Volume I
Program Self-Study Report

for

Electrical and Computer Engineering

Worcester Polytechnic Institute
Worcester, MA

June 25, 2008

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Prepared for
Engineering Accreditation Commission
Accreditation Board for Engineering and Technology
111 Market Place, Suite 1050
Baltimore, Maryland 21202-4012
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Self-Study Report

Program Name: Electrical and Computer Engineering
Degree Awarded: Electrical and Computer Engineering
Institution Name: Worcester Polytechnic Institute

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Report Organization

This self study is the second for the WPI Electrical and Computer Engineering (ECE) program which was first accredited after the 2002 ABET visit. At that time self study reports for both the Electrical Engineering (EE) as well as the new ECE program were submitted to ABET. This time, only an ECE Self Study report is offered since the WPI ECE department has made a request to ABET to terminate our EE program. Termination of the EE program was covered in a separate letter with justification to ABET.

This volume (Volume 1) contains our Self Study. Volume 2 contains the four ABET specified appendices (Course Descriptions, Faculty Vitae, Laboratory Equipment, and Institutional Summary) while Volume 3 includes all other supporting material appendices.

Report Preparation

All ECE faculty have been involved in the preparation of this self-study and in preparing the supporting documentation. Profs. Hossein Hakim (Associate Head) and Fred Looft (Head) have played the largest roles in writing and assembling this report.

ECE Program Summary History

On July 1, 1992, the name of the department was changed to Electrical and Computer Engineering, in recognition of the substantial role of computer engineering in the undergraduate and graduate curricula, and growing computer engineering research and development activities. In addition, a significant number of students had been pursuing courses of study with a strong computer engineering component. As a result, in academic year 1995-96 the department established a formal concentration in Computer Engineering, partially in response to student requests.

As the Undergraduate Program Committee (UPC) continued monitoring the administration of the Computer Engineering concentration, it was noted that the Computer Engineering concentration tended to cause overspecialization and narrowing of focus at the expense of breadth within ECE. Subsequently, the UPC began seriously considering the implementation of an ECE major in the 1998-99 academic year. The possibility of developing an ECE major had first been raised explicitly in late 1995 when the ABET criteria for ECE programs were distributed to the department faculty. As part of this consideration, a survey was conducted in the fall of 1999 of all ECE undergraduate students regarding a number of issues, including areas of focus and preferred name of major. The survey results confirmed the UPC's concern
regarding excessive focus in that nearly half the students surveyed indicated a single area of focus within ECE and of those over 60% focused on computer engineering.

In 1999, the UPC began the detailed process of developing an ECE major. At that time there were only four accredited ECE major programs in existence (Carnegie Mellon, U. C. Boulder, U. Minn. Duluth, and Rutgers). It is interesting to note that currently there are 16 accredited ECE programs.

After consideration of numerous implementation issues, the ECE program was created as a separate degree program and offered to a few students in order to be able to bring the program to ABET for accreditation. In AY 2000-01 the faculty of WPI approved the addition of the program of study titled “Electrical and Computer Engineering.” Subsequently, in May of 2002 two students graduated with the ECE degree and we requested an accreditation visit.

Between the previous ABET visit in 2002 and our scheduled visit this year, we have been offering both the Electrical Engineering (EE) and Electrical and Computer Engineering (ECE) degree programs. It is important to note that there are no curriculum components that are unique to either the EE or ECE program. This is important since the termination of the EE program will make no difference whatsoever to the courses, laboratories, faculty or other curriculum components offered as part of our ECE program. Indeed, as noted in our letter to ABET seeking termination of our EE program, there are no students left in the EE program who are seeking the EE degree. This outcome was planned for and is consistent with our long term plan which has always been to phase out the EE major.

Program Options and Program Delivery
The undergraduate ECE program is a full-time, day, on-campus program. Within the ECE major, students may pursue concentrations in subspecialties such as power systems, microelectronics, signals and communications, networking, and computer engineering. Specialties are, however, not noted on student transcripts and are, as a result, only reflect the thematic relationship of the courses taken and the capstone project topic.

Total undergraduate enrollment (four years) in the fall of academic year 2007-08 was 300 students. As of March, 2008, we have the following distribution of students majoring in Electrical and Computer Engineering: 71 first-year: 72 second-year: 76 third-year: 81 fourth year students of which 3 are on coop. We also have 3 transfer (year not determined). The undergraduate enrollment trend over the past six years has been a slow decrease in the total number of ECE students but appears to have stabilized at about ~75 students per class year. The number of graduates for AY 2007-08 were as follows.

1 EE BS degree
82 ECE BS degrees
52 ECE MS degrees
4 ECE PhD degrees.

Program Delivery
The following points are pertinent to the ECE curriculum, and indeed apply to nearly all of the program curriculums at WPI.

1 Additional details provided in the ABET 2002 ECE Self Study report.
3 Discussed in 2002 ABET ECE Self Study.
The nine-month academic year is divided into four academic terms, called A, B, C, and D. There is a fifth term (E) in the summer. All terms are exactly seven weeks in length. Terms A and B fit into the normal fall semester, while terms C and D represent the spring semester.

Students normally enroll in three courses or equivalent activities each term. Hence they complete six courses per semester and twelve each academic year.

The course meeting schedule is compressed, with classes meeting four or five hours per week in lecture and, for courses with labs, typically an additionally three hours a week in lab. Since students study fewer subjects at a time, they can study them more intensely.

Each term-length course is approximately equivalent in academic content to a 3 semester hour course. Hence, in one semester the student attempts the equivalent of approximately 18 semester hours (9 in the first term of the semester, and 9 in the second term).

It is extremely rare for undergraduate students to take courses as part of off-campus, web based or distance educational programs.

Co-operative education is not particularly common in ECE since many students gain industrial experience through their capstone project (described below) or by working a summer internship.

About half of the ECE courses have laboratories associated with them.

Program Structure

Certain aspects of WPI’s educational system are different from common practices at other universities. WPI’s overall system of education is referred to as the “WPI Plan,” which was developed in the late 1960’s with substantial support from the NSF and other foundations. The WPI educational philosophy emphasizes student responsibility for his/her own learning, the need to “learn how to learn,” the value of teamwork and cooperation, and the value of demonstrating outcomes. This philosophy motivates the following aspects of our system:

- There are no required courses, although “Distribution Requirements” (e.g. p.41, Table 2.4) assure that students receive exposure to the appropriate breadth of academic disciplines.
- The grading system, with one exception, does not include the failing grade. Students simply receive “no record (NR)” of courses that they fail to pass, or in which they would have received a “D” or lower. Recorded grades are A, B, and C. The equivalent of a failing grade (NAC for “Not Acceptable”) is reserved for project work where the failure of an individual student may negatively impact his/her team members. It should be noted that failure to pass courses does have significant consequences. Students who do not meet satisfactory academic progress standards are first put on warning, then probation (no financial aid), and then are suspended.
- The unit of credit is called the “unit” and a regular course load for one term represents one unit of work. Hence, one course carries 1/3 unit of credit. Finally, 1/3 unit is approximately equal to 3 semester hours of credit.
- The Degree Requirements for graduation (e.g. p.39-40, Table 2.3) are as follows
  i. at least 15 units (the equivalent of 135 semester hours) of credit
  ii. completion of three major projects (in the humanities, the technology/society interface, and the major area of study)\(^4\)
  iii. a social science component,

\(^4\) Starting in the fall of 2007, matriculated first year students are required to complete two major projects and a humanities and arts distribution requirement.
iv. a physical education component, and
v. satisfy the Distribution Requirements in the major area.

- Note that the **graduation requirement** of 15 units is less than the normal full-time course load that would represent 16 units (4 terms of one unit each for 4 years). This provides some flexibility to the student and results in a credit requirement for graduation approximately equal to 135 semester hours.

- **Projects** are a major component of the WPI education, and have their own jargon. The Humanities component through to end of the 2006-07 academic year was called the “Sufficiency”. Starting with the 2007 matriculating class the requirements changed and the new requirement is now called the “Humanities and Arts Requirement”. The second project requirement represents a project at the interface of society and technology and is called the "Interactive Qualifying Project" (IQP). The third and final project is completed in the senior project in the major area and is called the "Major Qualifying Project" (MQP).
  
  - Newly matriculated students (2007) fulfill a **humanities and arts requirement** by completing two units of work consisting of six student-selected courses. In completing this requirement, students meet the breadth and depth components of the requirement\(^5\).
  
  - Completion of the MQP satisfies the ABET Capstone Design requirement.

- Both the IQP and MQP are often performed for corporate, government, or foundation/NGO sponsors, and often by students who reside for a full term at an off-campus site (as far off campus as Bangkok). These experiences are then not “academic exercises;” they are **real undertakings** that are valued by the sponsors. The projects do, of course, have valuable academic content which is assured by the resident faculty advisors. The students receive credit (generally 1 unit) and grades for these projects.

**Program Administration**

The ECE department is overseen by a Department Head (DH, Prof. Fred Looft) appointed by the Provost, for a five-year term, possibly renewable. The head is assisted by an Associate Head (AH, Prof. Hossein Hakim) who devotes approximately 30% of his time to administrative duties. These persons administer the undergraduate ECE program, as well as the ECE graduate program. The department head reports to the Provost. WPI is not organized into colleges.

The departmental committee structure is also straight forward. Following are the major committees:

- **Undergraduate Program Committee** (UPC) - manages all advising activities, assists students with projects (including advertising and helping to link students with project advisors), and all other UG activities except those related to the curriculum. For example, the UPC also manages all aspects of BS/MS program recruiting, advising students on careers and graduate school opportunities, manages all aspects of the ECE version of the ABET Capstone requirement (our MQP), and manages all oral project presentations and competitions.

- **Graduate Program Committee** (GPC) - responsible for all aspects of the graduate program (except curriculum) issues such as MS and Ph.D. rules and regulations, graduate seminar offerings, scheduling and managing the department research day, making recommendations for TAs, interacting with visiting students, managing the BS/MS program rules and regulations, running the quarterly special guests seminars, reviewing graduate program applications and other related activities.

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\(^5\) WPI 2008-09 Undergraduate Catalog - p. 26
• Curriculum Committee (CC) – responsible for assisting the Associate Head with assessment of the undergraduate program, also responsible for all curriculum issues including reviewing course offerings and scheduling, proposing and/or reviewing courses for addition to the curriculum or removal, managing area reviews (e.g. computer/digital focused reviews, communications and networking area course reviews, etc), recommending courses for cross listing, and reviewing and making recommendations for changes to program distribution requirements.

• Internal Tenure Committee - responsible for annual reviews of non-tenured, tenure track faculty, and for participation in deliberations at tenure review time.

• Ombudsperson - responsible directly to the Department Head and charged with reviewing all cases of suspected academic honesty violations, researching issues from student (or parent) complaints, and interacting with students and faculty in an extremely confidential manner so that the Head has the information needed to make informed decisions while maintaining confidences. In all academic honesty cases, the Ombudsperson is charged by the Head with monitoring every case and insuring strict adherence to WPI academic honesty policy rules and procedures (p.70, 2008-09 UG catalog).

• Internal Advisory Committee (IAC) – an elected group of ECE faculty who meet about once a term to be briefed by the Head on current issues and, as necessary, make recommendations.

Ad-hoc committees are created as necessary to handle special events and issues. The most prominent and long term of these ad-hoc committees is the “Computer Engineering Review Committee (CERC)” which is composed of faculty who teach in computer or digital area courses, and which is tasked with insuring the quality of the digital/computer engineering labs and course content.

Issues From Previous Evaluation

The WPI ECE program was first accredited following the 2002 ABET visit. At that time, the single identified program weakness was the perceived lack of discrete math in the 2002 ECE program distribution requirements. In response, the department faculty voted to add a discrete math course to the program distribution requirements and notified ABET accordingly. ABET then responded that the issue was “resolved”.6 The only other item noted that was of some importance to the EE/ECE Department (at that time) was that the development and consideration of first year learning outcomes were not consistent across campus (ibid, p.3). However, no department or program was singled out as a result of this observation.

