circuits I	C - ECE	E	C - CSE
ECE 2311	Continuous-Time Signal/System Analysis	C - ECE	E	C - CSE
ECE 2799	ECE Design	C - ECE	E	C - CSE
ECE 2801	Embedded Comp. Systems	C-CE	E	C - CSE
ECE 3801	Advanced Logic Design	C-CE	E	C - CSE
ECE 3803	Microprocessor System Design	C-CE	E	C - CSE
ECE 3810	Advanced Digital System Design	C-CE	E	C - CSE
ECE 4801	Advanced Comp. System Design	C-CE	E	C - CSE
CS 1101/1102	Intro to Program Design	E	C - CS	E
CS 2011	Machine Org. and Assembly Lang.	E	C - CS	E
CS 2022	Discrete Mathematics	C - ECE	C - CS	E
CS 2102	Object-Oriented Design Concepts	E	C - CS	E
CS 2223	Algorithms	E	C - CS	C - CSE
CS 2303	Systems Programming Concepts	E	C - CS	C - CSE
CS 3013	Operating Systems	E	C - S	C - CSE
CS 3041	Human-Computer Interaction	E	C - CS	E
CS 3043	Social Implications of Info. Processing	E	C - CS	E
CS 3133	Foundations of Computer Science	E	C - CS	C - CSE
CS 3733	Software Engineering	E	C - CS	C - CSE
CD 4513	Distributed Computer Systems	E	C - S	C - CSE
CS 4514	Computer Networks	E	C - S	C - CSE
CS 4515	Computer Architecture	E	C - S	C - CSE

Educational Objectives and Outcomes

Educational Objectives

The educational objectives for the B.S. degree in Computer Systems Engineering are that all graduates:

- 1) Are able to apply fundamental principles of mathematics, science, and engineering to design, modify, and improve computer systems of all sizes.

- 2) Have the interpersonal and communication skills, an understanding of ethical responsibility, and a professional attitude necessary for a successful engineering career.
- 3) Have the ability to engage in lifelong learning.
- 4) Have an appreciation for the interrelationships between basic scientific knowledge, technology, and societal issues.

In addition to the educational objectives, the B.S. degree in Computer Systems Engineering will be ABET accredited.

Educational Outcomes

The educational outcomes for the B.S. degree in Computer Systems Engineering are that all graduates will:

- 1) Be prepared for engineering practice, including technical, professional, and ethical components.
- 2) Be prepared for future changes in computer systems engineering.
- 3) Have a solid understanding of the basic principles of computer systems engineering, both the hardware and software of a computer system.
- 4) Demonstrate knowledge in the sub-field of computer systems engineering.
- 5) Understand appropriate scientific concepts, and have an ability to apply them to computer systems engineering.
- 6) Understand the engineering design process and have an ability to perform engineering design, which includes the multidisciplinary aspects of the engineering design process, the need for collaboration and communication skills, plus the importance of cost and time management.
- 7) Understand options for careers and further education, and the educational preparation necessary to pursue those options.
- 8) Have an ability to learn independently.
- 9) Have the broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI.
- 10) Have an understanding of the computer systems engineering profession in a societal and global context.

Competing Programs

As previously mentioned, there are currently four ABET-accredited CSE programs in the nation. They are at:

- Arizona State University
- Boston University
- University of Houston - Clear Lake
- University of Massachusetts Amherst

Of these, the degree programs at Boston University and University of Massachusetts Amherst are of particular interest due to their geographical proximity to WPI. By adopting this major, WPI will not be the first to offer such a program, whether in the nation or even in Massachusetts. However, due to the strengths of our Electrical and Computer Engineering (ECE) and Computer Science (CS) departments, there will be a limited amount of new resources that will need to be devoted to this program. With this new degree option, WPI will be offering three B.S. degree choices (ECE, CS, CSE) compared to the two existing choices, in fields that are still growing at a very strong rate. In addition to providing a degree program at WPI, with its rich history in engineering and the sciences, WPI's B.S. CSE program will have a competitive advantage over programs at some other universities. The WPI projects' program will offer a significantly richer project experience in computer systems engineering, especially with the plethora of computing systems companies in the area.

Resource Requirements

The resources needed to implement the B.S. CSE program are already in place. The reason is that the courses students will be taking to obtain a B.S. in CSE are in WPI's Electrical and Computer Engineering department as well as the Computer Science department. The need for additional faculty may present itself in the even the major draws a large number of students to the two departments.

Other Constituencies

In developing the B.S. CSE program, the group sought input from: Undergraduate Admissions, the Career Development Center, practicing professionals, and various faculty members from both the ECE and CS departments at WPI. In addition, the computer systems engineering discipline is supported by its closeness to the fields of computer science and computer

engineering, and with that association comes a large number of national organizations which can provide guidance on the program.

Multidisciplinary MQPs

A valuable experience of all undergraduate engineering students is their project work. The ability to engage in productive group work in projects is essential because engineers no longer work by themselves. Projects done at the undergraduate level should be modeled after those done in industry and in post-graduate academia. Additionally, employers look favorably upon project experience in prospective candidates. Faculty members should be encouraged to develop multidisciplinary MQPs – this can be done by either having multidisciplinary MQPs factor into tenure decisions or having financial incentives for sponsoring multidisciplinary MQPs. Faculty should simultaneously encourage students to look for MQPs outside their department that are relevant to their interests.

At WPI, the MQP is the experience where WPI seniors and a few juniors apply all the classroom knowledge they have accumulated to a real project. There are almost no real engineering projects today that consist of work in a single discipline alone. The car engine is an excellent example; a working engine in today's world cannot be built by a team of mechanical engineers alone. Chemical, electrical, and computer engineers need to be part of the team that constructs a successful prototype. An example of a multidisciplinary project is a mechanical engineering doing an MQP in biomedical engineering in the specific field of assistive devices.

Engineer of 2020 reiterates the point that there is a “growing need to pursue collaborations with multidisciplinary teams of technical experts [...] important attributes include receptiveness to change” (10). Exposure to multidisciplinary projects will help individuals grow due to the fact that one's mind will be receptive to changes in thought processes and engineering concepts.

Employers value project experience and a candidate who has engaged in multidisciplinary projects. John Falcioni, editor-in-chief of *Mechanical Engineering Magazine*, makes the argument that the engineer who has the best understanding of the overall picture is the one who is best-equipped to take on a leadership role in engineering projects. This will be the student who understands the interaction between engineering disciplines. Brad Robbins, Vice President and General Manager of Teradyne, stressed that “the most important skill that a college graduate needs coming into an entry-level position is the ability to solve technical problems. The ability to work in a multidisciplinary team is a key skill that all candidates must have.”

The value of a multidisciplinary MQP is that it provides students with an experience that is closer to the real world; additionally, employers value a multidisciplinary project experience prior to graduation. The encouragement of faculty to propose multidisciplinary MQPs does not

require the addition of any resources to WPI. All it requires is the time of an individual who is willing to stress the importance of multidisciplinary projects.

Double Majors

The introduction of a multidisciplinary program such as CSE and the promotion of multidisciplinary MQPs are just a couple of ways through which WPI can encourage the spread of multidisciplinary activity. To further encourage multidisciplinary study at the undergraduate level, WPI should make it more feasible for a student to double major in two technical disciplines. This initiative can be realized in the implementation of a one-unit MQP for students who pursue a major in two engineering fields. It should be noted that the term double major refers to a student pursuing two majors, each of which is in an engineering field.

The reduction in the requirement from two distinct MQPs to one MQP serves two purposes: a student will be able to obtain a breadth of knowledge in two disciplines *and* will complete a single multidisciplinary MQP. The significance of the latter has been developed in the previous recommendation. A breadth of knowledge at the undergraduate level was reiterated in the literature as well as the interviews with faculty and industry participants. For example, John DeGaspari, Associate Editor of *Mechanical Engineering Magazine*, focuses on microelectromechanical systems, commonly known as MEMS. MEMS is a cutting-edge field that is equal parts mechanical engineering and electrical engineering. The author mentions that the best MEMS projects happen when there are people involved that know the basics of both engineering fields, as they are the ones who have the breadth of knowledge to envision the project from start to end.

Industry interviews also made the point that they prefer a breadth of knowledge in a candidate. Jim Grochmal, a Mechanical Engineering Manager at Teradyne, stated that “a breadth of experience in multiple fields is preferable to depth in one field.” Tasto, a Computer Systems Engineer at Teradyne, also talked about the benefits of a broad undergraduate degree: “the benefit of having a broader background will be very beneficial for those students who wish to get into management.” WPI can make its prospective students more competitive in the job market by allowing a double major to complete their degree requirements with the completion of a one-unit multidisciplinary MQP. Professor Hart, Department Head of Civil Engineering, stated that: “the real value would be a clear message to the prospective employers or graduate schools that the student is a real hot shot and would be a benefit to their respective programs.”

With the continual outsourcing of engineers, it becomes even more imperative for individuals to possess a diverse portfolio of knowledge in engineering in order to appear as a desirable commodity in the eyes of employers. This point is echoed in *Engineer of 2020*, “Thus, engineers educated in the United States will continually need to prove how they will bring

additional value to the marketplace” and what better way to do this than to have a broad undergraduate background. Employers and faculty promoted the idea of a double major as a marketable method for showcasing a breadth of knowledge.

Unfortunately, the current structure of WPI makes it *very* difficult for a student to double major in four years. It is not necessary that a student must finish a double-major in four years, but due to time and financial constraints, students often do not have more than four years of undergraduate study. A student must plan his/her time very carefully in order to complete four projects and the degree requirements for two engineering majors. Janet Richardson, WPI Vice-President of Student Affairs, noted at her son’s RPI graduation that there were many double majors in comparison to those at WPI. The lack of double majors does not reflect on the quality of the WPI student. Rather, WPI’s current system is not conducive to students who wish to pursue dual majors.