Summary of Major Activities since Previous Visit

Since the last ABET visit, there have been several changes to the wording of the program distribution requirements. The first was noted above and was the addition of discrete math as a required course for all ECE students. The second was approved in the past year and changed the wording of the distribution requirements to allow ECE majors to use course credits from the new WPI Robotics Engineering (RBE) major to meet certain ECE distribution requirements. The third was in the spring of 2008 and restricted the counting of credits toward the 15 courses in ECE rules to courses at the 2000 level or above. This last change was a result of adding a 1000 level first year ECE seminar course to the ECE curriculum and not wanting students to use this course to satisfy the ECE 15 course requirement rule.

A summary of major program changes in the past six years is provided in Table 1.1.

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6 ABET letter to President Parrish, p.13.
Following is a brief summary of other major activities in the undergraduate program since 2002.

- Continued **comprehensive review** of ECE curriculum resulting in the deletion and addition of various courses.
- Addition of several **new courses** (Table 1.1).
- Addition of a **first year seminar** course ECE101x, taught twice to good reviews and then proposed as a permanent course in the spring of 2008 (approved in spring, 2008; now ECE 1799).
- Deletion of the **Computer Engineering minor** (since we requested that our EE degree program be terminated) followed by creation and approval of a **new ECE minor** (approved by WPI faculty in January, 2008).
- **Changes to the BS/MS program** requirements to make it easier for students to participate and double count approved courses (approved by WPI faculty in January, 2008).
- **Renovated two major laboratory spaces** with new computer, lab equipment, and modern AV capabilities, as well as in some cases new carpeting and other physical plant improvements.
- Continued laboratory and computer **facility upgrades**.
- Addition of **tenure track faculty** members in wireless ad-hoc networking and security (Lou); digital systems and reconfigurable computing (Huang); software radios and communication systems (Wyglinski); and adaptive signal processing for next generation wireless communication systems (Klein).

### Table 1.1. Summary of ECE Program Changes

<table>
<thead>
<tr>
<th>Acad. Year</th>
<th>Changes to Distribution Requirements</th>
<th>Courses Dropped</th>
<th>Courses Added</th>
<th>Other Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td></td>
<td></td>
<td></td>
<td>first ECE program graduates</td>
</tr>
<tr>
<td>2002-03</td>
<td>• added discrete math</td>
<td></td>
<td>3711 Electro Optics, 3810 Adv. Digital System Design (VHDL), 330x Wireless Networks</td>
<td>first ABET visit - seeking ECE program accreditation</td>
</tr>
<tr>
<td>2003-04</td>
<td></td>
<td>3815 VHDL and 3902 VLSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-05</td>
<td></td>
<td>3306 Audio Engineering</td>
<td></td>
<td>all undergrad EE codes changed to ECE</td>
</tr>
<tr>
<td>2005-06</td>
<td></td>
<td></td>
<td>3308 Wireless Networks made a permanent course</td>
<td></td>
</tr>
<tr>
<td>2006-07</td>
<td></td>
<td>4502 Elec. Power Systems</td>
<td>BME 2204, 3011, 4011, 4201 and 4023 cross listed, 230x Intro to Comm. and Networks, 101x First Year Seminar</td>
<td>all grad EE codes changed to ECE</td>
</tr>
<tr>
<td>2007-08</td>
<td>• RBE courses can be used to meet ES requirement, • all ECE 1000 level courses excluded from course distribution counting</td>
<td>3711 Electro Optics, 3305 Avionic Systems</td>
<td>3703 changed to 4703 (Real Time DSP), 3901 changed to 4904 (semiconductor devices), 101x made permanent (spring, ’08)(now) 1799, First Year Seminar, 230x made permanent (spring, ’08)(now)2305, Networks, 443x approved as an experimental offering (Applied Bioelec. Signal Processing)</td>
<td></td>
</tr>
</tbody>
</table>
• Significant involvement by ECE faculty and technical support staff in the development of the nation’s first Robotics Engineering Program. This program has about equal components in the ECE, CS and ME departments.

• Continued expansion of student opportunities to conduct their senior projects at off-campus locations (including foreign locations) at corporate facilities.
Criterion 1 - Students

Admissions
Students are admitted into WPI as a whole, not into a specific department. Students first officially declare a major in the December-January time frame of the first year and then can transfer to an academic advisor in that major. Students may change majors and advisors at any time. WPI does not have an upper division or a separate “engineering educational unit”. Hence, there is no special entry admissions requirements into engineering majors.

WPI recruits and seeks to enroll the appropriate number (typically ~800-810) of well-qualified undergraduate students each year. As well as recruiting students for our academic departments, specific outreach is performed for women, multicultural students, international students, high-ability students, and transfers. The undergraduate Admissions Office directs a comprehensive campaign of direct mail, electronic mail, staff travel, on-campus programming and alumni activity toward students who have expressed an interest in WPI. The faculty and the Department of Physical Education and Athletics provide additional support for Admissions Office efforts.

Professional members of the admissions staff review applications each fall and winter. During the selection process, the Admissions Office pays close attention to course selection, trends in grades on the high school transcript, overall grade point average, rank in class, courses taken and grades earned in the senior year of high school (especially in mathematics and the sciences), recommendations from counselors and high school faculty, and a required personal statement by the applicant. Students are required to have a sequence of mathematics courses that includes pre-calculus. Two laboratory science courses are required, usually physics and chemistry. For the class entering in August 2007 more than 5,600 applications for admissions were reviewed.

Beginning with applicants for fall 2008 entrance, SAT and ACT scores are optional. Students may submit scores from the Scholastic Aptitude Test (SAT) or the American College Test (ACT) or may choose to submit alternative materials, such as research papers, project work, or design concepts in lieu of standardized test scores. For those students submitting test scores, the Admissions Office will use the best critical reading, writing, and math scores a student submits for the SAT. If a student submits both the SAT and ACT, the office will use whichever scores are higher. The class entering in the fall of 2007 had a combined SAT score (math and critical reading) of 1291. Details of SAT scores and number of students enrolled in ECE for the past five years are shown in Table 1.2.

Table 1.2. History of ECE Admissions Standards for Past Five Years

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Composite SAT</th>
<th>Percentile Rank in High School</th>
<th>Number of New Students Enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>AVG.</td>
<td>MIN.</td>
</tr>
<tr>
<td>2003-04</td>
<td></td>
<td>1230</td>
<td></td>
</tr>
<tr>
<td>2004-05</td>
<td></td>
<td>1284</td>
<td></td>
</tr>
<tr>
<td>2005-06</td>
<td></td>
<td>1270</td>
<td></td>
</tr>
<tr>
<td>2006-07</td>
<td></td>
<td>1285</td>
<td></td>
</tr>
<tr>
<td>2007-08</td>
<td></td>
<td>1291</td>
<td></td>
</tr>
</tbody>
</table>

* not specifically tracked

The number of students enrolled in ECE as both full and part time undergraduate, (as well as graduate) for the past five years are shown in Table 1.3. As can be seen, the population of ECE undergrads has dropped significantly since 2003, mirroring similar drops in EE/ECE departments across the US.
(ECEDHA\textsuperscript{7}, personal conversations). We believe, however, that ECE class sizes will stabilize in the next few years at about 80 students per class.

**Table 1.3. ECE Enrollment Trends for Past Five Academic Years**

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time Students</td>
<td>479</td>
<td>419</td>
<td>357</td>
<td>316</td>
<td>300</td>
</tr>
<tr>
<td>Part-time Students</td>
<td>16</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Student FTE</td>
<td>497</td>
<td>424</td>
<td>368</td>
<td>318</td>
<td>303</td>
</tr>
<tr>
<td>Graduates</td>
<td>60</td>
<td>62</td>
<td>69</td>
<td>76</td>
<td>78</td>
</tr>
</tbody>
</table>

material removed

The ECE department will be closely monitoring these demographic course registration changes in future years and adapt the number of sections and per term course offerings as needed to best match our desire for relatively small class sizes.

**Academic Advising**

The WPI Plan results in educational experiences that are usually different for each student. Advising must be specifically tailored for the individual, which adds a new level of complexity and responsibility for the advisor. The Office of Academic Advising (http://www.wpi.edu/Admin/OAA/) reports to the Dean of Undergraduate Studies and is responsible for coordinating the undergraduate advising program. The advising staff provides training and support to all the academic advisors and is a resource for students.

**WPI Advising Guidelines**

In 1993 the WPI faculty formally endorsed the following statement on the goals of academic advising and the responsibilities of academic advisors:

*The primary purposes of WPI's academic advising program are to:*

- Assist students in the development of **meaningful educational plans**, which are compatible with their life goals
- Help students **accept responsibility** for their own education
- Aid in students’ **professional development** by providing guidance in curricular and professional choices.

*An academic advisor's responsibilities include:*

- Helping the student to **design a program of study**, interpret catalogs and degree requirement audits, and choose among academic alternatives
- **Monitoring academic progress** and recommending appropriate resources to answer questions or solve problems related to academic, career, and personal matters.

**New Student Advisor - Orientation**

The advising process begins after a student has been admitted to WPI in early May. An office of academic advising (OAA) website known as "Designs\textsuperscript{8} provides incoming first-year students with

\textsuperscript{7} Electrical and Computer Engineering Department Heads Association

\textsuperscript{8} www.wpi.edu/OAA
guidance on course selections and the registration process. Students are asked to review the advice for selecting courses for the fall semester and register for their courses by the end of June. Students who would prefer to meet with an advisor may elect to attend an Advising Open House during the month of June. These open houses afford students (both first-year and transfer) the opportunity to learn more about WPI's academic requirements and meet with faculty in their intended major for course selection advice prior to registering for their courses online. Transfer students who can not attend one of the June advising open houses, are advised on an individual basis by scheduling a meeting with the Advising Office during the month of July. The Advising Office also works with the Registrar’s Office and the Scheduling Office to help students develop appropriate schedules.

During New Student Orientation, the four-day period before the academic year begins, students have the opportunity to review their schedule with their academic advisor. The objective is to help students develop an academic schedule that is oriented toward the students’ goals and interests. Further modifications to student schedules can be made up to the end of the fourth day of classes.

**First Semester Advising**

WPI’s first-year advising system for A and B Term is known as the **Insight Program**. Instead of assigning academic advisors to students based on what is often a tentative indication of major field of study, new students are assigned to one of 30 faculty advisors who are willing to make a modest but real commitment to working with a group of 25 to 30 first-year students who are housed together on one of the residence halls floors. These faculty members recognize that first-year advising is much more about mentoring students and much less about course scheduling. Insight advisors represent almost all the departments at WPI, and in many cases are the senior faculty members and the most experienced advisors. The faculty advisors are paired with student leaders, known as community advisors, and together they work with the group’s resident advisor to help first-year students make a successful transition from high school to college. At the end of the first semester in December, the students officially declare their majors and are assigned an advisor in the department of their declared major.

Transfer students are not part of the Insight Program. They go through the same orientation program, but are assigned an academic advisor from their department from the beginning.

First year commuter students are included in the Insight Program but are assigned, as a group, to a faculty advisor who is trained and focused on the special needs of these students.

In January, a small number of additional transfer and first year students are admitted. They have an abbreviated orientation program and are assigned advisors based on their indicated major.

**Faculty Advisor Support**

Faculty advisors are supported by the Office of Academic Advising[^9] which reports to the Dean of Undergraduate Studies, and by a faculty Committee on Advising and Student Life (CASL), which focuses on methods for improving the student advising system. The Office of Academic Advising assigns all academic advisors to students[^10] and provides support to advisors.

**Advising of ECE Majors**

Academic advising at WPI is decentralized in that each department is responsible for advising their respective majors. To make the advising process as efficient as possible a variety of online tools are

[^8]: http://www.wpi.edu/Admin/OAA/Designs2/
[^9]: http://www.wpi.edu/Admin/OAA/
[^10]: http://www.wpi.edu/Admin/OAA/resources.html
available to both the advisors and students. Electronic advising folders have been created to help advisors track student performance and progress toward completion of degree requirements. Advisors can also view student schedules and proposed schedules and post comments to their advisees in the folder. An “Academic Advisors Handbook” is also able to all advisors as a Web document\textsuperscript{11}.

Each year, the students and their advisors are asked to make plans for the upcoming academic year. This process starts with Academic Advising Day in February. No classes are scheduled for this day in order to give students and advisors time to meet and discuss the student’s progress toward meeting the degree requirements. Additional meetings are scheduled between the faculty advisor and student(s) as needed until the final student schedule is developed. In early April, students are then asked to register for their classes and projects for the following year.

All ECE students are assigned to an ECE faculty member as an academic advisor. Students are always free to change their advisor, subject only to the agreement of the new advisor to accept the student. At a minimum, the role of the academic advisor is to assist the student in choosing courses and other academic activities which will meet the requirements for a degree in the desired program. The ECE department faculty have historically committed themselves to going beyond this minimum, and work with students to optimize their programs with respect to the students' backgrounds and goals. Further, ECE advisors make a significant effort to broaden their advisees' outlooks regarding graduate school and career opportunities, as well as assisting with non-academic problems or concerns when appropriate. For example, two days prior to “advising day” evening meetings are held with each of the three lower classes (excluding seniors). At these meetings faculty present the most relevant information for students at that stage of their academic career and answer student questions. For upper level students, faculty also talk about graduate education opportunities, including the ECE BS/MS program. These sessions are very well received by students.

Throughout the year, grade reports are available to both students and their advisors over the Web. In addition a degree audit, also available over the Web, is used to monitor progress toward the degree. The audit lists the degree requirements that have been completed as well as the degree requirements that have not been completed based on a student’s declared major or program.

A final component of advising is the department undergraduate web site where general information and news such as schedule changes are posted\textsuperscript{12}.

\textit{Electrical and Computer Engineering Curricular Details}

First year students, both declared ECE majors and those who are considering ECE as a major, are encouraged to register for a new seminar/engagement course – ECE 1799 – first introduced in the fall of 2006. Students in this course learn about the many different facets of the ECE major and, new in 2007, are engaged through several laboratory session to have a hands on experience in ECE.

First-year ECE students\textsuperscript{13} begin studying electrical and computer engineering simultaneously with their study of calculus and physics. While this presents some challenges to the teachers of these first two ECE courses (ECE-2011, ECE-2022) students immediately see the applications of their mathematics and physics studies.

It is expected that all ECE students will become familiar with the fundamental concepts of active and passive circuits, electromagnetic fields, electronic measurements, digital circuits and basic computer systems design and programming, embedded microprocessors, and signal analysis, as well as basic

\textsuperscript{11} \url{http://www.wpi.edu/Admin/OAA/Handbook/}
\textsuperscript{12} \url{http://www.ece.wpi.edu/Undergraduate/}
\textsuperscript{13} Including those who have declared an ECE minor or who are in the Robotics, Aerospace, or Interactive Media and Game Development (IMGD) programs.
experimental and laboratory techniques. This subject matter is contained the sequence ECE 2011, ECE 2022, ECE 2111, ECE 2201, ECE 2311, and ECE 2801. Students are also expected and advised to develop some breadth in one or more areas of their own choosing. This may involve, for example, study in social sciences, life sciences, computer science, management engineering, engineering sciences or in advanced mathematics. The ECE section of the Undergraduate Catalog provides advising information, including typical course sequences that have been selected to lead a student toward competence in one or more of the eight specialized areas of electrical and computer engineering. The advisor can be of particular help to the student in this selection.

Beyond the ECE core curriculum described above, the ECE Distribution Requirements mandate a basic level of breadth in both the "electrical engineering" and the "computer engineering" side of the profession. Beyond this minimum, the academic advisor helps the student select a sequence of courses which is neither too narrow and specialized, nor too broad and diffuse. A choice from two or more related or mutually supportive areas (such as RF circuits and Communications) is usually advised. The faculty advisor and the student work out a tentative selection of courses and independent study in the freshman year, or early in the sophomore year. This program is periodically reviewed as the student defines more clearly an area of interest, and to verify satisfaction of the college and ECE course distribution requirements.

The WPI Degree Requirement Audit

The "WPI Degree Requirement Audit," available both electronically and on paper to the student and his/her advisor, is designed to help the student and advisor keep track of progress toward both WPI's "Degree Requirements" and the specific program "Distribution Requirements". A sample audit for an ECE graduate of the class of 2008 will be described below.

While this is not a transcript, the grades received in each activity are included. In addition to the normal letter grades, "L" indicates credit (generally for math or science) received by advanced placement. No grade implies that the course has been registered for and either in progress or not yet completed. The audit form is customized for each major.

The audit form is annotated below corresponding to the numbers marked on the sample audit (following the descriptors below).

(The audit and the description of the audit was removed since it reflects an actual student and any student audit is a reasonable substitute.)

Advising on Careers and Majors

The Career Development Center (CDC) offers a wide range of support programs and, in particular, organizes the Major Selection Program for students who are undecided about their major. The mission of the Major Selection Program (MSP) is to assist students in the selection of a major that meets their interests and aptitudes. The MSP program is designed for first-year students; however, it is open to any

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14 2008-09 WPI Catalog (p. 57) – Robotics, Power Systems, RF and Microwaves, Communications and Signals, Biomedical, Analog Microelectronics, Aerospace, and Computer Engineering
15 http://www.wpi.edu/Admin/CDC/Students/counsel.html
16 http://www.wpi.edu/Admin/CDC/Students/program.html
student who wishes to explore academic and career options. To accomplish this process, MSP offers a variety of services including:

- Career and academic counseling
- Self assessment instruments
- A Career Resource Center with printed and computer accessed materials on majors and professions
- Individual meetings with peer/career advisors, upper-class students, faculty, alumni or employers who provide insights into various majors and careers
- Corporate tours and job shadowing opportunities.
- A non-credit seminar is typically offered during B term. The seminar is marketed to first-year students participating in the Insights program and to other undecided students on-campus.

In addition, the Career Development Center meets individually with students who do not participate in the Major Selection Program and want some guidance regarding major selection or career information. We provide one-on-one counseling appointments, administration and interpretation of self assessment instruments, and job shadowing.

**Transfer Students**

The WPI Admissions Office evaluates full-time and part-time transfer candidates using the following required credentials (in addition to the WPI transfer application):

- Submission of all prior college transcripts (high school transcripts must be included if the applicant has been enrolled in college for three semesters or less)
- Two recommendations (one must be academic; the other may be either academic, from the military or from an employer)
- Autobiographical statement or resume outlining all academic and work activity from date of high school graduation to date of application to WPI
- Essay on transfer goals.

Fifty to sixty-five percent of our transfers enter WPI from accredited four-year colleges and the remaining transfers enroll from accredited two-year colleges. As of the fall of 2007, WPI has articulation agreements with Quinsigamond and Bristol Community College. Only the agreement, with Quinsigamond Community College (QCC) in Worcester, is active, since QCC has a two-year basic engineering program that is ABET approved for engineering technology. WPI accepts graduates of this program provided the student has a grade point average of 3.0. The same process described above for all other transfer credit applied to the courses approved as transfer credit from QCC. The advising office conducts a yearly review of the articulation agreement and the agreement is updated as needed.

Transfer decisions are made primarily by Michael Smith (for domestic transfers) or by Ed Connor (for international students/permanent residents) in the WPI undergraduate Admissions Office. In certain cases, applicants may be brought to a Transfer Committee including the Director of Admissions. WPI typically enrolls between 20-30 transfer students for the spring semester and 60-70 transfer students for the fall semester.

Students who submit satisfactory credentials with a transcript of a 2.8 GPA or higher (2.5 GPA or higher if transferring from a competitive institution) and have completed at least calculus are usually offered admission. The Admissions Office recommends completion of calculus prior to entering WPI and will work with appropriate students to assist them in taking pre-requisite coursework.
Evaluation of Transfer Credit

Any course considered for transfer credit must be relevant to WPI's educational mission. The following kinds of courses and/or programs are not recognized for transfer credit: Vocational, correspondence, pre-college, remedial, review, noncredit CEU, adult enrichment or refresher courses, and CLEP examinations.

The decision to award transfer credit is determined by the WPI department offering comparable courses. Elective credit, either free elective and department elective credit, may be awarded for courses with no WPI equivalent if deemed relevant to WPI's program. Courses taken at regionally accredited post-secondary institutions that are comparable to courses offered at WPI will be reviewed for course content and level by the WPI department offering the comparable course. Only those courses in which the transfer student received a grade of C or better will be evaluated for possible transfer credit.

The Office of Academic Advising and the Projects and Registrar's Office coordinate transfer credit evaluation. The appropriate faculty members in the respective departments make all decisions regarding transfer credit. Staff members make no transfer credit decisions.

Current WPI students who wish to take courses at a regionally accredited post-secondary institution must obtain a WPI Transfer Credit Authorization form from the Projects and Registrar's Office. This form and the course description must be taken to the WPI department head or designated representative and academic advisor for approval before the course is taken. On the form, the department head may specify a minimum grade higher than C for transfer. This minimum grade depends on the institution at which the course is taken and the criticality of the course to the department. Courses that have not been pre-approved may not receive transfer credit.

Transfer students are subject to the same academic review process as any other WPI student. This review and monitoring process indicates that transfer students perform as well as other WPI students and their retention graduation rates are about the same as other students.

The number of ECE students that have been accepted as transfer students at WPI for the past 5 years is detailed in Table 1.4.

<table>
<thead>
<tr>
<th>AY</th>
<th>Transfer Students Enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>10</td>
</tr>
<tr>
<td>2004-05</td>
<td>2</td>
</tr>
<tr>
<td>2005-06</td>
<td>7</td>
</tr>
<tr>
<td>2006-07</td>
<td>7</td>
</tr>
<tr>
<td>2007-08</td>
<td>3</td>
</tr>
</tbody>
</table>

Evaluating Student Performance

The WPI Undergraduate curriculum is organized with two seven-week terms in the fall (A and B), two in the spring (C and D), and one (optional) in the summer, term E. Students normally take nine credit hours of course or project work per term, which is equivalent in the WPI system to one unit of work. That is, three credit hours equals 1/3 unit in the WPI system.

Satisfactory Academic Progress

In order to assist students, parents and the academic advisor in determining whether a student is making satisfactory academic progress, WPI has adopted both of the following guidelines, effective Term A, 1989:
1. The student must complete at least 4/3 units of work in two successive terms, including [if applicable] Military Science, Physical Education and Consortium courses.

2. The student must complete at least 8/3 units of work in four successive terms, including [if applicable] Military Science, Physical Education and Consortium courses.

Term E (Summer School) will be included if the student is registered full time.

**Academic Warning**

Each student’s academic record is reviewed by the Registrar's Office at the conclusion of terms B and D according to the guidelines above. If a student’s performance falls short of either guideline 1 or 2, the student, parent and academic advisor will be notified that the student is not making satisfactory progress. The notification will place the student on Academic Warning. At this time, the student is urged, with the help of his/her advisor, to identify the nature of the academic difficulty and to formulate a course of action for overcoming the difficulty.

**Academic Probation**

During the next review of academic progress, should the student fail once again to maintain satisfactory academic progress, the student, parent and academic advisor will be notified. This notification will place the student on Academic Probation for two terms and will prevent the student from receiving financial aid, will result in loss of eligibility for team sports, will prevent the student from obtaining undergraduate employment in the Co-op Program and will prevent participation in the Global Perspective Program.

Students who obtain no academic credit (exclusive of Physical Education or ROTC-related courses) in either Term A or Term C are e-mailed by the Director of Academic Advising informing them of the following change of academic status if they earn no academic credit for the next term for which they are registered. In the e-mail, the students are also urged to seek academic support services through the Academic Advising Office.

Students who fail to obtain credit for two consecutive terms shall:

- Be placed on Academic Probation if they are currently classified as making satisfactory progress, or
- Be placed on Academic Suspension if they are currently on the list of students on Academic Warning or on Academic Probation

Subsequent academic reviews shall follow the rules for all students.