The current requirement for a double major is to complete two distinct one-unit MQPs. Thus the recommendation is a reduction of the requirement by one whole unit. The reason for the choice of a single one-unit MQP is that it fits in with the current WPI system. For example, let us investigate the issues that come up if the requirement for double majors was to complete a 4/3 unit MQP. The rationale behind the 4/3-unit MQP is that the student will still have to put forth more effort than a student pursuing a single engineering degree. The problem arises when the student wants to work in a team of students. A possible result is that the student wanting to double-major will have to work noticeably harder than everyone else on the team. The project partners might view this as an opportunity to delegate more work to the student who is signed up for more credit. It is difficult enough for advisors to differentiate how much work each student is doing. In addition, having to keep track and making sure one student works a certain amount more than the rest of the group is just too cumbersome. As a member of the Committee on Academic Operations (CAO) for a year, one of the authors saw many cases where MQP advisors wanted to change a grade for that very reason. The question of whether one unit is enough for a double-major MQP is a good one. If a student can show sufficient mastery of two different disciplines as determined by his project advisor(s) within the one-unit framework on a single project, that it should certainly be enough. As long as the student has a faculty champion that agrees that the MQP has enough material in the respective departments then the MQP should be allowed. The student already has to take the engineering requirements for two majors, and currently, the MQP for each major is the final hurdle that many students simply do not have the energy or time on their schedules to pass over.

Therefore, with no additional resources required, the WPI faculty and administration should change the requirement so that double majors need only to complete a single one-unit MQP with the stipulation that any such project will incorporate a significant amount of technical concepts from both subjects affirmed by faculty advisors in each of the respective departments.

Monitoring MDE Program at Purdue

Throughout the course of our research, only one program with the title ‘Multidisciplinary Engineering’ was found. This program, at Purdue University, incorporates a broad survey of many engineering programs at the undergraduate level. WPI should monitor the undergraduate major program at Purdue titled ‘Multidisciplinary Engineering’ (MDE).

To understand the value of the MDE program at Purdue it is important to understand why it was created. The program was created in response to the recommendations made in *Engineer of 2020*. Specifically, the book calls for the undergraduate degree to become more of an engineer- in-training degree, and the graduate degree to be a specialization degree. The book alluded to creating a program that would address the need of “how to enrich and broaden engineering education so that those technically grounded graduates will be better prepared to work in a constantly changing global economy” (1). A new program would differentiate itself in that engineers would be able to maintain “a robust marketplace for US engineers will be how they can bring additional value to offset this difference” (10).

Purdue University created a MDE program in response to *Engineer of 2020*. In fact, the program was supported by a \$1 million grant from the National Science Foundation. The program will be reviewed for ABET accreditation in the fall of 2007. According to the website, Purdue’s program in MDE is “intended for the student whose interests and abilities would be best served by a course of study that builds on several new and existing engineering and science disciplines, rather than focuses on one of the traditional disciplines.” The program integrates multiple engineering disciplines – looking at the four-year plan of study a graduate of this program will have exposure to classes in writing, chemistry, mathematics, engineering science, biology, and some basic electrical engineering. The four-year program of study can be found in Appendix E. One aspect of this program that was very interesting was that the mathematics was spread out over four years of undergraduate education. A problem at WPI lies in the fact that most students are done with their math requirements early in sophomore year and they have forgotten it by the time they take upper level courses, where math skills are especially essential for success.

This program should be watched closely as the first class will graduate in the spring of 2008. If the program is successful, which can be measured by how successful its graduates are in competing for positions in industry or in graduate schools, then WPI should consider implementing such a program. From current interviews with employers and faculty, they would **not** look highly upon the program. For example, studying one specific major is important for marketing purposes – it is unlikely that one would find too job postings for MDE majors. A resume submitted for an electrical engineering job with the background of MDE may very well

be ignored. Professor Hart illustrates the concern of having a skill set that matches the needs of a prospective employer:

“I know a student who graduated last year with a Bio-Engineering and Environmental Engineering degree. The student took the same courses as a Civil Environmental Engineering student except for the fundamental civil course such as structures, ... etc. This student was outstanding – and I gave excellent recommendations to companies I knew in the Civil/Environmental Engineering field. Unfortunately the student was not offered a job by those companies because they did not see the standard degree they wanted (that license boards required, also what they were used to and understood), and finally what they could fit into different sub-areas of the department. They agreed with me that he was outstanding – but nonetheless would not offer a job.”

This student was in fact a Civil and Environmental Engineering student and he still did not obtain the position – an MDE candidate would have not done much better. Professor Hart also mentioned the fact that students pursuing graduate school may have a problem: “to receive a master’s degree at CE (many other schools in the world) and probably many other engineering fields – a student is expected to have at least an equivalent to a BS in the root engineering area.” The point is that although all interviews advocated a broader appeal the MDE program may be too broad for its own good.

On the other side, some employers accepted the idea of a broad engineering degree. Owen Barthelmes, Director of Engineering at Amphenol, said “no matter what type of engineering degree you receive, the fact that you were able to obtain the degree says a lot. It says that you have a internal drive, are self-motivated, and intelligent.” Joe Wrinn who has been at Teradyne for 37 years noted “it really doesn’t matter what the major of the candidate is as long as they have an understanding of the basics. The title of the major is only useful for marketing purposes.”

Regardless if the program is successful, WPI should monitor to it to see how it is accepted by industry and graduate schools. WPI may look to implement the program or parts of it in the future.

Auxiliary Recommendations –Computer Science, Writing, and Multidisciplinary Course List

Computer Science Requirement

WPI undergraduate engineering students should be exposed to computer programming directly in at least one of the courses they take during their time at WPI. Possessing computer programming skills is a necessity for engineering graduates today. With the ubiquity of computers in today’s engineering workplace, employees are expected to write their own programs for special applications. One of the questions asked to all candidates interviewed was what are some of the skills that WPI undergraduate engineering students need upon graduation? The one skill that resonated among all majors was knowledge of a programming language. Constance Horwitz of the CDC stated that she is astonished by how many engineering job

descriptions require the knowledge of some computer programming language. Her astonishment derives from the fact that the job positions are looking for non Computer Science majors to have programming skills. Andrew Solitro, an Electrical Engineer from Teradyne, reiterated the point: “knowledge of C/C++ and Visual Basic are extremely helpful [...]”

A follow-up to the recommendation would be to address what specific programming language engineering students should learn. Urszula Tasto, a Systems Engineering Manager at Teradyne, provided the answer: “If you know one [programming language] you will be able to pick the rest up on your own.” If you are learning a new programming language your life is made easier if you have been exposed to the language of programming on some level.

Based on interviews held with WPI staff and industry participants, we recommend that WPI communicate to the undergraduate engineering students the importance of computer science as part of the general engineering education.

Writing

All WPI students should engage in multiple writing-intensive activities as a graduation requirement. Throughout our interviews, a common motif was that the average engineering graduate is a deficient technical writer. The possession of solid technical writing skills is a clear way for an engineer to distinguish themselves in industry. One of the issues that all interview candidates were asked to address was how can WPI engineering undergraduates distinguish themselves in the job market. Hossein Hakim, ECE Professor, provided some important insight that should not be ignored: “Another skill many WPI students lack when they leave is the ability to clearly communicate their thoughts on paper.” It should be noted that the industry participants also notice that WPI students do not graduate with strong writing skills. Lonnie DeLuca, a Mechanical Engineer at GE, stated: “However, WPI students cannot sell themselves well and in general do not communicate as well as other college graduates. The bigger schools have more required liberal arts classes like English, freshman writing, etc. where they are required to get up in front of an audience.” Brad Robbins, Vice President and General Manager of Teradyne, commented that he wishes he took a course in college that dealt with how to effectively communicate your ideas through writing. The internal as well as the external recognition that WPI students need to be stronger writers should motivate the WPI administration and faculty to take action on this issue.

Multidisciplinary Course List

The hope that every undergraduate student will graduate with a multidisciplinary engineering major may never happen. What WPI can do is stress the need to stay broad while pursuing a single major in a traditional engineering field. In light of the necessity for the engineer of 2020 to be skilled in various technical disciplines, a list of courses in each technical

major that will be especially useful for students outside that major ought to be identified and they should be publicized as courses that will help make a student a multidisciplinary engineer.

The need for undergraduate engineering students to be broad in their coursework was evidenced in the literature and interviews. *Engineer of 2020* states that “Engineering schools should introduce interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate programs” (55). It is pertinent to note that ‘interdisciplinary’ in the above quotation has the same meaning as ‘multidisciplinary’ as it is used in this report. Lonnie DeLuca, a Mechanical Engineer at GE, also empathizes with this notion:

“Although I would recommend learning as much as possible in your major, one cannot live in a bubble. Engineering in general is a multi-disciplinary field. A chemical engineer’s pharmaceutical is no good without a mechanical engineer making the correct type of packaging. Aerospace engineers can’t make a plane fly without electrical systems or fuel controls. GE would look for a student that has a very basic understanding of high-level engineering concepts related to their field.”

Furthermore, many students come to WPI with AP credit and therefore have extra spaces in their schedule during their junior and senior years. Andrew Solitro, EE ’99, was frustrated that “I really didn’t know what to take when I was an undergraduate. Let me phrase that differently, I didn’t know what courses were going to be beneficial 5-7 years out of my job.” A natural inclination would be to accuse the student for not taking advantage of the academic advising resources available to him. This information should be provided by WPI to the academic advisors so that they are able to advise effectively.

The details of such a list are essential if they are to be implemented at WPI. How can WPI create gather a comprehensive list of courses and ideas that students should know upon graduation? Professor Hakim answered this question: “It would be beneficial to have an outside panel every semester that consists of industry leaders in various fields that discuss emerging trends in their field. Students need to know what is valued in industry. This information should be channeled through the Career and Development Center or some other group on campus.” The CDC already has contacts with many outside companies. Jeanette Doyle of the CDC mentioned that companies prefer to come to WPI outside Career Fairs because there is no cost to the company.