**Academic Suspension**

Should a student on Academic Probation fail to make satisfactory academic progress during the next review period, the student will be suspended from WPI. The notification will prevent the student from enrolling as a full-time student or in the case of a special student for at least the next two terms. Subsequent readmission is subject to approval (with possible conditions) of a petition through the Registrar to the Committee on Academic Operations (CAO). As a general rule, a student readmitted after suspension will be placed on an Academic Probation status.

New students (first year or transfer) who fail to obtain academic credit for the first two terms will be placed on Academic Suspension and not allowed to enroll for the following terms. Readmission is subject to approval by the Committee on Academic Operations.

**Improvement in Status**

Students on Academic Warning or Academic Probation have the opportunity to improve their status by progressing through the levels in reverse order. If a student on Academic Probation satisfactorily meets the academic credit achievement guidelines at the end of the next review period, s/he will be moved to the
list of students on Academic Warning. A student on Academic Warning would be moved back to Satisfactory Academic Progress status.

**Term E (Summer Session) Review Period**

An exception to the guidelines stated above can occur when a student registers full time for Term E. At the conclusion of Term E, a review is conducted which covers the current and previous five terms. If the student has completed 10/3 units of acceptable work, the student’s academic progress status will improve. Thus, a student on Warning status after the Term D review will start terms A and B on Satisfactory Academic Progress. A student placed on Academic Probation after the Term D review will be on Warning status for terms A and B. A student on Suspension status after the Term D review will be able to register for terms A and B on Academic Probation.

**Summer Bridge Program**

Students who finish the academic year on Academic Warning or Probation status, but who have passed at least 2 units of academic work during the previous four terms, are eligible to participate in the Summer Bridge Program. Students who participate in the program enroll in Term E for two courses and a four-week study skills program. Successful completion of the courses and the study skills program will result in the academic status rising one level (Academic Probation to Academic Warning, or Academic Warning to Satisfactory Academic Progress). The Office of Academic Advising coordinates this program.

Once the academic review is conducted, academic status is updated immediately in banner web and a letter is sent to the student from the Registrar’s Office notifying them of the status change. Additionally, a letter from the Provost’s Office is sent to the parent with a copy of the letter sent to the student. This letter outlines the academic support available to the student upon their return.

**Student and Advisor Review of Academic Performance**

Four days after the conclusion of every term, students are able to view their grades on-line which are posted on their unofficial transcript through the web information system. Only those courses for which the student earned a grade of “C” or better are displayed on the transcript. Grades are mailed home to parents at the end of B and D term. Grades are not mailed home to parents of those students who been able to legally establish “independent status.”

The Registrar conducts an official review of each student’s academic progress at the end of B term and D term. Those students, whose academic status changed (Academic Warning, Academic Probation or Suspension) as a result of this review, receive written notification of the change. The student’s academic status is also annotated on the unofficial transcript. In addition, parents also are mailed a copy of the notification of change in academic status if it results in the student being placed on Academic Warning, Probation or Suspension.

Academic Advisors are of course included in this process. Students who have had a change in their academic status are flagged on the advisee list in the electronic advising folder so advisors can easily identify those students who need their attention. Advisors can always view all of their advisees’ grades through the online transcript in the student’s advising folder and both students and advisors can monitor a students’ progress toward graduation through an online degree evaluation process.

A list of students who are on Academic Warning, Probation or Suspension is sent to the Academic Advising Office. Additionally, the Advising Office also receives a list from the registrar’s office of those students who do not earn any credit in A and C term. The Advising Staff then contacts all of these students by both mail and e-mail strongly urging them to come in for a consultation regarding academic support services.
Graduation Requirements
Each department establishes a mechanism or committee to review the degree audit for each student during the final year of study to ensure that each graduating student will satisfy both WPI and ABET requirements. It is important to note that the development of a program of study and the satisfaction of degree requirements are the responsibility of each student. Each Academic Advisor helps the student design a program that meets each student’s individual goals as well as the degree requirements in engineering. During the last semester, both the Registrar and the Program Review Committee notify students if degree requirements are missing. Thus the students have the opportunity to adjust the schedule before the completion of the academic year. The final review to ensure that all requirements have been met is the responsibility of the Registrar.

Enrollment and Graduation Trends
Tables 1.5 shows the number of students who have graduated from ECE since the last ABET visit in 2002-03.

<table>
<thead>
<tr>
<th>Degree</th>
<th>02-03</th>
<th>03-04</th>
<th>04-05</th>
<th>05-06</th>
<th>06-07</th>
<th>07-08</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS</td>
<td>133</td>
<td>103</td>
<td>128</td>
<td>88</td>
<td>96</td>
<td>83</td>
</tr>
<tr>
<td>MS</td>
<td>43(^{17})</td>
<td>36</td>
<td>48</td>
<td>35</td>
<td>39</td>
<td>52(^{18})</td>
</tr>
<tr>
<td>PhD</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

\(^{17}\) Includes 8 MS graduates of the “Power Systems Management” program offered on-site at a local power utility.
\(^{18}\) Includes graduates from the Corporate and Professional Education (CPE) program and part time student graduates.
CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

**Assessment** = one or more processes that identify, collect, and prepare data to evaluate the achievement of program educational objectives. **Evaluation** = one or more processes for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which program educational objectives are being achieved, and results in decisions and actions to improve the program.

**Mission and Goals Statements**

**Mission Statement** - Provide a copy or summary of any applicable institutional, college, departmental, and program Mission Statements and document where they are published.

The Mission and Program Objectives of the Department of Electrical and Computer Engineering (ECE) have been developed to be consistent with those of the Worcester Polytechnic Institute as given below. The ECE program objectives, mission statement and goals are published in the 2008-2009 WPI Undergraduate Catalog (p.56), are posted in the department in our display case (first floor lounge) and are available on the department web site: [http://www.ece.wpi.edu/Undergraduate/ug-goals.html](http://www.ece.wpi.edu/Undergraduate/ug-goals.html).

**ECE Mission Statement**

To be prepared for employment as a contributing engineer and/or for graduate-level education, students within the ECE Department receive instruction that is balanced between theory and practice. In fact, much of our curriculum integrates theory and practice within each course. It is common to study new devices and techniques, and then immediately work with these devices/techniques in a laboratory setting. In response to the breadth of ECE, all students work with their academic advisor to develop a broad-based program of study. As with most engineering curricula, ECE study includes a solid foundation of mathematics and science.

Discipline-specific study in ECE usually begins early in a student's career - during the second half of the freshman year - with courses providing a broad overview of the entire field. During the sophomore and junior years, students learn the core analysis, design and laboratory skills necessary to a broad range of ECE sub-disciplines. When desired, specialization within ECE occurs during the junior and senior years. In addition, all students complete a major qualifying project (MQP). This project, typically completed in teams during the senior year, is an individualized design or research project that draws from much of the prior instruction. Utilizing the benefit of individualized instruction from one or more faculty members, students develop, implement and document the solution to a real engineering problem. Many of these projects are sponsored by industry, or are associated with ongoing faculty research. These projects form a unique bridge to the engineering profession.

The **WPI mission statement** can also be found on the web and in the 2008-09 UG catalog (p.3).

**WPI Mission Statement**

WPI educates talented men and women in engineering, science, management, and humanities in preparation for careers of professional practice, civic contribution, and leadership, facilitated by active lifelong learning. This educational process is true to the founders' directive to create, to discover, and to convey knowledge at the frontiers of academic inquiry for the betterment of society. Knowledge is created and discovered in the scholarly activities of faculty and students ranging across educational methodology, professional practice, and basic research. Knowledge is conveyed through scholarly publication and instruction.

*Adopted by the Board of Trustees, May 22, 1987*

Finally, as also found on the WPI web, the goals of the undergraduate program are as follows.

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19 [http://www.wpi.edu/About/statements.html](http://www.wpi.edu/About/statements.html)

20
The goals of the undergraduate program are to lead students to develop an excellent grasp of fundamental concepts in their principal areas of study; to lay a foundation for life-long renewal of knowledge; to gain a mature understanding of themselves; and, most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need. These principles are today manifest in the WPI Plan, a unique, project-oriented program which emphasizes intensive learning experiences and direct application of knowledge. WPI remains committed to continued educational improvement and innovation.

ECE Program Educational Objectives (PEOs)

Program Educational Objectives - List the Program Educational Objectives and state where these are published.

The following program educational objectives are published on the ECE web site\(^{21}\) and have been endorsed by the ECE faculty.

ECE Program Educational Objectives

The WPI ECE program educates future leaders of the electrical and computer engineering profession with a program characterized by curricular flexibility, student project work, and active involvement of students in their learning. Through a balanced, integrated curriculum, graduates of the BS program in ECE will achieve:

- An education which is strong both in the fundamentals and in state-of-the-art knowledge,
- Preparation for immediate professional practice as well as graduate study and lifelong learning,
- Broad preparation for their professional and personal lives, providing the basis for effective professional and civic leadership and informed citizenship,
- Strength in all forms of technical and nontechnical communication,
- The ability for effective teamwork,
- An understanding of the broad social and ethical implications of their work.

Endorsed by the ECE faculty on 23 August 2006.

The first formal adoption of a statement of Program Educational Objectives by the ECE faculty was on May 8, 1997. This statement has subsequently been modified in relatively minor ways, the most recent revision reflecting the addition of the new program in Electrical and Computer Engineering (Adopted by the ECE faculty on March 28, 2001). The current statement is essentially identical to the March 2001 statement but reformatted for easier reading.

To assist in evaluating how well our students meet our stated objectives, the following specific, measurable objectives may be extracted from the above statements:

- Graduates should be "leaders of the electrical and computer engineering profession,"
- Graduates should display the results of "an education which is strong both in the fundamentals and in state-of-the-art knowledge,"
- Graduate should display the results of an education which is "appropriate for immediate professional practice as well as graduate study and lifelong learning,"

\(^{20}\) http://www.wpi.edu/About/statements.html
\(^{21}\) http://www.ece.wpi.edu/Undergraduate/ug-goals.html
Graduates should display "effective leadership and informed citizenship."

Graduates should be "technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work."

Relation of Program Educational Objectives to WPI Mission Statement

Consistency of the Program Educational Objectives with the Mission of the Institution - Describe how the Program Educational Objectives are consistent with the Mission of the Institution.

The parallel nature of WPI’s Mission and the ECE Program Educational Objectives is evident. The ECE PEOs reflect the expected accomplishments of our graduates a few years after graduation. These objectives are consistent with the WPI Mission statement as is evident from the statement above. By educating students in the fundamentals of electrical and computer engineering we are preparing them for careers in professional practice. By developing their abilities to solve practical problems of importance to society we are preparing them for civic contribution as well as professional practice.

We further prepare students for civic contribution, leadership, and life-long learning by providing them with a broad education including communication and life-long learning skills. These Program Educational Objectives also subsume Program Outcomes which are entirely consistent with the ABET Criteria (a) - (k). Therefore, our Program Educational Objectives are deemed to be consistent with the ABET Criteria for Accrediting Engineering Programs.

Relation to WPI Undergraduate Goals

Although the ECE Program Educational Objectives are actually more detailed and enumerated, the similarity between the ECE Objectives and the WPI Goals are mostly self evident. For example, the concepts of life long learning, a broad education, global and societal context and others are clearly matched between the two statements. Other concepts, such as the ECE requirement to be able to perform engineering design and to have depth in at least one specialty of ECE are not directly or specifically addressed in the WPI Undergraduate Goals statement, but are an inherent component of the WPI Plan (below) that emphasizes “intensive learning experiences and direct application of knowledge”, particularly in a student’s “principal area(s) are study”.

Process for Determination of Program Educational Objectives

Process for Establishing Program Educational Objectives - Describe the process that periodically documents and demonstrates that the Program Educational Objectives are based on the needs of the program’s various constituencies.

The ECE curriculum grew out of the early 1990’s EE curriculum which had its beginnings with the implementation of the “WPI Plan” in 1970. Briefly, the WPI Plan for undergraduate education is characterized by student responsibility for his/her learning, an outcomes-orientation via student projects, and by emphasis on the liberal as well as the technical and professional components of the BS degree.