In addition to gathering information from companies through a panel, the interviews conducted with industry participants this summer shed some light on the type of courses that would be beneficial to undergraduate engineering students. Writing and computer programming stood out among all of the interviews and their importance at the undergraduate level is captured in two recommendations. In addition to those courses, Owen Barthomes, Director of Engineering at Amphenol RF mentioned that in addition to his engineering coursework “classes in management, project management, and multicultural communication would have been very helpful. A knowledge of CAD package is very useful, specifically Pro-E or SolidWorks.” He

also mentioned the benefit of a psychology class that could have exposed him how to motivate people. Knowledge of computer aided design was reiterated by ME and EE's. Brad Robbins, Vice President and General Manager of Teradyne, listed that he would have liked to have a course in engineering product development, cultural awareness, and effective communication through writing. John Toscano, ME '97, remarked that a control class and a course that taught you how to design and run a valid experiment would have been extremely beneficial.

The interviews displayed that employers do have similar thoughts on courses that undergraduate engineering students should have exposure to upon graduation. Thus the WPI administration and faculty should actively work to develop and maintain lists, by major, that detail courses that students in their major should consider when developing their plan of study.

CONCLUSIONS

The sources represent the different relevant constituencies, such as academia, industry, as well as WPI enrollment and WPI post-graduate placement. The demands and views of these different groups are often in conflict, and the recommendations reflect the synthesis of all the constituencies contacted. Conclusions, in the form of recommendations to the WPI Faculty, are derived from analysis of data collected from the aforementioned sources. The recommendations pertain to the creation of multidisciplinary programs or multidisciplinary enhancements to current programs of study.

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APPENDICES

Appendix A – WPI Department Head Interviews

A list of the department heads contacted is provided below. The interviews of those Department Heads we were successfully able to meet with are provided in this appendix.

Department Heads Contacted:

- 1.) Fred Looft
- 2.) Gretar Tryggvason
- 3.) Christopher Sotak
- 4.) David DiBiasio
- 5.) Michael Gennert
- 6.) Frederick Hart
- 7.) Arthur Gerstenfeld
- 8.) Richard Sisson
- 9.) Sharon Johnson

Mechanical Engineering, September 1, 2006

Gretar Tryggvason, Department Head

1.) What skills does a WPI engineering graduate, in your field, need to possess coming out of college? What skills will this candidate need in order to succeed after 5 years of industry experience? After 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are you going to use the material in high level classes coming out of college? Does it depend on the job?

Coming out of college, everyone needs to have the basic technical skills in mechanical engineering, such as statics, dynamics, thermodynamics, etc. However, more importantly, a student needs to have a general can-do attitude and general problem-solving skills. 5-10 years out of college, a person still needs to possess the same skills as he/she did coming out of college, but they need to be more mature, which will come with experience in an engineering position.

A student needs to have balance between depth and breadth. In multidisciplinary projects, students will often try to dissect them such that a clear line is drawn between disciplines. This is what we would like to avoid, because a successful approach will require an understanding of all the different disciplines, and students who are well-versed in more than just their field will do better. The material you learn in high-level classes may not ever come into play in jobs, but those classes do broaden your problem-solving skills, which you will certainly need.

2.) How important is one specific major assuming that the candidate has studied some branch of engineering? In your opinion, what are the advantages and drawbacks of being enrolled in a

multidisciplinary engineering program vs. being in a traditional single-field engineering program?

Studying one specific major is only important for marketing purposes. An employer is more comfortable hiring someone with a degree in a subject that is common. One of the reasons why mechanical engineering is so popular is that it is so broad – a degree in mechanical engineering enables a graduate to solve problems in a wide variety of fields, from civil to chemical to even electrical engineering.

A multidisciplinary major will not do well if it is not accredited. It will also not do well because it lacks a brand name, and people in industry and academia are not familiar with it. The primary advantage of being enrolled in a multidisciplinary major is that many of the problems that engineers solve are at the interface of different disciplines.

3.) Where do you see your field heading in the next 5 to 10 years? Specifically, what are the hottest “offshoot” fields of work in your branch of engineering?

The hottest fields right now are robotics, mechatronics, and computer modeling of different systems in both solid and fluid mechanics. The reason why robotics is more popular than mechatronics is that its name is more recognizable, and consequently more marketable.

4.) If WPI was to offer a multidisciplinary engineering program of study which engineering departments would be most compatible with yours? Why?

Electrical Engineering and Computer Science are the most compatible with mechanical engineering – robotics and mechatronics are the two most obvious offshoot fields. Nanotechnology is also a very hot field.

5.) How has the exponential increase in computer power changed your field in the past decade? Has the increase in technology led to more interdisciplinary projects in academia? How do you foresee computers changing your field in the next 5 to 10 years?

Computers were originally invented to solve mechanics problems, such as rocket trajectory problems for the Army. Finite element method (FEM) software was one of the first to be built for computers. CAD/CAM programs followed shortly thereafter. Computers have come a long way since their initial introduction, and computer packages are becoming more and more intuitive and will certainly move further in that direction. With computational tools becoming better, less time is taken up doing rote calculations and more time is spent thinking critically about engineering problems. This makes it important for the next wave of engineers to have more breadth in their background because they will be called on to model complex situations that span across different engineering fields.

6.) *Do you think the atmosphere at WPI is conducive to a new program in multidisciplinary engineering? What do you see as the biggest roadblocks?*

WPI is a mostly conducive atmosphere for a new program. We are always open to trying new things, although as an academic institution, we are inherently conservative. The most important consideration for any new program is that there must be a champion in the faculty who believes in this program so much that he/she will make it a priority.

7.) *How does a double major in Electrical and Mechanical engineering compares to a single major in Electro-Mechanical engineering?*

Questions previously answered. Marketing is the main reason why a double-major in two established fields is better.

Electrical and Computer Engineering, September 6, 2006

Hossein Hakim, Associate Department Head

1.) *What skills does a WPI engineering graduate, in your field, need to possess coming out of college? What skills will this candidate need in order to succeed after 5 years of industry experience? After 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are you going to use the material in high level classes coming out of college? Does it depend on the job?*

Students need to have a solid understanding of the fundamentals of their field whether it is Electrical and Computer Engineering or some other engineering field. If a student does not understand the basics then they will have a very hard time finding a position in industry. Furthermore it is important for a student to be well versed in one engineering field. It is nice to have a breadth of knowledge but it is better to be able to show solid proficiency in one area.

Beyond the solid understanding of the fundamentals, it is pertinent to be able to communicate with the people around you. Strong interpersonal skills will go a long way in terms of being able to market yourself in industry. Engineers find themselves talking with teams of engineers from across the world on a weekly basis and therefore cross-cultural skills are also becoming increasingly important. Another skill many WPI students lack when they leave is the ability to clearly communicate their thoughts on paper. Furthermore you need to have the ability to learn on your own and to be creative. No matter how broad your undergraduate engineering education is you are still going to need to learn on your own once you have a position in industry.

Regarding breadth and depth, it really depends on what you want to do coming out of school. If you know you want to do acoustical engineering, then more depth in that area would be beneficial to you. If you are not sure what you want to do a broader approach is always better. In terms of staying broad there are certain programs that work well together. For example, Computer Science complements Electrical and Computer Engineering. It is more beneficial to

study *one* engineering field and use the electives to broaden your scope than to stay broad in two separate engineering fields.

2.) How important is one specific major assuming that the candidate has studied some branch of engineering? In your opinion, what are the advantages and drawbacks of being enrolled in a multidisciplinary engineering program vs. being in a traditional single-field engineering program?

As stated above, it is more beneficial to study *one* engineering field and use the electives to broaden your scope than to stay broad in two separate engineering fields. For example, Electrical and Computer Engineers can broaden their scope by supplementing it with four or five Computer Science classes.

It is easier to market yourself if you have a solid grounding in one field in comparison to having familiarity with two fields.

3.) Where do you see your field heading in the next 5 to 10 years? Specifically, what are the hottest “offshoot” fields of work in your branch of engineering?

More jobs are being sent overseas. Specifically, lower level positions are being outsourced. The higher level positions and the development of advanced knowledge in any field will always stay in the United States. Thus WPI graduates are increasingly going to have to show their value by demonstrating that they are creative and that they can learn on their own.

Fiber optics and reconfigurable computer systems are two areas that are hot offshoot fields in Electrical and Computer Engineering. Electrical and Computer Engineering applied to assistive device is also a popular field. It is more beneficial to major in Electrical and Computer Engineering and then go to work in the Biomedical field rather than to major in Biomedical Engineering. Again this comes back to the point that a strong foundation in one discipline is more beneficial to some knowledge about Electrical Engineering, Mechanical Engineering, and Biology.

4.) If WPI was to offer a multidisciplinary engineering program of study which engineering departments would be most compatible with yours? Why?

The most compatible programs are Electrical and Computer Engineering and Computer Science. The hardware and software of computers are very closely linked.

5.) How has the exponential increase in computer power changed your field in the past decade? Has the increase in technology led to more interdisciplinary projects in academia? How do you foresee computers changing your field in the next 5 to 10 years?

Engineers need to be mobile and independent. Many industry positions have you work at home some days and work at a desk other days. In fact, you may find yourself squatting in someone else's desk at another location some days. The only thing you carry with you for work to all three places is your computer. Additionally you will have meetings every couple days to meet and discuss your work and then you are back on your own again until the next team meeting.

6.) *Do you think the atmosphere at WPI is conducive to a new program in multidisciplinary engineering? What do you see as the biggest roadblocks?*

WPI is very accepting of new programs and is willing to change but you need to make a clear argument and be prepared for opposition.

7.) *How does a double major in Electrical and Mechanical engineering compares to a single major in Electro-Mechanical engineering?*

Answered in question 1.

8.) *Do you have any additional thoughts on the subject?*

It would be beneficial to have an outside panel every semester that consists of industry leaders in various fields that discuss emerging trends in their field. Students need to know what is valued in industry. This information should be channeled through the Career and Development Center or some other group on campus. For example, it is good for all students at WPI to have some knowledge of computer programming upon graduation.

Civil & Environmental Engineering, September 10, 2006

Frederick Hart, Department Head

1.) *What skills does a WPI engineering graduate, in your field, need to possess coming out of college? What skills will this candidate need in order to succeed after 5 years of industry experience? After 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are you going to use the material in high level classes coming out of college? Does it depend on the job?*

Difficult question – Primary skill would be ability to solve problems, design, work in teams ... etc.

I suppose you're thinking of fundamental skills such as ability to solve a specific problem such as design a pump, size a beam ... etc.

Of course, specific skills are needed. I would check the contents of the FE exam to identify those specific skills.

<http://www.ncees.org/exams/fundamentals/>

After 5 years, a CE would normally have a PE – so look for PE exam contents to answer that question.

<http://www.ncees.org/exams/professional/#material>

2.) How important is one specific major assuming that the candidate has studied some branch of engineering? In your opinion, what are the advantages and drawbacks of being enrolled in a multidisciplinary engineering program vs. being in a traditional single-field engineering program?

Major drawback would be if the student is not able to qualify and pass the FE exam. For CE this is an absolute must.

3.) Where do you see your field heading in the next 5 to 10 years? Specifically, what are the hottest “offshoot” fields of work in your branch of engineering?

There are so many possible off-shoots it is pointless to mention one because one may take that example as a “big hot area” – when it is really just one of many.

4.) If WPI was to offer a multidisciplinary engineering program of study which engineering departments would be most compatible with yours? Why?

CE/Chemical – For environmental related areas
 CE/Mechanical - For mechanical related areas
 CE/Electrical – For sensor/measurement related areas
 CE/CS – For IT related areas

Traditionally, a fundamental CE degree (the undergraduate degree) is designed to provide a student with the foundation of the discipline. The Professional degree (A Master’s degree) goes further, and is often combined with some of the above combos – for example, my master’s degree is environmental and I worked closely with Chemical Engineers and Biologists.

5.) How has the exponential increase in computer power changed your field in the past decade? Has the increase in technology led to more interdisciplinary projects in academia? How do you foresee computers changing your field in the next 5 to 10 years?

Primary influence is ability to communicate, transfer information, and accommodate changes in a project quickly. Civil Engineering projects typically need teams – often multi-disciplinary teams. Passing great amounts of information through data base files, drawings, photos, videos

... etc. is very helpful. In many instances, teams are located throughout the world – you can have a team conducting detailed designs and drawings in one part of the world, while managers and other experts are located in another part of the world.

6.) Please provide your thoughts on the following hypothetical program of study. Let's say a student comes to WPI and majors in general engineering. This student spends the first 3 years of his/her undergraduate experience gaining an intensive education in the sciences and engineering. Some time in his/her third year, this student will decide on a specialty and end up graduating in 5 years with an M.S. in the chosen engineering discipline and a B.S. in Engineering (general).

Good idea in theory – but you had better closely examine the details. Clearly all engineering students (WPI and everywhere else) study just about the same things in the first 1.5 years (first year would be sciences/math, some social sciences, and some humanities. (By the way, all schools, including WPI stray from this formula with first year programs – by interlinking those fundamental areas with engineering disciplines – but the overall curriculum is not altered that much.)

The second ½ year would be more sciences and support engineering courses, such as thermodynamics, fluids, CS ... ETC). The next 1.5 years (to make-up your 3 year scenario) would have to involve new courses that all disciplines could support – this is a major curriculum change that all engineering departments would have to develop/work in harmony on – but more importantly, that the profession (examination/certification/accreditation boards would have to recognize.)

I suppose it would be possible to meet the first challenge (WPI Engineering departments working together), but you had better closely review FE exam requirements to see how an examination/certification board might influence this “harmony.”

As for the accreditation board, look into the ABET web site (talk to John Orr about this) to see how different engineering disciplines dictate what is taught (closely look at discipline specific requirements.)

Finally, to receive a master's degree at CE (many other schools in the world) and probably many other engineering fields – a student is expected to have at least an equivalent to a BS in the root engineering area. You may not have enough years to do that – so a student may have to use up 6 years just to get the equivalent BS degree and then an additional year (assuming double dipping is possible) to get the MS.

Summary – Work out the numbers closely. Do example curriculums for each engineering discipline.

7.) Do you think the atmosphere at WPI is conducive to a new program in multidisciplinary engineering? What do you see as the biggest roadblocks? Opportunities?

Biggest road block is the professions. How will engineering societies, boards, and of course the specific employers look at this idea.

8.) How does a double major in Electrical and Mechanical engineering compares to a single major in Electro-Mechanical engineering?

Same answer as 7 above – how would the profession view a single Electro-Mechanical degree? Is it an Electrical BS or a Mechanical BS? There is a host of organizations outside of WPI that influence this determination. As an example, I know a student who graduated last year with a Bio-Engineering and Environmental Engineering degree. The student took the same courses as a Civil Environmental Engineering student except for the fundamental civil course such as structures, ... etc. This student was outstanding – and I gave excellent recommendations to companies I knew in the Civil/Environmental Engineering field. Unfortunately the student was not offered a job by those companies because they did not see the standard degree they wanted (that license boards required, also what they were used to and understood), and finally what they could fit into different sub-areas of the department. They agreed with me that the student was outstanding – but nonetheless would not offer a job.

A double major in electrical and mechanical would at least be recognized by either professions as “one of them.” Being ME and EE may actually turn out to be beneficial in practice – but probably only for specific situations. The real value would be a clear message to the prospective employers or graduate schools that the student is a real hot shot and would be a benefit to their respective programs.

Finally, certainly a student who distinguishes himself or herself by going beyond the standard course of study may actually end up with a much better education and foundation to make a difference in their chosen engineering career. I think this is a root goal of WPI and why we would not want to consider the type of programs you are looking into. Not to do it because the tired old professionals would not approve of such radical knowledge is, of course, ridiculous, so I’m not implying that we should not look into such an approach to our educational programs. So my hardy support to those at WPI who want to continue with this forward way of thinking. However – we must be careful that we are still able to walk between the lines (constraints) that our professional societies have mapped for us.

Industrial Engineering, September 13, 2006

Sharon Johnson, Department Head

1.) What skills does a WPI engineering graduate, in your field, need to possess coming out of college? Is a breadth of experience in multiple fields better than depth in one field?

Basic technical skills are very essential. For an industrial engineering, this means knowledge of statistics is very, very important. Industrial engineering is different because the problems that need to be solved are generally not governed by any well-known laws. It is very important for

graduates to be able to translate the knowledge they gain in classes into situations that exist in the real world. Teamwork skills are very important, and along with that, general interpersonal skills are very valuable as people are at the heart of industrial engineering and processes, etc.

It is certainly valuable to have different perspectives. A multidisciplinary major just offers another set of technical skills, which is always desirable.

2.) How important is one specific major assuming that the candidate has studied some branch of engineering? In your opinion, what are the advantages and drawbacks of being enrolled in a multidisciplinary engineering program vs. being in a traditional single-field engineering program?

Management engineering, industrial engineering, and manufacturing engineering are all very similar and interdisciplinary in nature. Many times, employers don't really differentiate between hiring students from these three majors because the skills gained are very similar. Computer Systems Engineering has an advantage in that it is already well-established as a technical major, and it won't scare employers away.

3.) Where do you see your field heading in the next 5 to 10 years? Specifically, what are the hottest "offshoot" fields of work in your branch of engineering?

Healthcare provides a huge opportunity. Services is always a healthy market for industrial engineers. Educating other people about the importance of having efficient processes, such as Six Sigma, is a burgeoning area. It is important in industry to be able to do things in a way such that the results can be generally predicted.

4.) Do you think the atmosphere at WPI is conducive to a new program in multidisciplinary engineering? What do you see as the biggest roadblocks?

WPI is certainly VERY receptive to new ideas. Many of the people we have here are entrepreneurial in nature, which is why a many new ideas come up. Resources are the biggest roadblock standing in the way of a new major program. By resources, I mean finding faculty members who can dedicate themselves to this program as well as financial considerations.

Appendix B- Industry Participant Interviews***Teradyne, July 17, 2006***

Lunch Interview

Jim Grochmal, Electro-Mechanical Engineering Manager; Charlie Sweet, Senior Electrical Engineer; Eduardo Canizeres, Mechanical Engineer

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

Teradyne is looking for students who are willing to learn and that can think through and solve problems. If a student needs a specific skill that they were unable to obtain during their undergraduate education then Teradyne will pay to have them trained. The reason is that graduates that are right out of college are not a large expense to the company so Teradyne does not have a problem with providing supplementary training for their younger engineers. There are too many offshoots of Mechanical Engineering that it is almost too hard to get a broad exposure to the field in just four years.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

A strong candidate will be able to solve problems and have a solid understanding of the material in their field. Over time a candidate will develop a stronger understanding of the internal workings of the company and be able to solve more complex problems.

At Teradyne you will not need to actively use the material taught in higher level courses unless you are working in a specialized department. Generally, a strong foundation of the basic principles takes you a long way to being successful at Teradyne.

A breadth of experience in multiple fields is preferable to depth in one field. It should be noted that marketing such a program to companies will be difficult and may not be recognized initially.

3.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

The student with the broader skill set would be much more beneficial to Teradyne. Acoustical engineering is not a program of study that we actively look for in graduates.

4.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

A knowledge of CAD software would have been beneficial; although the CAD software we currently use was not available when I was in school. Additionally it is more important to learn how to learn rather than thinking that learning stops once you graduate.

5.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

WPI graduates are very competitive and can be found in all areas of the company. WPI graduates are unique in that they usually have more project experience than students coming from other colleges and universities.

6.) How does a double major in Electrical and Mechanical engineering compares to a single major in Electro-Mechanical engineering?