The previously accredited EE curriculum was created to be in concert with WPI’s Mission and educational philosophy which were in place prior to the formalization of PEOs. The formal process of establishing Objectives for the undergraduate ECE program began with the departmental Strategic Planning process in 1995. That process established three dimensions (Quality, Relevance, and Opportunity) upon which we reviewed and modified our existing EE program. The first published Educational Objectives statement was adopted by the ECE faculty in 1997, and has been revised since. The current objectives were modified only slightly with the implementation of the ECE program (replacing reference to "electrical engineering" with "electrical and computer engineering.")

The departmental Curriculum Committee (CC), consisting of the Associate Department Head and faculty representatives from various sub-areas of electrical and computer engineering, exercises overall
responsibility for the undergraduate curriculum, including review and proposal for modification of the Program Educational Objectives as needed. The Undergraduate Program Committee (UPC), also composed of faculty representatives from various sub-areas of ECE, exercises control over all aspects of the undergraduate program not directly involving courses. For example, the UPC manages all aspects of BS/MS program recruiting and rules/regulations, advising students on careers and graduate school opportunities, manages all aspects of the ECE version of the ABET Capstone requirement (our MQP), manages all oral project presentations and competitions, and so forth.

Program Constituencies

The following have been identified as the primary constituencies of the undergraduate electrical and computer engineering program:

- Current and prospective WPI ECE students,
- ECE Faculty,
- ECE Alumni,
- Employers, particularly the immediate employers of our graduates,
- ECE Advisory Board members, and
- Graduate and Professional Schools where our graduates seek advanced degrees,

The primary constituents are, and have been, our students, both current students and future students for whom we establish and improve our program. Our institution and curriculum clearly seeks to serve a particular sub-group of potential students, those who are "talented" in the words of the WPI Mission, and those who are capable of benefiting from our educational approach. Given this set of prospective students, we have attempted to determine and to meet their needs.

The faculty plays a dual role: as a constituent, but more importantly, as the group responsible for program determination and execution. It is important to note that the faculty’s first goal is to determine the needs of the various constituencies, rather than their desires. This is particularly significant for prospective, and even current, students. What a person needs at a given point in time may be very different from what he or she wants. The process of education, at least through the BS level, addresses the maturation of students very broadly. While an employer may be able to state his/her needs very clearly, a student may not be in such a position. This does not imply that we should not listen to our students; it just means that we must interpret what they are saying in terms of our mission as an institution.

Each of our constituents has a distinct, and different, involvement in the ECE program. Constituent needs also exist on several different time scales. For example, an aspect of an employers’ needs in electrical and computer engineering is student familiarity with the current state of technology, but this must be balanced with the education in fundamentals that will enable our graduates to adapt to the next technological breakthrough.

Secondary constituents could be identified and listed - ranging from the corporations who sponsor our students’ projects, to the parents of our students, to society at large - but the indicated list is felt to be sufficiently complete. Where appropriate these other groups are involved, but our desire is to restrict our constituent list to a manageable number.

Review of Constituent Involvement

The ECE department stays in touch with its constituencies by several means:

- Direct, two-way contact with individual constituents.
- One-way contact with feedback solicited.
- Indirect, via market studies, reports, etc.

**Prospective Students**

The ECE department does not independently contact prospective students in a broad fashion. However, we do have contact with prospective students via several mechanisms.

- Summer programs for junior high school and high school students (Camp Reach, Strive, Frontiers) involving intensive student-faculty contact over a period of 1 to 2 weeks.
- Campus visits by individual applicants and their parents, and departmental Open Houses, involving question and answer sessions as well as private meetings with faculty.
- High school visits, science fair participation, and similar activities by ECE and WPI faculty.
- Indirectly through Guidance Counselor breakfast events, and even casual discussions and hosting of Project Lead The Way laboratory sessions.
- One or more emails from the department head (currently F. Looft) to all accepted ECE students in the spring of each year. The simple reason for these emails is to encourage prospective students to re-visit WPI, to solicit any remaining questions, to respond to concerns that prospective students might have (e.g. “what type of computer should I buy?”) or even to help arrange individual interviews if a student requests one during a subsequent campus visit.

WPI as an institution devotes considerable attention to surveys and focus groups with prospective students and their parents. Such studies provides a profile of the expectations and desires of our applicant pool. However, as interesting and useful as this information is when provided to the individual departments, may not be directly translated into a curriculum.

It is also important to note that WPI faculty do pay attention to national trends and, when appropriate, respond to those trends and data. As an example, the two newest degree programs at WPI, Interactive Media and Game Development (IMGD) and Robotics Engineering (RBE), both grew out of faculty and Admissions observations that our potential matriculant pool was highly invested in computer gaming and robotics as evidenced by the large number of talented students involved in on-line gaming and FIRST competitions, respectively. ECE faculty have been intimately involved in the development of both of these majors as a result of their perceived impact on our own curriculum and program structure. While not directly related to ECE course and program development, as noted earlier such programs will have a significant impact on ECE operations, course offerings and course loadings because these two new majors specify ECE courses as part of their respective program curriculums.

**Alumni**

With about 5000 living alumni, the EE/ECE programs have a rich pool of knowledgeable constituents to draw upon. Our principal means of staying in touch with Alumni are our web pages and feedback solicited via email and alumni surveys.

More formally the ECE department re-initiated an annual survey in 2006 with a major survey of the classes 2, 5 and 10 years out. This survey provided useful data regarding our curriculum. The results from that survey were reinforced by a second survey of alumni 2, 5 and 10 years out in 2007. As a result of the success of our surveys ECE has helped the WPI campus computerize the annual survey for other

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22 The EE alumni need to be considered as part of our constituent pool because the ECE program has only been in existence since the last accreditation visit when the ECE program was initially put up for accreditation. The vast majority of our alumni grads are, as a result, previous EE program majors with accredited EE degrees.
departments. These surveys provide the principal quantitative data regarding evaluation of our Educational Objectives and Outcomes. However, it is important to note that since most alumni are from industry, their feedback also represents that from our industrial constituency.

Advisory Board

The ECE Advisory Board held its first meeting in November, 1985, and has met once or twice per year since that time. The board is composed of 10-14 members drawn primarily from industry, but with representation also from academia. Guidance for our academic programs, both undergraduate and graduate, represents a major Board activity. Input on the formulation and evaluation of program objectives is also solicited from board members. The board composition is given in the table below. Clearly, the board members are well placed in corporations of importance to the ECE department, including the computer, telecommunications, defense and microelectronics industries. Board members also represent the academic and entrepreneurial aspects of engineering career paths (e.g. Thomas Daly is a relatively recent WPI ECE grad who started his own software company which was voted in 2007 as the best small company to work for in NH). (This table was current at the time of the visit, it is not current as of this date - Nov. 2009)

### ECE Advisory Board Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Position/Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hogan, Patrick M.</td>
<td>Senior VP, Network Strategies, National Grid</td>
</tr>
<tr>
<td>Daly, Thomas</td>
<td>President, CTO, Dynamic Network Services, Inc.</td>
</tr>
<tr>
<td>Adiletta, Matthew</td>
<td>Intel Fellow, Intel Corporation</td>
</tr>
<tr>
<td>Arsenault, Thomas</td>
<td>President, Sensor Systems, BAE Systems</td>
</tr>
<tr>
<td>Counts, Lewis</td>
<td>VP Linear Products, Analog Devices</td>
</tr>
<tr>
<td>Gwynne, Jeffrey</td>
<td>Partner, Image Architects, LLC</td>
</tr>
<tr>
<td>Kramer, Kathleen</td>
<td>Dir. Engineering Programs, Prof. of Elec. Engin., Univ. of San Diego</td>
</tr>
<tr>
<td>Mezak, Stephan</td>
<td>CEO and Founder, Accelerance, Inc.</td>
</tr>
<tr>
<td>Orofino, Donald</td>
<td>Manager, DSP Development, The MathWorks, Inc.</td>
</tr>
<tr>
<td>Whatmough, Scott</td>
<td>Network Centric Systems, Director of Engineering, Raytheon Company</td>
</tr>
<tr>
<td>Stadler, Scott</td>
<td>Division Head, Communications and Information Technology Division, MIT Lincoln Laboratory</td>
</tr>
</tbody>
</table>

Additional members to the Advisory Board are actively recruited so that we have a board that is broadly representative of the department constituencies including industrial sectors not currently represented, additional members from academia, industrial members who are not senior managers or leaders but engineers, relatively recent graduates who are acting in entrepreneurial roles, as well as women and minorities.

Faculty

Of course, all faculty are involved in delivering the ECE curriculum on a day to day basis. Also, all faculty are involved in a substantive way with program assessment and evaluation. Formal means for collecting faculty input include participation on the Curriculum Committee, the Undergraduate Program Committee, ad-hoc committees to review and recommend changes to portions of the curriculum (e.g. the
Computer Engineering Review Committee (CERC), annual department retreats, monthly department faculty meetings, as well as their assessment input on their courses and other teaching activities. The department is sufficiently small that the “committee of the whole” works well both for transferring information and for collecting individual input.

Students

Input from students is solicited via input from the student groups (IEEE, Eta Kappa Nu, and Women in ECE) and course evaluations. The “open door” policies of all faculty and the department head further ensures that the needs and concerns of the students are known immediately. Finally, data from students is also obtained from the EBI survey, the senior survey given every year to graduating seniors, and ad-hoc surveys administered to select ECE groups depending on the topic being addressed.

Corporations and Employers

The primary direct input from corporations is via the ECE Advisory Board. Most recently the Department head has also taken on the goal of visiting (to the extent possible) and having private conversations with each advisory board member in the spring (of 2008) as a counterpoint to the fall group meeting. Secondary inputs are facilitated by groups such as WPI Corporate Relations where the staff stays in close contact with a broad range of corporations via planned on-site visits that are focused on developing relationships between departments, individual faculty, and corporate engineers and managers. Since a substantial number (42% in 2007-08, the most recent available data) of our Senior Projects are sponsored by corporations or, in some cases, research grants that require significant corporate or agency review and oversight, there are also numerous opportunities for corporate project liaisons to be in direct contact with the faculty advisors.

The WPI Career Development Center (CDC) maintains close contacts with most campus recruiters and sponsors annual “Corporate Roundtables,” to discuss topics of mutual interest. For example, the topic this year was “Internships, Co-op, and Student Project Work at Corporations”. ECE faculty occasionally also host on-campus recruiters (some of whom are alumni) to lunch and discuss topics of departmental interest and obtain anecdotal feedback on how our alumni are doing in their company.

Finally, although indirect, the speakers invited to the ECE graduate seminar series are often colleagues or acquaintances of individual ECE faculty, usually in higher level and influential positions. These more casual contacts occasionally also provide feedback on both how our graduates are doing, as well as providing insight for where industry is heading.

Graduate Schools

The only continuing mechanism for input regarding graduate school needs has been via the ECE Advisory Board, and this link has been quite helpful. The current member of the Advisory Board from the University of San Diego, provides excellent feedback for comparing our program to her observations of other programs. Our stated goal of preparing students for both immediate professional employment and for further study does result in conflicts and compromises in designing the curriculum, and having input from both “sides” is quite helpful.

Other Sources

Finally, institutions such as the ECE Department Heads Association (ECEDHA), the National Science Foundation, ASEE, the National Academy of Engineering, and the Boyer Commission devote time and attention to (a greater or lesser extent) assessing the needs of the science and engineering professions, and to making recommendations for change in our educational system. We pay attention to those reports. The hallmarks of our program, including emphasis on outcomes, teamwork, communications skills, and
student responsibility for learning are either based on, or supported by, these reports and recommendations. In fact, our program predates most of these reports.

Process for Establishing Program Educational Objectives

Describe the process that periodically documents and demonstrates that the PEOs are based on the needs of the program's various constituencies.

The departmental processes for determination of program objectives, and for their evaluation, have been integral parts of the departmental planning process, which has been formally conducted since 1984. This process is driven by the faculty, with substantial input from students and from the corporate community (primarily via our Advisory Board).

Copies of documents related to department goals and the objectives-setting process will be available for the visit. The current departmental Strategic Plan is included as Appendix E. Other documents will include Advisory Board minutes, Undergraduate Program Committee and Curriculum Committee minutes, Department meeting and retreat minutes, and similar related material.