The idea of a degree in Electro-Mechanical engineering is nice but the actual implementation of such a program may be very difficult. This is because there is not that much course overlap between the two engineering disciplines. The only area in which there is a significant overlap is in the area of Controls. Thus, you are forced to remove some courses from such a program so that a student will be able to get exposure to both fields. This is a tough decision because does that mean removing material science while keeping dynamics? These are real issues that would need to be addressed in the development of such a program. For some majors it is tough enough to fit in all the required courses into four years, never mind trying to squeeze the key courses in *two* disciplines into a four year experience. Additionally, marketing such a new degree would cause problems in the human resource department. If the members of human resources are not familiar with the program of study they may not consider the candidates resume.

Teradyne, July 17, 2006

Urszula Tasto, Semiconductor Test Division, Systems Engineering Manager

Urszula received her undergraduate degree at BU in Computer Systems Engineering in 2000.

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather

have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

I work in the Systems Engineering group. Systems Engineering hires graduates that have a solid understanding of software as well as a familiarity with the hardware of a computer. I went to Boston University and there received a degree in Computer Systems Engineering which exposed me to the software and hardware aspects of a computer. Computer Systems Engineering is a mixture of Computer Engineering and Computer Science. The Computer Systems Engineering is a sub-department of the Electrical Engineering department at BU. Therefore the type of candidate we look to hire lies at the interface between two traditional engineering departments.

The disadvantage of a degree like Computer Systems Engineering is that if you are looking for a job that deals solely with computer software then you are probably not the ideal candidate. This is because someone with a degree in Computer Science is likely to have more knowledge in Computer Science than a Computer Systems Engineer.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

A candidate coming out of college needs to have a thirst for learning new concepts and a desire to tackle problems they may not know how to solve. Entry level employees in Systems Engineering need to know how to program in C++ and Visual Basic. Teradyne also uses other programming languages like .NET. The point is that you do not need to know all of these languages coming to work for Teradyne. If you know one and can pick the rest up on your own then you will be just fine.

The skills that a candidate needs to possess coming out of college ultimately depends on the job description. For example, let's say there is a position open in Computer Science and Teradyne is looking for someone who knows how to program in C#. If I had the choice between two candidates that were equal in all aspects except one knew C# and one didn't, I would take the candidate that knew C#. However, if the candidate that did not know C# was a good problem solver and the candidate that did know C# wasn't, I would take the candidate who did not know C#.

An entry level systems engineer is going to need to know how to break a problem down into specific realizable tasks. For example, systems engineers receive specifications for a large system. A system engineer in the group needs to ensure that the engineers working on the hardware as well as the software abide by all the same standards. Thus, systems engineers need to be able to design at a high level.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

It is useful to have studied a variety of engineering fields. For example, all engineering students at BU, regardless of their discipline, receive a foundation in engineering which includes a course in mechanics.

My husband is a Electrical Engineering manager at another company. While he was an undergraduate he took a number of courses in Mechanical Engineering which helps me in his job today. It has helped him because he manages a cross-functional team.

Again the importance of a specific major depends on the job description. If Microsoft is looking for a software engineer they are not going to care how much knowledge of hardware engineering you have if it does not relate to the position.

The benefit of having a broader background will be very beneficial for those students who wish to get into management.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

I would definitely choose the candidate who was broader and had an electrical engineering degree. Although it depends on the job for which you are applying. In general, if you are unsure of what you want to study at the undergraduate level then you should stay broad.

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

There are so many things that would have been good to learn at the undergraduate level. Rather you should know how to learn and be able to take on a problem where you don't know all the answers. Teradyne advocates practical engineering and a good portion of the engineers time is spent learning new material on the job.

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

Yes we do hire WPI graduates. In terms of competitiveness a number of my colleagues are WPI graduates. To get more specific information regarding WPI graduates you may want to speak with the human resources department. In addition to WPI Teradyne hires from Northeastern, RPI, BU, and MIT.

Teradyne, July 13, 2006

Joe Wrinn, Semiconductor Test Division, Electrical Engineering Manager

Joe has worked at Teradyne for 31 years and received his undergraduate background in Electrical Engineering.

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

It is important to note that graduates coming into Teradyne are not productive for the first 6-9 months. During this transition period a new hire learns how to transfer the theory they learned in school to practice.

That being said, a graduate coming into Teradyne needs to know how to think and solve problems. The fact is that most people will change their career several times throughout their lifetime and as a result the broader education you can get at the undergraduate level the more options you will have in searching for a career. Additionally with a global economy it is imperative that you can understand people of different cultures and know where they are coming from. Furthermore, a student should specialize at the Master's level rather than the undergraduate level.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

Again the skill you need coming out of college and after being in industry is problem solving. One's problem solving ability will become more proficient with experience in the industry. It's tough to say what skills you are going to need coming out of college. For example, I'm a EE major and I remember solving a problem a couple years ago which required my knowledge of solid state physics. I took a course in solid state physics when I was an undergraduate and was able to apply some of the concepts from that course in my work. I didn't know I was going to need that knowledge 30 years ago. I think staying broad and expanding your palette of knowledge while you're an undergraduate should be something that is done as frequently as possible.

It really comes down to what you're passionate about and not what the outside world wants.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

It really doesn't matter what the major of the candidate is as long as they have an understanding of the basics. The title of the major is only useful for marketing purposes. Let me come back to what I mean by an understanding of the basics. For a EE this would be an understanding of circuit theory, feedback, control loops, and transistors.

What is always good to see in a potential new hire is how they solved a problem. This problem is usually realized in a project. Projects never go 100% according to plan. What I'm looking for is how the graduate was able to overcome the issue of their project.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

If the students were equal otherwise, I would choose the student with the broader background. Regarding multidisciplinary combinations, here are my suggestions:

- 1.) CS + MA
- 2.) EE + ME
- 3.) EE + BB
- 4.) EE + PH

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

See answer to question 2 which address the value in having breadth.

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

WPI graduates are very competitive. Nothing comes to mind that is lacking in all WPI graduates. On the east coast we hire from WPI, RPI, MIT, McGill, and Northeastern. On the west coast we hire from Berkeley, Stanford, and Harvey-Mudd.

Amphenol RF, June 23, 2006

Owen Bartholmes, Director of Engineering

1.) In your experience, what does Amphenol RF look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

College graduates coming into an entry-level position need to have hands on practical knowledge of how to apply the ideas that they have learned. The application of their engineering knowledge is a crucial asset.

It is important for Mechanical Engineers to know about geometric tolerancing and how to detail a drawing. Even more importantly, Mechanical Engineers need to know how to use CAD because this is what they spend most of their time doing when they come to work for Amphenol. As a new hire demonstrates their proficiency in basic drafting, they will be given additional responsibilities and tasks. A new hire needs time to get their arms wrapped around the inner-workings of the company understanding the naming conventions, formats, and specific nuances of how the company operates internally. Other skills that are important for a new hire is the ability to understand and be able to apply Finite Element Analysis.

No matter what type of engineering degree you receive, the fact that you were able to obtain the degree says a lot. It says that you have a internal drive, are self-motivated, and intelligent. The value of depth and breadth will depend on the company. For example, at Amphenol, a broad skill set is more desirable.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

It is important for candidates to have the feeling of the culture of a specific company whether or not that is Amphenol. This is the very reason why co-ops and internships are so valuable. Not only do they give you industry experience, but they give you the opportunity to work in an atmosphere that you will need to adjust to. In college you can't prepare ten years out. The most valuable experience you can get is spending time in the company working.

At Amphenol it is beneficial if a candidate has a solid foundation of the basics behind electrical engineering and mechanical engineering. This is because connectors, what we make, are electro-mechanical components.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

The number of students graduating with an engineering degree in the U.S. has been declining. I think more and more engineers are going to have to be able to adapt to various situations and be less of an expert and more of a generalist.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

The ideal candidate for Amphenol would be a student who has knowledge of RF circuit design. Increasingly, more ECE students are graduating with lots of knowledge of computer engineering but when it comes to high-frequency applications they are lost.

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

Tolerancing is a skill that is skipped over at the undergraduate level and many times we have to send new hires back to an extended education program to learn geometric dimensioning and tolerancing.

In addition, classes in management, project management, and multicultural communication would have been very helpful. A knowledge of CAD package is very useful, specifically Pro-E or SolidWorks.

Other classes that would have been good to have exposure to are psychology and communications so I would have had a better idea of how to interact and motivate people.

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

Most of the schools Amphenol looks to hire from are in the Connecticut area since we are based here. Outside of Connecticut we look to hire from RIT, Clarkson, RPI, and WPI. WPI is a school we have been looking into more recently due to the amount of project experience WPI graduates receive.

Advanced Micro Devices, June 5, 2006

Sean White, Hardware Engineer

Sean received his B.S. in Physics as well as his M.S. in ECE from WPI. He graduated with his M.S. in 1991.

1.) In your experience, what does Advanced Micro Devices look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

The specific skill set of an undergraduate is not important. What is important is that the graduate has a firm understanding of the basics of his/her field, whatever field that may be. Graduates need to know how to think critically. This can be shown in project work where you tackle a project that interests you and through this project you are able to demonstrate your ability to problem solve. Therefore more than anything else, a college graduate coming to an entry-level position needs to have strong project work in school and in industry via a co-op or internship.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

College is a place where you need to understand the basics. For an ECE this involves having an idea how a circuit works if a schematic is placed in front of you. Specific knowledge of how to apply the basics will come on the job and depend on the industry you eventually are apart of. That being said, a candidate needs to be able to work effectively with other people. If you cannot do this then you will not be as successful as you otherwise could have been.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

You really should follow your passion and engage yourself with projects and classes that interest you. If you are successful at what you do then you will be able to market your skills and job opportunities will certainly arise.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

I would rather hire the student with the broader background. That being said, you should take advantage of the time you have as an undergraduate to get exposure to things that you know absolutely nothing about. When I was an undergraduate at WPI I would use my electives to take classes in departments that I did not belong to because I had an interest in learning as much as I could.

Regardless of your degree, if you work hard, are thorough, and precise, you will be able to market your skill set to an employer and will find work.

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

A knowledge of quantum computing and semiconductor physics would have been helpful. Although I think it really depends on what niche of your industry you get involved with. You can't predict what you are going to need to know. Keep an open mind and take courses that interest you.

Some of the skills that are useful to know in Advanced Micro Devices are a knowledge of performance modeling and simulation. If given a design for something, how do you go about improving upon that design.

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

We have a preferred list of schools that we hire from. WPI is currently not on that list. We look to hire graduate students that come from universities that have very strong graduate programs in digital computing. These universities tend to be some of the larger ones like University of Michigan that has a strong graduate program in Computer Engineering. MIT also has a very strong graduate program.

GE Aviation, August 1, 2006

Lonnie DeLuca, Lead Engineer / Employment Recruiter at WPI, WPI Mechanical Engineering '02

1.) In your experience, what does GE look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

GE would look for any student who has a rock-solid understanding of the SCIENCE behind engineering. These are the basic advanced high school level/ early college classes (Physics 1 & 2, Calc 1, Lin Alg, etc). Getting these 'theory' science classes down is the ticket to solving the sophisticated and complicated problems we encounter everyday in engineering at GE.

Only slightly second in importance is the SCIENCE classes in the MAJOR FIELD OF STUDY. For a Mechanical Engineer, this might be Heat Transfer, Fluids, Stress Analysis, Dynamics and Statics. Again, Getting these ‘theory’ science classes down is the ticket to solving the sophisticated and complicated problems we encounter everyday in engineering at GE.

Once the foundation has been set, GE would want to see that the student takes classes in what they are truly interested in. This SHOULD be what the student major is. Unfortunately, with the some students I see it tends not to be the case. (i.e.. “my mom says I should go into Healthcare because there are a lot of baby boomers, so I am biomed... but I really love to go to air shows and I have a pilot’s license!”). We want to make sure that the student really WANTS to continue in their major field after college if we’re taking the time to invest in them. By taking several high-level classes in their major that tells us that they are interested in the field and have a curiosity to learn more.

Although I would recommend learning as much as possible in your major, one cannot live in a bubble. Engineering in general is a multi-disciplinary field. A chemical engineer’s pharmaceutical is no good without a mechanical engineer making the correct type of packaging. Aerospace engineers can’t make a plane fly without electrical systems or fuel controls. GE would look for a student that has a very basic understanding of high-level engineering concepts related to their field. For example, we would expect that a Mechanical Engineer would understand how electrical resistors could be in parallel or series and what the effect on voltage might be because of it. We wouldn’t expect them to remember that this is Ohm’s Law or go into any more detail.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we ever going to use those high level classes?

There are only three skills I think students need to possess coming out of college, some of which may be surprising. I’ve listed them in order of importance.

1. Demonstrated “Thirst for knowledge” in the field they are studying
2. Demonstrated teamwork experience IN INDUSTRY
3. A solid knowledge of the science behind their engineering major.

It is often thought at WPI that project work is the best way to get the above skills. I cannot disagree more. #1, Colleges are required to have a senior capstone engineering class, and many universities turn this into an “MQP” type project, usually paired with industry (BU, NEU, Michigan, Ohio State, MIT, for example). The project work does not differentiate you. #2, although companies are increasingly socially aware and appreciate the global mindset of an IQP, without a strong MQP project work is meaningless to companies.

MQPs need to be tailored to your specific major and what you want to do in your career. If you want to use them as a gateway to getting a job, then you need to be in an industrial setting. If you're looking to do research, then staying at WPI or going to another university lab is a great option. But don't go to a project center for the location if your main goal is to get a job out of it. Often times the work offered at project centers are not exactly what the student would like to do and the center may be somewhere that the student wouldn't feel comfortable moving to long-term.

A better way to get the above skills is through a co-op or internship with an industrial company that you may want to work for after college. This internship can even be linked up to an MQP project, many companies see this as a win-win situation. Companies look for prior employment **IN YOUR MAJOR**. Working at Joe's Supermarket or the community pool during the summers in between college years doesn't cut it in today's job market.

Companies tend to train employees in the 'engineering' of their product and will not give you the high-level decision making skills that you used to have in your engineering class projects. If you have the science fundamentals you can be trained in any specific types of engineering you'll need to do for your job.

These three skills paired with continuous on-the-job learning will make your career a success 5 and 10 years out.

3.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

If GE worked in Acoustics, yes. If not, no. This question is really going to be company dependent. I would love it if all of WPI were ME/Aero double majors; it would be the perfect fit for GE Aviation. But, it limits the option that the student has. So unless the student is absolutely sure they want to be an Acoustics Engineer and work for 1 of 10 companies in the country, the broader the better (for marketing reasons only). It really depends on what the student wants to do in their career.

4.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

1. More emphasis on the major concepts rather than trying to data-dump in the 7 weeks term.
2. More math in the engineering classes. At the graduate levels, this is key to being successful.
3. Increased emphasis on the science behind the engineering classes.

4. More 'general' engineering elective classes at the sophomore level, like CAD 101, Research 101, etc.

5.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

Yes, we are always looking to hire more WPI graduates! WPI has a very good reputation locally for good engineering work. WPI graduates tend to be more technically focused than the bigger schools we recruit from (BU, Northeastern, Michigan etc.).

However, WPI students cannot sell themselves well and in general do not communicate as well as other college graduates. The bigger schools have more required liberal arts classes like English, freshman writing, etc. where they are required to get up in front of an audience.

Also, because WPI is such a tight knit and close school, students get used to speaking with people just like them (engineers). Interviewers are usually NOT engineers. WPI students need to understand their audience and be able to boil their technical projects down into two or three main selling points and NOT go into every detail. Students at larger schools that we recruit from talk to acting majors, marketing majors, etc, not just engineers. Their social skills in general are more adjusted to different types of audiences, which shows in WPI interviews.

The school needs to provide better training in the soft skills to make WPI students more competitive. WPI students are some of the smartest around, but if you can't sell yourself no company is going to see how great you truly are.

Teradyne, August 3, 2006

Brad Robbins, Vice President and General Manager

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

I am the Vice President and General Manager of our Systems Engineering group. The systems engineering group requires a broad knowledge of computer engineering and computer science.

The most important skill that a college graduate needs coming into an entry-level position is the ability to solve technical problems. The ability to work in a multidisciplinary team is a key skill that all candidates must have.

The thing you have to keep in mind is that engineering is fundamentally different than other professional degrees like law and medicine. The big difference being that an engineering can

enter the workforce and have a degree in hand after four years. That being said, an entry level position at any company, including Teradyne, values a particular skill set of that college candidate. Therefore I think you must be careful not to be too broad and leave after four years not having a particular skill set that is of value to a company.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

See answers to questions 1 and 5.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

A broad degree in engineering can be valuable for a particular subset of students. Let me clarify this point. On the west coast we hire a number of graduates from Harvey Mudd. These students graduate with a degree in Engineering. We only look to hire the top students in Engineering at Harvey Mudd. This is because I think it is valuable to have a student that can demonstrate competence in one specific field. It is tough enough finding those graduates as it is. So what I'm saying is that if you are the cream of your crop, no matter how broad your field is I'm going to hire you. If you're not, you are better off in focusing in one specific field and being able to come to the table with one degree on your belt.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

The idea of being a generalist is very helpful in Engineering although it is difficult to get much of this exposure during a four year undergraduate education. If you can be broader it definitely will aid you in your career but you must be mindful of the points I made in question 3.

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

The biggest thing that I can think of is global awareness. I work on a daily basis with people from all over the world and being able to understand where they are coming from, which many times has to do with their background, is vital. Some sort of education in cultural skills is important for an incoming graduate.

As a software engineer you may find yourself working with someone in India or Germany on a project.

Here are a list of things that come to mind that would have been good to know:

- 1.) Engineering product development
- 2.) Cultural awareness
- 3.) Effective communication through writing

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

I'm not too familiar with the specifics of how we hire on the east coast but what I can tell you is that we do have a number of WPI graduates working at Teradyne. On the west coast we look to hire from Harvey Mudd, Cal Tech, and University of Arizona.

The biggest competitor of WPI on the east coast, in terms of who Teradyne looks to hire from, would be MIT. MIT graduates are very strong and are good at what they do. That being said, MIT's students tend to specialize quickly and become very good at that one thing. They seem to have a harder time thinking more broadly and tend to be less well-rounded. WPI graduates on the other hand are broader thinkers and self-driven which I think is a consequence of the unique course and project structure at WPI.

Teradyne, July 31, 2006

Mereen Mamman, Electrical and Computer Engineer

Mereen received her B.S. in Electrical and Computer Engineering from WPI in 2005. She has been working at Teradyne for the past year. I work in a group called the Test Assistance Group (TAG) which provides one-on-one support to customers. We take requests that deal with problems customers have with our testing units. We then perform measurements and attempt to fix these problems for them.

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

Teradyne starts you off with some very basic projects. You need to have knowledge of the fundamentals. Specifically, you should know Microelectronics. I found myself referencing my Microelectronics books numerous times to familiarize myself with topics that I had not looked at in a couple years. Within Microelectronics, knowledge of op-amps and their applications are very useful.

It is useful to have knowledge of Visual Basic. If you do not know this language it is easy to pick it up if you have knowledge of some programming language. This I think is an important skill to have coming out of school as an engineer. There is definitely **a lot** to learn coming to Teradyne. For example, I found myself working with measuring leakage current on the order of pico-Amps. The analysis of this problem led me to learning some aspects of Physics I had not previously known.

I think a co-op would have been beneficial to me because it would've aided me in making the transition from college to industry.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

Regarding the high level classes, thus far I have only used information that I learned in my basic ECE classes. I have not used the material I learned in the higher level classes such as ECE 4902.