The Undergraduate Program and Curriculum Committees oversee both policy and operational aspects of the undergraduate program, and identifies needs and opportunities for changes and program improvements (e.g. course changes, program or distribution changes, etc). A major recent example of high-level change is the recognition of the need to address the fact that “Computer Engineering” is now more than just a specialty within EE. Specifically, since we are not seeking reaccreditation of the previous EE program, we have i) dropped the Computer Engineering Minor that was offered as a minor to all students (EE and non EE majors), ii) created an ECE minor available only to non-ECE majors (in recognition that the ECE degree has by design a significant CE component required of all ECE majors), and iii) modified the ECE distribution requirements accordingly.

Relation of Objectives to Program Outcomes

The WPI degree requirements, together with the ECE program distribution requirements and supported by academic planning and academic advising information, produce a curriculum which supports our educational objectives. Table 2.1 illustrates the links between our objectives and our curriculum.

The curriculum and Program Outcomes should prepare students to demonstrate accomplishment of the Educational Objectives. Below, we list our ECE program outcomes and, in Table 2.2, indicate the Outcomes that support each Objective.

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24 See also: CRITERIA 3 - PROGRAM OUTCOMES.
Table 2.1 Relation of Educational Objectives to Curricular Elements

<table>
<thead>
<tr>
<th>Objective</th>
<th>Principal Relevant Curricular Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaders of the electrical and computer engineering profession.</td>
<td>Substantial independent work, including projects and team work.</td>
</tr>
<tr>
<td>An education which is strong both in the fundamentals and in state-of-the-art knowledge</td>
<td>Balanced selection of basic and advanced courses, substantial math/science requirements.</td>
</tr>
<tr>
<td>Appropriate for immediate professional practice as well as graduate study and lifelong learning,</td>
<td>Balance of applications and theoretical courses, emphasis on independent learning, in projects and outside class.</td>
</tr>
<tr>
<td>Effective leadership and informed citizenship.</td>
<td>Substantial course and project work in humanities and social science, and relation of that work to the ECE major.</td>
</tr>
<tr>
<td>Technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work.</td>
<td>Requirements for major written documentation and oral presentation of project work, substantial teamwork experience, strong liberal education component.</td>
</tr>
</tbody>
</table>

The following are the equivalent of the ABET A-K we talked about when you met with me.

**ECE Program Outcomes**

Based on the department's educational objectives, students will achieve the following specific outcomes within a challenging and supportive environment.

1. Preparation for engineering practice, including the technical, professional, and ethical components.
2. Preparation for future changes in electrical and computer engineering.
3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software.
4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE problems.
5. An understanding of the engineering design process, and an ability to perform engineering design, including the needed teamwork and communications skills.
6. Demonstration of in-depth understanding of at least one specialty within ECE
7. An ability to communicate effectively in written and oral form
8. An understanding of options for careers and further education, and the necessary educational preparation to pursue those options
9. An ability to learn independently
10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI
11. An understanding of engineering and technology in a societal and global context.
Table 2.2 Relation of Objectives to Outcomes

<table>
<thead>
<tr>
<th>ECE Educational Objectives</th>
<th>ECE Program Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>strong in the fundamentals</td>
<td>3, 4</td>
</tr>
<tr>
<td>strong in state-of-the-art knowledge</td>
<td>1, 6</td>
</tr>
<tr>
<td>appropriate for immediate professional practice</td>
<td>1, 5</td>
</tr>
<tr>
<td>appropriate for graduate study</td>
<td>4, 6, 8</td>
</tr>
<tr>
<td>appropriate for lifelong learning</td>
<td>2, 8, 9</td>
</tr>
<tr>
<td>prepared for professional leadership</td>
<td>2, 10</td>
</tr>
<tr>
<td>prepared for informed citizenship</td>
<td>2, 10, 11</td>
</tr>
<tr>
<td>develops the ability to communicate</td>
<td>5, 7</td>
</tr>
<tr>
<td>develops work in teams</td>
<td>5</td>
</tr>
<tr>
<td>develops an understanding of the broad implications of work</td>
<td>1, 10, 11</td>
</tr>
</tbody>
</table>

The ECE curriculum is described in detail under Section 3. The structure and content of the curriculum directly addresses our stated objectives. As a result of the WPI general Degree Requirements and the ECE Distribution Requirements, a basic process is in place to assure that all students complete the curriculum with appropriate components to their education and standards of performance. Further, as described below, a system of ongoing evaluation is used to collect information related to accomplishment of educational objectives over the longer term, and to validate the performance of our curriculum against our educational objectives.

Achievement of Program Educational Objectives

Achievement of Program Educational Objectives - Describe the assessment and evaluation process that periodically documents and demonstrates the degree to which the Program Educational Objectives are attained.

We have adopted the common view that Educational Objectives refer to characteristics and abilities demonstrated by our alumni in the initial years after completion of the ECE program. We evaluate the achievement of these Objectives in four fundamental ways:

- Via on-going reviews of our distribution and other program requirements so that they reflect an ability by all students to achieve the stated objectives.
- Via data from our Outcomes Assessment process since our Program Outcomes should prepare graduates to demonstrate Educational Objectives.
- Via initial and continuing career success of our graduates.
- Via a range of contacts with our alumni and corporate constituencies, principally including Alumni Surveys and Advisory Board input.

Several time scales are involved in evaluation of objectives. First, we wish to determine that the curriculum is in fact providing an education which can be expected to lead to achievement of the stated objectives. Second, we wish to verify that students are learning the desired aspects. Third, we wish to verify that our alumni are displaying results consistent with the objectives in their professional lives.

Following is a summary of the tools used:
- Primary evidence for accomplishment of Objectives:
  - Alumni Surveys conducted 2, 5 and 10 years after graduation,
  - Input from the Advisory Board members and other corporate contacts.
- Evidence for accomplishment of Outcomes which leads to accomplishment of Objectives:
  - Criterion 3 (Section 3) describes the process and results of our assessment of the level of accomplishment of our program outcomes by students.

**Program Distribution Requirements versus Program Education Objectives**

The WPI degree requirements and the ECE distribution requirements are presented in Tables 2.3 and 2.4, respectively. The ECE curriculum is designed to help graduates meet the Program Educational Objectives as explained below. Further, the Program Outcomes presented briefly above and described in detail under Criterion 3 have been developed specifically to ensure the attainment of the program educational objectives. The direct relationship between the specific objectives and outcomes is demonstrated in Table 2.2. It is reasoned that a curriculum that accomplishes its outcomes is also likely to be one that attains its objectives.

**Objective 1. An education which is strong both in the fundamentals and in state-of-the-art knowledge.**

The main vehicle available for educating students in the fundamental and advanced principles of ECE is appropriate coursework that meets both the WPI degree requirements as well as the ECE specific course distribution requirements. Thus, every ECE graduate must complete 10 units (30 courses) of study in the areas of mathematics, basic science, engineering science and design, of which at least 5 units (15 courses) must be foundation and advanced electrical and computer engineering course work as shown in **Tables 2.3 and 2.4** (item #2a).
Table 2.3 - WPI Degree Requirements

WPI’s academic requirements are specifically designed to develop an overall educational experience which meets the goals of the college. Each requirement plays a supporting role as follows:

- To provide intellectual breadth and a better understanding of themselves and the diversity and creativity of human experience, every WPI student must complete a **Humanities and Arts Requirement**;

- To provide an understanding of the priorities of other sectors of society, develop the ability to communicate effectively with disparate groups, organize and derive solutions to complex problems, and gain an awareness of the interrelationships between technology and people, every WPI student must complete an **Interactive Qualifying Project (IQP)**;

- To provide a capstone experience in the professional discipline, to develop creativity, instill self-confidence and enhance the ability to communicate ideas and synthesize fundamental concepts, every student must complete a **Major Qualifying Project (MQP)**;

- To provide for learning through an academic program with fabric and course balance while encouraging individual student choices within that framework, every student must fulfill **Distribution Requirements**.

**WPI Terms and Credit Units**

The Bachelor degree from WPI normally is based upon a residency at WPI of 16 terms. WPI operates on a system with four seven-week terms, two in the autumn semester (Terms A and B) and two in the spring semester (Terms C and D). A summer session, Term E, is also available. The normal academic load for each term is defined as one unit of work, usually divided among three courses or projects. Thus, the usual credit unit for courses or independent study/projects is 1/3 unit. Qualifying Projects, defined on pages 14-25 (2008-09 catalog), require one full unit of activity which may be concentrated into a single term (especially if conducted off-campus) or spread throughout an academic year. The degree will be awarded upon completion of the following:

**Degree Requirements**

1. **The Humanities and Arts Requirement** - Qualification by overall evaluation of two units of work in the humanities and arts. To provide intellectual breadth and a better understanding of themselves and the diversity and creativity of human experience.

2. **The Interactive Qualifying Project** - Successful completion of a qualifying project relating science and/or technology to society (the Interactive Qualifying Project, or IQP) representing at least one unit of credit in project or independent study work. The format of the documentation is to be in accordance with current WPI policy on such documentation.

   An IQP shall address a topic relating science and/or technology to society. In this context, both “society” and “technology” should be construed as broadly as possible. Technology refers to the application of rational and efficient principles to a body of knowledge or to the control of space, matter and/or human beings. Thus, the IQP encompasses not only techniques of production embodied in tools and machines, but also advances in methods of social and economic organization, in managerial techniques, and in methods of analysis in science, mathematics, and engineering. Society refers not only to a grouping of individuals but also to the culture, values, laws, customs, and institutions shared by these individuals.

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25 http://www.wpi.edu/Pubs/Catalogs/Ugrad/Current/require.html - Effective for students matriculating after August 1, 2008.
As can be seen in Table 2.3, item #4 clearly states that there are Distribution Requirements for each of the separate degree programs at WPI. These program distribution requirements address specific program of study requirements within the context of Objective 1 (fundamental and advanced program courses).

The WPI degree requirements, however, also clearly address program objectives such as Objectives #3-6 when compared to WPI requirements for Social Sciences (WPI #5), Humanities and Arts (WPI #1) and the Interactive Qualifying Project (WPI #2).

### ECE Program Distribution Requirements

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3. <strong>The Major Qualifying Project</strong></td>
<td>Successful completion of a qualifying project in the major area of study (the Major Qualifying Project, or MQP) representing at least one unit of credit in project or independent study work. The format of the documentation is to be in accordance with current WPI policy on such documentation.</td>
</tr>
<tr>
<td>4. <strong>Distribution Requirements</strong></td>
<td>Satisfaction of published academic activity distribution requirements in or relating to the major area of study. These requirements total no more than ten units (including the MQP) and are specified by general topical subject area, not by specific courses. Completion of distribution requirements will be certified by the appropriate departmental or Interdisciplinary and Global Studies Division (IGSD) Program Review Committee (PRC), upon recommendation by the student’s academic advisor. For students desiring designation of a major area for which a determination regarding distribution requirements has not previously been made and published, a faculty committee will be appointed by the department head or IGSD dean to review and approve the student’s program of study.</td>
</tr>
<tr>
<td>5. <strong>Social Sciences</strong></td>
<td>Completion of 2/3 unit of work in the social sciences, exclusive of qualifying project.</td>
</tr>
<tr>
<td>6. <strong>Residency Requirement</strong></td>
<td>A minimum of eight units must be completed satisfactorily in residence at WPI. (It is anticipated the normal residence at WPI will be 16 terms.)</td>
</tr>
<tr>
<td>7. <strong>Minimum Academic Credit</strong></td>
<td>The minimum academic credit required for the Bachelor degree is 15 units. Credit accumulated beyond the published distribution requirements shall be accomplished by the addition of “free elective” work.</td>
</tr>
<tr>
<td>8. <strong>Physical Education</strong></td>
<td>Qualification in physical education shall be established by completing 1/3 unit of course work (four PE classes) or its equivalent. Such an equivalent, for example, may be participation in club or varsity sports.</td>
</tr>
</tbody>
</table>

As can be seen in Table 2.3, item #4 clearly states that there are Distribution Requirements for each of the separate degree programs at WPI. These program distribution requirements address specific program of study requirements within the context of Objective 1 (fundamental and advanced program courses).

The WPI degree requirements, however, also clearly address program objectives such as Objectives #3-6 when compared to WPI requirements for Social Sciences (WPI #5), Humanities and Arts (WPI #1) and the Interactive Qualifying Project (WPI #2).
### Objective 2. Preparation for immediate professional practice as well as graduate study and lifelong learning.

The two major required projects (MQP, IQP), faculty and professional seminars, reinforcement during state-of-the-art classes, and special presentations on our BS/MS program and other post-BS degree educational opportunities form the basis for informing students about graduate study and life-long learning opportunities. Other structures, events, requirements and organizations that support the preparation of students for professional practice, graduate study, and lifelong learning include the following.

- **IEEE Student Branch and Worcester County Branch of the IEEE** - professional meetings, events, invited speakers, dinners, luncheons, shows, visits and other professional interactions.
- **Women in ECE Group** - corporate visits, speakers, various events
- **Etta Kappa Nu (HKN)** - corporate visits, speakers, various events

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### Table 2.4 - ECE Distribution Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Minimum Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mathematics and Basic Science (Notes 1a-1d)</td>
<td>4</td>
</tr>
<tr>
<td>2. Engineering Science and Design (ES/D) (including the MQP) (Notes 2a-2g)</td>
<td>6</td>
</tr>
</tbody>
</table>

**Notes:**

1. **Mathematics and Basic Science:**
   - a. Must include at least 7/3 units of math (prefix MA). Mathematics must include differential and integral calculus, differential equations, discrete mathematics, and probability and/or statistics.
   - b. Must include at least 2/3 units of physics (prefix PH).
   - c. Must include at least 1/3 units of chemistry (prefix CH) or 1/3 units biology (prefix BB). d. Must include an additional 2/3 units of math or basic science (prefixes MA, PH, CH, BB, or GE).

2. **Engineering Science and Design (including the MQP):**
   - a. Must include at least 5 units within the Electrical and Computer Engineering area (including the MQP). All courses with prefix ECE (except ECE 3601) and ES 3011 are applicable to these 5 units.
   - b. The 5 units within the Electrical and Computer Engineering area must include at least 1 unit of courses from these approved Electrical Engineering courses: ECE 2112, 2201, 2204, 2312, 3011, 3113, 3204, 3305, 3306, 3311, 3501, 4011, 4023, 4201, 4304, 4703, 4902, 4904, and ES 3011.
   - c. The 5 units within the Electrical and Computer Engineering area must include at least 2/3 units of courses from these approved Computer Engineering courses ECE 2801, 3801, 3803, 3810, and 4801.
   - d. The 5 units within the Electrical and Computer Engineering area must include 1/3 unit of Capstone Design Experience. (This requirement is typically fulfilled by the MQP.)
   - e. Must include at least 1/3 unit of computer science (prefix CS), at the 2000 level or above (other than CS 2011, CS 2022, CS 3043 which cannot be applied to this requirement).
   - f. Must include at least 1/3 unit of engineering science (prefix ES) at the 2000 level or above. ES 3011 cannot be applied to this requirement.
   - g. Must include an additional 1/3 unit of engineering science and design at the 2000 level or above, selected from courses having the prefix BME, CE, CHE, CS (other than CS 2011, CS 2022, CS 3043), ECE (other than ECE 3601), ES, FP, ME or RBE.
Objective 3. **Broad preparation for their professional and personal lives, providing the basis for effective professional and civic leadership and informed citizenship.**

There are a variety of degree requirements described in Table 2.3 dedicated to Objective 3, including the Social Science requirement, the Humanities and Arts requirement, and the Interactive Qualifying Project (IQP). These unique requirements are among the major strengths of the WPI educational program and provide a firm foundation for helping students become informed and contributing citizens. We also maintain a very active student chapter of the Institute of Electrical and Electronic Engineers that helps students begin the process of serving their professional community.

Objective 4. **Strength in all forms of technical and nontechnical communication.**

Effective communication, essential for success, requires facility in both written and oral communication. The main opportunities for students to develop written communication skills are the Humanities and Arts requirement, the IQP, the MQP, and a few report writing intensive core cores including ECE 2799. We also note that in all laboratory courses, students are expected to thoroughly document their work in formal lab reports which are critiqued.

Formal oral communication is stressed in ECE 2799 and the MQP and is often required for the IQP. Further, there is a day set aside in April at WPI, the so-called “Project Presentation Day,” when no classes are held and students make presentations on their MQP work.

Objective 5. **The ability for effective teamwork.**

Teamwork is an integral part of the WPI educational plan, and certainly is reinforced in ECE laboratory and project work. The two required projects (MQP and IQP) are both teamwork intensive over an extended period of time. All ECE laboratory experiences are teamwork focused. Finally, ECE 2799 is not only team work centric, the course teaches teaming and scheming skills as part of the syllabus.

Objective 6. **An understanding of the broad social and ethical implications of their work.**

Students develop a broad background in the social and ethical implications of their work through a number of different mechanisms. These include the IQP, the Humanities and Arts requirement, the Social Science and Policy Studies requirement, our projects based course ECE 2799, and presentations on ethics and social implications that are part of the syllabus of some ECE courses.

Alumni Survey

The full results for the 2007 (fall) alumni survey are reported in Appendix L.1.A and L.1.B and in Section 4 (Continuous Improvement). Briefly, starting in 2006 the ECE department pioneered a new method for performing on-line, efficient, and fast-turn-around (a few weeks) internet based surveys of alumni who have been out 2, 5 and 10 years. Because of the success of our approach, ECE has recently made the commitment to perform such surveys every year as opposed to only a few years prior to an ABET review. Also, the ECE department has made our approach available to other departments and, in fact, has hosted surveys for other departments when requested.

Our focus for the most recent survey was modified slightly to obtain as much data as we could concerning:

- basic student data (degree year, focus area, majors, minors, etc),
- continuing education (degrees, area),
• current work status (level, title, company, working as an engineer or not, employed or not, etc),
• student perceptions of how well the ECE department achieves its stated program educational objectives,
• student perceptions of how well the ECE department achieves the goals of the MQP (a superset of the ABET capstone project),
• various questions concerning how well WPI is achieving various goals related to the IQP (global awareness, ability to work across time and space, team work, cultural sensitivity, etc),
• questions related to the best aspect of a student’s education at WPI,
• questions related to the best aspect of a student’s education in ECE
• questions related to the aspect of the WPI education that is most in need of improvement,
• questions related to the aspect of the ECE education that is most in need of improvement.

In reviewing these results we are interested in two different aspects: first, a determination of the relative importance which our alumni place on the various components of our Objectives; second, the alumni view of their preparation. With regard to program improvements, we pay the greatest attention to the areas of **high** importance in which the preparation is rated relatively **low**. It is also a matter of concern if our constituents (alumni in this case) rate an aspect of our Objectives as relatively unimportant, regardless of their view of the preparation in that element. Survey responses are collected on a five point scale (1=not at all, 5=very much, and not-applicable).

Details from the survey are presented in **Section 4** and the summary results presented in **Figure 2.1** at the end of this section (p.47). Our conclusion from our surveys is that there are no serious issues with respect to accomplishment of these aspects of our Objectives. Regardless, there are areas we are working to strengthen student preparation in (Criteria 4).

While it is difficult to extract statistically significant results from comments, the following appeared to represent the major areas of emphasis in each category. It should be noted that a given topic may be noted as a strength by one group of respondents, and as a weakness by another group!

1. **Most valuable part of WPI education:**
   - removed
   - removed
   - removed
   - removed

2. **Area most in need of improvement:**
   - removed
   - removed
   - removed
   - removed

3. **Comments on project work:**
   - removed
   - removed
   - removed

4. **Other comments:**
   - Overall, the open ended comments from students provided insights to the perceived value of a WPI degree (“It was a culmination of everything at WPI that produced the right formula for
success.”) as well as issues that need to be addressed in both the short and long term (“career opportunities”, “more courses outside the major”, more focus on writing and oral communication skills”).

While no conclusions can be drawn from any one comment, the survey results do serve to highlight a key question: “Is the ECE program meeting the needs of its constituencies?” The alumni responses obviously represent the alumni constituency, and furthermore they bear on two other constituencies. These respondents were students in the past, and hence can reflect on the impact of their education on their lives and careers. Also, many are employed by our corporate constituency. The general level of satisfaction, together with suggestions of areas where more can be done, indicates that there is certainly no significant mismatch between our students' needs and the education which they receive.

Advisory Board Input

As described above regarding constituent involvement, the ECE Advisory Board addresses at least one topic related to the undergraduate ECE program at each of its once-yearly meetings. Following are topics related to the undergraduate program discussed at the past five Advisory Board meetings.

- October 2007
  - **Retreat Issues**: decline in enrollments, first year engagement course development, funding for strategic programs (sources, influence, corporate support), laboratory and curriculum modernization needs (ibid), rankings (went down, what can ECE do to help WPI?)
  - **Program Improvement Issues**: curriculum - how to improve breadth and depth, skills development - how important are management and other skills; students - how are our students doing in industry; future knowledge - where is industry headed? what are the evolving needs of new employees? how important is a globally aware student?

It was clear from board discussions that our students are doing well in industry. Board members remarked that they were impressed how well ECE students could adapt to their environment, be productive from nearly day-one, have a short learning curve, and perhaps most importantly, know how to find the information they needed to solve problems. Board members generally believed that we had an excellent program/curriculum, that our students were as good as and often better than those hired from other universities, that we needed to insure that we kept our curriculum modern (no specific courses mentioned other than perhaps networking, which we are doing), and that a globally aware student is a “plus” but that we might consider a course in cultural differences so that our students who are sent abroad can culturally and socially adapt better. In fact, the discussion comments from this board meeting paralleled the comments we heard during a 2006 special summer curriculum review meeting where we invited in for a morning mini-retreat multiple corporate contacts and talked about the priority for undergraduate engineering education. The results from that meeting were a list of emphasis areas which were, in order, the following

1. **written and oral communication skills** - it was noted by board members that WPI did a good job with communication skills, but that the development of additional opportunities for further practice of oral and written communications skills were always desirable
2. **team work skills** - WPI does a good job with teamwork because of the IQP and MQP
3. **fundamentals of engineering knowledge** - have to make sure (in ECE) that we do not de-emphasize breadth of engineering studies (fundamentals)
4. **focus area knowledge** (in ECE, BS degree level) - ECE does a good job, but need to stay current and constantly review/revise the curriculum
5. **advanced knowledge** (in ECE, the MS degree level) - need to encourage the MS degree, but industry will demand this anyway

- **ABET**: review ABET criteria, review objectives and outcomes (are there any issues, what are our opportunities?), ABET A-K discussion, general discussion of department-curriculum-program opportunities. Board members affirmed that they believe our students are sufficiently prepared and that our students’ abilities are aligned with our stated objectives and outcomes.