Coming out of college a graduate is going to have to face an interview which is the first barrier that tests your knowledge. My interview with Teradyne was very technically oriented. I was asked a number of general ECE questions. They made you think and ensured that you knew the fundamentals of your major.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

I think it is more important to be focused in one discipline. This is because you will really have to learn a lot about the company you work for when you start. There is no way that you will be able to learn everything before leaving school. Thus, get a solid foundation in one field and then move onto industry.

I find myself still studying and learning new material. At time it's frustrating because you think that you would be more knowledgeable coming out of school.

4.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

Texas A+M offers a course on testing and measurement which is specific to Teradyne's field. This would have been very useful to me but it is impossible to provide courses on every company at WPI.

Knowledge of OrCAD, EE CAD software, would have been helpful.

5.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

I do not know much about the hiring process but there are a number of WPI graduates at Teradyne that I work with on a daily basis.

Teradyne, June 12, 2006

Andrew Solitro, Electrical and Computer Engineer

Andrew Solitro, class of 1999, graduated with a degree in Electrical Engineering. He has been working at Teradyne for the past seven years.

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

For EE, Teradyne looks for a candidate who has an understanding of the fundamentals of EE. This pertains to a knowledge of circuit analysis.

Knowledge of simulation tools and programming languages is helpful but definitely not necessary.

Project experience through the MQP and IQP is always something Teradyne will look at in candidates coming from WPI. Specifically they are interested with how you were able to overcome the difficulties in your project.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

Since I have been at Teradyne I have never had to use the knowledge I obtained in my high-level EE classes. A knowledge of the fundamentals is all I have needed the past seven years. I took this one class in audio engineering that I thought was interesting but it has done nothing for me. I looked to get a job at Bose but they are not going to hire someone who has taken one class in audio engineering.

Unless you know exactly what you want to do, which most people don't, I'd give the advice to stay as broad as you can. Keep your options open because you don't know where you will end up in industry.

If you have a process you need to know how to decrease the cost, increase the quality, and decrease the time.

3.) How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?

The tradeoff between breadth and depth is as follows: You need to know enough about one area so that you can demonstrate you have an understanding of the fundamentals. At the same time you want to stay as broad as you can to keep your options open.

For example, I'm an Electrical Engineer but one thing that would be useful to have taken a class in is how to design a test floor so as to optimize the productivity. There is probably a course in Industrial Engineering that I could've taken that would have been beneficial to me.

4.) If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?

Again I would prefer the student who had the broader exposure if they could show a solid understanding of the fundamentals.

Regarding combining various engineering programs, computer engineering and software are the most compatible. You could also combine manufacturing, mechanical, and industrial engineering with EE.

5.) What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?

A knowledge of C/C++ and Visual Basic are extremely helpful seeing as how they are the two primary programming languages utilized at Teradyne.

Circuit analysis and simulation tools like PSPICE.

It would have been good to know how to optimize a setup so as to maximize productivity.

A course in project management.

How do you ensure the quality of a product?

Computer Aided Design → SolidWorks.

It all comes down to do you have the skills to meet the needs of the company. If a company is looking for someone who has skills x, y, and z and they can find one guy that knows all three they are going to hire him over hiring three individuals one of whom has each of the skills.

I really didn't know what to take when I was an undergraduate. Let me phrase that differently, I didn't know what courses were going to be beneficial 5-7 years out of my job.

6.) Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?

Teradyne looks to hire from WPI, BU, MIT, and McGill. You can't distinguish who the WPI graduates are from the MIT graduates. You may want to talk to my boss regarding more insight into who we look to hire from and what schools are competitive.

Teradyne, July 25, 2006

John Toscano, Mechanical Engineering Manager

John Toscano graduated from WPI in 1997 with a degree in Mechanical Engineering. He has worked at Teradyne for the past nine years.

1.) In your experience, what does Teradyne look for in a college graduate coming into an entry-level position? Specifically, what is the tradeoff between breadth and depth? Would you rather have someone who is really focused in one area or someone who knows engineering concepts well but has explored multiple branches of engineering?

Project work and summer experiences are the top two things Teradyne looks for in a college graduate. These experiences often are good indicators of how the candidate will perform once he/she is on the job.

For a Mechanical Engineer, a knowledge of CAD and geometric dimensioning and tolerancing are important but not mandatory. Teradyne can send new hires away to learn different skills that will be necessary in order for them to succeed.

2.) What skills does a candidate need to possess coming out of college? What skills will this candidate need to continue to succeed after 5 years of industry experience? 10 years? Is a breadth of experience in multiple fields better than depth in one field? Are we going to use those high level classes?

The ideal candidate, in ME, knows stress analysis, structural materials, CAD models, electrical fundamentals, and a familiarity with geometric dimensioning and tolerancing.

In addition, the candidate is going to need to fit in with the team at Teradyne. If he/she can't get along with the people in my group then they will not be successful. We're not looking for specialists, rather we are looking for someone who understands the fundamentals and is able to apply them to practice.

See Appendix F for a partial listing of skills that we keep track of with our Mechanical Engineers.

3.) *How important is one specific major assuming the candidate has studied some branch of engineering? Would you rather just see someone who has studied a variety of fields at a prestigious undergraduate engineering institution? What's the tradeoff?*

A major is only useful for marketing purposes. It doesn't matter so much what you major in as long as you have the skills that I have described in the previous two questions. On a daily basis about 10% of your day will be spent doing analysis, the rest of the day is spent on obtaining the correct information, taking data, and interacting with other people in the company. People that have the added benefits of additional skills that may or may not be applicable to the company is just an added bonus.

4.) *If a new major was introduced at WPI in a field related to the target field (i.e. acoustical eng. in relation to mechanical eng.), would you prefer one student over the other, provided all other things were equal? More specifically, if you had an acoustical position would you rather have someone that was solely focused on acoustical or was broader in the sense that they had an electrical engineering degree as well?*

It would honestly depend on the candidate but the person with the broader background would probably be a better fit for Teradyne.

5.) *What knowledge would you have liked to have when graduating from college that you didn't? Specifically, what knowledge would have helped you in the position that you are in today?*

- 1.) A class that teaches you how to design and run a valid experiment.
- 2.) A knowledge of control theory
- 3.) LabView

It would've been really beneficial if you had labs in thermodynamics, heat transfer, fluids, dynamics, and stress analysis. These classes you just seemed to crunch numbers and learn a lot of topics in a short amount of time. I was never able to develop an appreciation for how to apply the ideas in these classes.

6.) *Do you look to hire WPI graduates? If so, why? How do WPI graduates compare to schools that you hire from more frequently? What could be done to improve WPI graduates' competitiveness in the job market?*

Carnegie Mellon has students that are solid in software. We look to hire students from WPI and MIT and other schools that are close to Teradyne. What school we hire from also has a lot to do with the politics of the company. If a lot of the senior VP's came from MIT then Teradyne is going to look to hire more students from MIT.

Appendix C – WPI Administrator and Staff Interviews

Admissions Interview, March 31, 2006

Kristin Tichenor, Associate Vice-President, Enrollment Management

- 1.) *Do you think it's important for us to focus on just one multidisciplinary program and really sell it as opposed to introducing multiple programs at the same time?*

She advocates a broader appeal, because one program alone will attract so few students. Mechatronics (the example that I introduced and briefly explained to her) might attract one student per year, and that is simply not a feasible long-term plan for a program. Anything we can put out there that broadens our programs is great. A lot of HS students are undecided—these programs will give them new avenues. We need to create an infrastructure for these “special” HS students, the ones who want more than just one major. It should also be formalized so that it can be appropriately recognized on their transcripts.

- 2.) *What do high school students want from WPI in terms of academics that we do not offer yet? Is there one specific program that they always ask for that is multidisciplinary?*

Architecture is the most popular. Others are forensics, nanotechnology, bioinformatics (which is actually in the works right now), genetics, etc. I proposed to Kristin the possibility of Acoustical Engineering, because I can immediately see the market for that locally with BOSE being located in Framingham and Cambridge Soundworks also located throughout New England. She agreed that Acoustical Engineering is a good potential new program.

- 3.) *What are the most important factors that high school students consider in any sort of new program? For example, what sort of student has enrolled in IMGD so far?*

I asked her first how IMGD came about. The story is as follows: Every year, there's a faculty retreat, and two years ago, Bill Durgin, the Associate Provost for Research, asked faculty to come up with a new multidisciplinary program, and Profs. Gennert and Quinn came up with the idea for IMGD. Kristin said that at college fairs, HS students were asking about IMGD even before we had done any publicity on it.

As far as important factors, we need to assure students that there are faculty who are committed to the program and that there is at least one cohesive 4-year schedule for this program as well as plenty of literature on what kinds of jobs students can expect to get when they graduate.

4.) *What is the official list of our “peer” schools?*

The list is at <http://www.wpi.edu/News/Conf/CACHET/members.html>

5.) *From the research that we have done so far, Purdue is the only school that has a cohesive “multidisciplinary” program. WPI will likely be the first to implement such an initiative among our peer schools if this all works out. Do you think that this is a worthy investment for the future of WPI?*

It depends on what we offer. If it’s a flexible program that supplements our current offerings, then that will definitely appeal to students. It is definitely in our best interest to consider programs which do not require any additional resources in terms of labs or faculty.

6.) *As we move forward with this project, what can we give you that would be useful to your marketing efforts? What sort of data do you need to convince high-school students that this is an exciting opportunity and that there is a real future for them in this particular field (or combination of fields)?*

Any information from employers saying they want a certain program would be great. This will probably be the kind of program that won’t appeal to students who haven’t chosen a college yet, but definitely will attract students who have gotten into WPI and are looking at specific options.

Career Development Center, April 5, 2006

Connie Horwitz, Assistant Director, Employer Relations

1.) *What companies hire the most WPI undergraduates?*

The top hiring companies for 2005 were:

- | | | |
|-------------------------|-----------------------------------|-------------------------|
| 1.) Raytheon | 9.) IBM | 17.) Teradyne |
| 2.) United Technologies | 10.) U.S. Patent and Trade Office | 18.) Waters Corporation |
| 3.) General Electric | 11.) BAE Systems | 19.) NMS Communications |
| 4.) MIT Lincoln Labs | 12.) Charles River Laboratories | 20.) Cytoc |
| 5.) EMC | 13.) Athena Diagnostics | 21.) Intel |
| 6.) Fidelity | 14.) Empirix | 22.) Bose |
| 7.) Meditech | 15.) GZA Environmental | 23.) DePuy |
| 8.) General Dynamics | 16.) National Grid | |

2.) *Is there a need for undergraduate multidisciplinary programs at WPI?*

Her gut reaction was no. Employers usually come looking for students who are specifically of one discipline or another. Although if there was a degree in Electro-Mechanical

Engineering she is sure that there would be a solid demand for it. She has seen some trends among what employers are looking for in all disciplines. That is, employers always like to see competence in programming, business, communications, and the arts. The overall message is that success for any graduate in a technical major depends on the individual's ability to communicate and connect with the people that he/she works with.

When employers come to WPI looking for new hires the reason that they are usually looking for a student who is a purist in one discipline is because there is a job opening due to expansion, turnover, or attrition.

3.) *Have companies requested that WPI graduates have certain skills coming out of college?*

Every company wants more courses in their fields or courses that teach their technology.

4.) *How important is ABET accreditation to employers?*

Employers are not familiar with ABET accreditation and most do not know much about it or what it is. They assume the school has a solid reputation based on the reputation of the institution.

5.) *Could you provide me with a contact for the companies that hire the most WPI graduates?*

She was only able to provide me the following three people.

Caleb A. Warner, Raytheon Integrated Defense Systems, WPI Alumnus, 978-858-4337,
Caleb_A_Warner@Raytheon.com

Ryan Walsh, Pratt & Whitney (United Technologies), WPI Alumnus, 860-565-9217,
ryan.walsh@pw.utc.com

Victoria (Tory) Regan, General Electric, WPI Alumna, 781-594-8779,
victoria.regan@ae.ge.com, Team Leader for GE recruiting on campus




6.) *If you were in my shoes, in what ways would you go about getting answers to this issue?*

You should definitely speak with the Dean of Undergraduate Studies once that position has been filled.

Appendix D – Results of myWPI Poll

The following poll was open to students on myWPI from September 15, 2006 – September 24, 2006.

What do you think of the idea of a new major in Computer Systems Engineering, a combination of Computer Engineering and Computer Science? It should be noted that this program would not replace any current WPI program.

I think the program would be beneficial to WPI students.	568 / 47.33%
	
I do not think the program would be beneficial to WPI students.	99 / 8.25%
	
I do not know enough about the fields of Computer Engineering and Computer Science to answer that question.	533 / 44.42%
	

Appendix E – Purdue Multidisciplinary Engineering Four-Year Plan of Study⁴¹

Freshman Year		
Fall Semester		
Course #	Course Title	Credits
MA 16X	Plane Analytic Geometry and Calculus I	4/5
CHM 115	General Chemistry	4
ENGR 126	Engineering Problem Solving & Computer Tools	3
ENGL 106/108 or COM 114	First Year Composition or Fundamentals of Speech Communication	4/3
ENGR 100/103/104	Freshman Engineering Lectures	1
Total:		15-17
Spring Semester		
Course #	Course Title	Credits
CHM 116 or CS 159	Chemistry or Programming Applications for Engineers	4/3
MA 162/166	Plane Analytic Geometry and Calculus II	4
PHYS 172	Modern Mechanics	4
ENGL 106/108 or COM 114	First Year Composition or Fundamentals of Speech Communication	4/3
Total:		14-16
Sophomore Year		
Fall Semester		
Course #	Course Title	Credits
MSE 230	Structure and Properties of Materials	3
MA 261	Multivariate Calculus	4
ME 200, CHE 211, ABE 201	Thermodynamics	3
SCI 190	Integrated Science	3
	General Education Elective	3
	MDE Professional Seminar*	1
Total:		17
Spring Semester		
Course #	Course Title	Credits
IDE 495A	MDE I: Physical Properties in Engr. Systems*	3
IDE 495B	MDE II: Manufacture and Assembly*	3
ECE 201	Linear Circuit Analysis I	3
MA 262	Linear Algebra & Differential Equations	4
EPCS 201	Engr. Projects in Community Service	1
	General Education Elective (optional)	3

⁴¹ “MDE Four-Year Plan of Study – Purdue Engineering.”
<https://engineering.purdue.edu/ENE/Undergrad/MDE/plan>. September 2006.

Total:		14-17
Junior Year		
Fall Semester		
Course #	Course Title	Credits
ABE 591W/BME 595U	MDE III: Nonlinear Dynamics of Biological Systems*	3
IDE 496D	MDE IV: Multidisciplinary Modeling and Computational Methods*	3
EPCS 301	Engr. Projects in Community Service	1
IE 343 or Technical Elective	Engineering Economics or Technical Elective	3
	Technical Elective or Undergraduate Research*	3
	General Education Elective	3
Total:		16
Spring Semester		
Course #	Course Title	Credits
	MDE V: Multiscale and Multisystems Engr*	3
ABE 460 or ME 365	Sensors and Process Control or Systems and Measurements	3
ME 309 or CE 340 & 343	Fluids	4
EPCS 302	Engr. Projects in Community Service	2
	General Education Elective	3
IDE 301	Professional Seminar	1
Total:		16
Senior Year		
Fall Semester		
Course #	Course Title	Credits
	MDE Selective*	3
	IE 343 or Technical Elective	3
	Engr. Management & Entrepreneurship*	3
	Engr. Projects in Community Service or Undergraduate Research* or course with lab	3
	General Education Elective	3
Total:		15
Spring Semester		
Course #	Course Title	Credits
	MDE Selective*	3
	MDE VI: Communication Systems Engineering*	3
	General Education Elective	3
	General Education Elective	3
IDE 485	MDE Design*	3
Total:		15
Minimum Four-Year Total Credits:		124

APPENDIX F- Teradyne Continuous Learning Matrix

Continuous Learning Matrix Mechanical Engineering Management Skills	
Manag Interpers. Rel.	Personnel
Situational Leadership	Personnel
Negotiating to "Yes"	Personnel
Time Management	Personnel
Technical Speaking	Personnel
Power Speaking	Personnel
Career Development	
Tolerancing Analysis Methods (six-sigma)	TBD
Mechatronics	College Course
Project Management Tools and Techniques	Personnel
	ASME/Lowell
Formal GD&T Training Basics	Foster/WPI
	ASME/Lowell
Formal GD&T Training Advanced	Foster/WPI
FMEA Training	Reliability team
Project lead experience	Manager / Mentor
Legal / Corporate Processes	
NDA / Joint Development	Manager
Patents / Intellectual Property	Manager
Purchasing Process	Manager
Ethics	Manager
Reliability	Manager
SLM Overview	Manager / SLM
Interview Skills	
Interview Training	Personnel
Lunch / Tour Class	Personnel
Relevant Experience	
EMI shielding/grounding (electrical x-training)	Russ Bechard
Grounding techniques for signal integrity (electrical x-training)	Russ Bechard
Power distribution (electrical x-training)	John Russo

HALT experience (design of fixtures and data gathering process)	Reliability team
Design of Experiments (DOE)	TBD
Acoustic noise measurement / analysis	John Toscano
Clearquest Bug Tracker (submitting and closing bugs)	TBD
Computer Tools	
EMS Introduction	Steve Hess
EMS Variatnl Modeling	Steve Hess
Solid Works CAD - Basics	US CAD
Solid Works CAD - Advanced Part and Assembly	US CAD
Solid Works CAD - Sheetmetal and Weldments	US CAD
Solid Works CAD - cable Routing	US CAD
Solid Works CAD - Stress Analysis (Cosmos)	Bruce Cowgill
Solid Works CAD - Circuitworks module	Bruce Cowgill
SMARTTEAM - PDM software and process	Steve Hess
ProE CAD - Basics (Parts and drawings)	PTC
ProE CAD - Advanced Assembly	PTC
ProE CAD - Sheetmetal	PTC
ProE CAD - Surfaces	PTC
ProE CAD - Stress Analysis (Mechanica)	PTC
ProE CAD - ECAD module	TBD
INTRALINK - PDM software and process	Steve Hess
Allegro Viewer and .emn creator	TBD
Visio	OJT
Jump Statistical analysis tool	TBD
FlowTherm (thermal x-training)	Rhonda Allain
Microsoft Excel	TBD
Microsoft Powerpoint	TBD
Lab Equipment	
EG 4/200 Prober Basic Operation	Alec Gomez
TSK UF200S Prober Basic Operation	Alec Gomez
TEL P12XL Prober Basic Operation	Alec Gomez
Lab Windows	Manual
Microscope	Online
Network Analyzer	Parrish
Soldering Practices	Parrish
TDR Equipment	Parrish
Wafer Works	Alec Gomez
XYZ Fixture	Art Lecolst
Reliability Fixture (The Rock)	Parrish
CMM (Coordinate Measuring Machine)	Kristin Lorenze

Oscilloscope basics	Bill Bodkin
TDR/VNA test equipment basics	Charlie Sweet
Wind Tunnel / hydraulic resistance testing (thermal x-training)	Tim Scott
Processes	
PC Design (PCB tracker)/ Outline Drawing	Scott Shankle
PCard & Hdplt Deflect	Integration
PCard Mfg fixt/tools	OJT
Oracle E-req creation	Ann Rugnetta
I/F Planarization	Integration
Floorplan Creation	OJT
Integration Evaluations	Manual
Safety	
CPR	Personnel
Hazardous Materials	Personnel
First Aid	Personnel