- **Initiatives and Opportunities**: Senior Project Review (two reports available) - problems and opportunities identified, ECEDHA (ECE Dept. Heads Assoc.) annual survey data - where ECE stands relative to other colleges and departments

- **Action Items**: visit all board members in spring of 2008, add 2-3 new board members

**October 2006**

- **Department Overview**: strategic initiatives (robotics, first year program, IMGD, communications area courses)

- **The Future of Engineering**: impact of globalization, impact of off shoring, measuring and insuring student success, staying competitive, education change, ABET

- **Review of Strategic Plan**: general discussion and review of accomplishments

- **Critical Issues**: removed

- **Review of 2799**: (engineering design project course), review of what constitutes engineering design, review what program outcomes are covered in 2799

**October 2005**

- **Department Review**: promotions and tenure, new faculty and instructors, graduate systems engineering degree program (first cohort class graduation), NSF Career awards, building renovations and improvements

- **Retreat Issues**: IMGD being developed (ECE involvement), realignment of grad program, alumni outreach (led to development of an on-line survey system), alignment of curriculum with faculty research interests (at graduate level), first year program development and status

- **Capstone (MQP) Study**: summary of results, review of findings

- **Strategic Plan**: detailed review of plan, goals and desirements, established a series of new goals for ECE based on the SP
  - new first year experience (done)
  - communications skills (excellent report quality, 2008 oral presentations were very good)
  - emphasis on professional engineering including life long learning, graduate education, and so forth (instituted a new BS/MS program, doing more to inform students about graduate school and other post-BS educational opportunities)
  - enhancing cross-disciplinary education (strongly supporting robotics program, supporting IMGD program)

**October 2004**

- **Review**: annual report, successes, accomplishments, funding, new faculty, etc

- **Undergrad Issues and Opportunities**: staffing/faculty, lab space

- **Graduate Issues and Opportunities**: need to increase # of grad students, use of adjuncts (want to reduce numbers and improve quality)

- **Strategic Plan**: implementation, process

**October 2003**

- **Annual Review**: annual report, successes, accomplishments, opportunities
Review of Goals: implement ECE major, new department head, discrete math

(EBI) Annual Survey Review: higher than ..., lower than ..., opportunities for improvement

ECE Paradigm Shifts: improve graduate program, significantly increase research proposals and funding, hire based on strategic decisions and areas of need.

In general the Advisory Board discussions are in agreement with the alumni surveys. Both indicate a significant range in perceived importance among the aspects in our Objectives (and Outcomes) statements. In particular, the general education and societal components are seen as less important than the disciplinary components. We (the faculty) interpret these discussions to mean that the core disciplinary components of the electrical engineering education are viewed by our advisory board members to be pre-eminent and that other aspects, such as general education, global and civic awareness, form significant additional components of students' education which are valuable for life as well as for technical performance.

Placement Data

Given that our Objectives and Outcomes are relevant to our corporate constituency, the success of our graduates in job placement is one indication of their success in meeting our Outcomes and longer-range success in meeting our Objectives. Table 2.5 presents placement rates and starting salaries for BS graduates for the past four years.

These data are very positive, both with regard to placement rate and to the starting salaries of our graduates compared to the national average. Further, a review of the types of corporations for which our graduates work indicates a match with the faculty’s expectations. Overall, we can conclude that our graduates do meet the needs of industry for entry-level electrical and computer engineers since placement is good during normal and high-demand periods. Given the cyclic nature of high tech, no change in program objectives and outcomes will guarantee a job offer when there are few open positions in industry.

<table>
<thead>
<tr>
<th>Class</th>
<th>Percent Placed</th>
<th>Average salary</th>
<th>Estimated National Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>89 %</td>
<td>$ 60,821</td>
<td>$ 54,900(^{26})</td>
</tr>
<tr>
<td>2006</td>
<td>96 %</td>
<td>$ 55,818</td>
<td>$ 52,900(^{27})</td>
</tr>
<tr>
<td>2005</td>
<td>89 %</td>
<td>$ 56,314</td>
<td>$ 51,100(^{28})</td>
</tr>
<tr>
<td>2004</td>
<td>87 %</td>
<td>$ 51,187</td>
<td>$ 49,400(^{29})</td>
</tr>
</tbody>
</table>

Conclusions

While a significant amount of objective data is available regarding the manner and degree to which our graduates achieve our Educational Objectives, it is not possible (or appropriate) to attempt to quantify each aspect. Via the program outcomes, as well as the quality of the entering students and the overall educational environment during their college experience, we have confidence that our graduates are prepared to accomplish our objectives. Alumni surveys, reviews of alumni career data, and input from our corporate constituents provides evidence that our graduate are in fact accomplishing our objectives. Indeed, the data illustrated in the last table of our 2007 alumni survey (Appendix L.2), reproduced below in Figure 2.1 clearly shows that our own graduates strongly believe that they have achieved all of our educational outcomes at least at the “average” level or higher.

\(^{26}\)http://www.doe.mtu.edu/news/degree_worth.html
\(^{27}\)http://money.cnn.com/2006/02/13/pf/college/starting_salaries/index.htm
\(^{28}\)http://www.graduatingengineer.com/resources/articles/20050420/Starting-Salaries
\(^{29}\)http://money.cnn.com/2004/02/05/pf/college/lucrative_degrees/
Figure 2.1 - Summary of 2007 Alumni Survey Data - Educational Objectives
CRITERION 3. PROGRAM OUTCOMES

Program outcomes: Narrower statements that describe what students are expected to know and be able to do by the time of graduation (skills, knowledge, and behaviors students acquire throughout the program).

Outcomes of the Electrical and Computer Engineering Program

List the Program Outcomes and describe how they encompass Criterion 3 and any applicable Program Criteria. Indicate where the Program Outcomes are documented.

The WPI ECE department has historically elected to create its own outcomes and, specifically, not to adopt the ABET a-k outcomes in direct form. Following are the outcomes of the Electrical and Computer Engineering program as adopted by the ECE faculty on March 28, 2001. Based on the stated objectives, students will achieve the following specific educational outcomes: (ABET a-k equivalent again)

1. Preparation for engineering practice, including the technical, professional, and ethical components.
2. Preparation for the future changes in electrical and computer engineering.
3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software.
4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE.
5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.
6. Demonstration of in-depth understanding of at least one specialty within ECE.
7. Demonstration of oral and written communications skills.
8. Understanding of options for careers and further education, and the necessary educational preparation to pursue those options.
9. An ability to learn independently.
10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI.
11. An understanding of engineering and technology in a societal and global context.

These outcomes are in agreement with the overall Institute Mission and Goals, and put the WPI statements in the context of electrical and computer engineering.

ECE program outcomes are documented on our web pages30, in our undergraduate catalog31 and are posted in the first floor student lounge area of the ECE building (Atwater Kent building).

Relation of Program Outcomes to ABET Requirements

The Outcomes from ABET Criterion 3 are listed below for reference:

30 http://www.ece.wpi.edu/Undergraduate/ug-goals.html
31 p.56 of the 2008-09 catalog
A. An ability to apply knowledge of mathematics, science, and engineering
B. An ability to design and conduct experiments, as well as to analyze and interpret data
C. An ability to design a system, component, or process to meet desired needs
D. An ability to function on multi-disciplinary teams
E. An ability to identify, formulate, and solve engineering problems
F. An understanding of professional and ethical responsibility
G. An ability to communicate effectively
H. The broad education necessary to understand the impact of engineering solutions in a global and societal context
I. A recognition of the need for, and an ability to engage in life-long learning
J. A knowledge of contemporary issues
K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The eleven WPI ECE Program Outcomes encompass all of the ABET Outcomes (a-k). The mapping is not always one-to-one because of the need to implement Outcomes which match WPI's Mission and Goals. Also, some of the ABET Outcomes represent higher priorities of the WPI ECE department than others, but all are included to an appropriate level. Table 3.1 indicates the relations between the two sets using ABET’s A through K scheme. (The key mapping between our outcomes and ABET outcomes.)

<table>
<thead>
<tr>
<th>ABET Criteria</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPI ECE Outcomes</td>
<td>3,4,6</td>
<td>4,9</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>10,11</td>
<td>2,8</td>
<td>11</td>
<td>1,6</td>
</tr>
</tbody>
</table>

Relation of ECE Program Outcomes and ECE Educational Objectives
Describe how the Program Outcomes lead to the achievement of the Program Educational Objectives.

The Program Outcomes are chosen so that they are demonstrable by students upon graduation, whereas the Program Educational Objectives are intentionally more broad, long range, and as a consequence somewhat more difficult to measure quantitatively. Nevertheless, the Outcomes were chosen to provide an education which should lead to demonstration of the desired Objectives. For example, the "Professional Leadership" Objective is supported by the Outcomes which seek to assure a technically competent graduate (Outcomes 1, 3-6). The rest of the relationships between Outcomes and Objectives have been previously stated in Table 2.2.

Relationship of Courses to Program Outcomes
Below in Table 3.2, each of our program outcomes is related to a component (or components) of the WPI plan and ECE courses. Below, ECE 2799 and the required third year project (IQP) and fourth year project (MQP) are described.
ECE 2799. Electrical and Computer Engineering Design

The goal of this course is to provide experience with the design of a system, component, or process. Basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a stated objective. Fundamental steps of the design process are practiced, including the establishment of objectives and criteria, synthesis, analysis, manufacturability, testing, and evaluation. Students work in small teams and are encouraged to use creativity to solve specific but open-ended problems, and then present their results. ECE 2799 is strongly recommended for all students as a preparation for the design element of the MQP. It is anticipated that ECE 2799 will be of most benefit to students when taken well in advance of the MQP (late sophomore year or early junior year).

The Interactive Qualifying Project (IQP)

At WPI, students are expected to develop an understanding of how science and technology are embedded in the fabric of society. The Interactive Qualifying Project (IQP) challenges students to address a problem that lies at the intersection of science or technology with society. During the IQP, students work in interdisciplinary teams, often with an external sponsoring organization, to develop solutions to real world problems. In doing so, students learn something about the role of science and technology, its impact on society, its place in meeting human needs and human efforts to regulate, control, promote and manage our changing technologies.

The Major Qualifying Project (MQP)

The qualifying project in the major field of study should demonstrate application of the skills, methods, and knowledge of the discipline to the solution of a problem that would be representative of the type to be encountered in one’s career. The project’s content area should be carefully selected to complement the student’s total educational program. In defining the project area within which a specific topic is to be selected, the student and academic advisor should pay particular attention to the interrelationships that will exist between the bodies of knowledge represented by courses, independent studies, and Preliminary Qualifying Projects; and by the Interactive Qualifying Projects.

MQP activities encompass research, development, and application, involve analysis or synthesis, are experimental or theoretical, emphasize a particular subarea of the major, or combine aspects of several subareas. In many cases, especially in engineering, MQP’s involve capstone design activity. Long before final selection of a project topic, serious thought should be given as to which of these types of activities are to be included. Beyond these considerations, the MQP can also be viewed as an opportunity to publish, to gain experience in the business or public sectors.

The following indicates how our outcomes are met by portions of the WPI Plan.
Table 3.2 Relationship Between Program Outcomes and WPI/ECE Degree/Curriculum Components

<table>
<thead>
<tr>
<th>ECE Program Outcome</th>
<th>WPI/ECE Curriculum/Plan Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preparation for engineering practice, including the technical, professional, and ethical components.</td>
<td>various course and team projects, IQP, MQP, humanities and arts requirement, major area courses, written and oral communications requirements, support for and activities of student professional society organizations</td>
</tr>
<tr>
<td>2. Preparation for the future changes in electrical and computer engineering.</td>
<td>advanced level courses and laboratories in ECE, MQP, department presentations on post-graduation opportunities (work, BS/MS, grad school, etc)</td>
</tr>
<tr>
<td>3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software.</td>
<td>ECE electrical and computer engineering courses (distribution requirements)</td>
</tr>
<tr>
<td>4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE.</td>
<td>mathematics distribution requirements, applications of mathematics in ECE courses, capstone project activities</td>
</tr>
<tr>
<td>5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.</td>
<td>ECE 2799, advanced level ECE courses, ECE capstone project activities, MQP</td>
</tr>
<tr>
<td>6. Demonstration of in-depth understanding of at least one specialty within ECE.</td>
<td>ECE distribution requirements, ECE capstone project activities</td>
</tr>
<tr>
<td>7. Demonstration of oral and written communications skills.</td>
<td>ECE 2799, IQP, MQP, HU&amp;A requirements, project presentation day</td>
</tr>
<tr>
<td>8. Understanding of options for careers and further education, and the necessary educational preparation to pursue those options.</td>
<td>department presentations, career development center (CDC) programs, recruitment fairs</td>
</tr>
<tr>
<td>9. An ability to learn independently.</td>
<td>project activities (MQP, IQP), upper level courses</td>
</tr>
<tr>
<td>10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI.</td>
<td>distribution requirements, MQP, IQP, HU&amp;A requirements</td>
</tr>
<tr>
<td>11. An understanding of engineering and technology in a societal and global context.</td>
<td>WPI global program, IQP, MQP (particularly those off campus), HU&amp;A requirements, upper level ECE courses</td>
</tr>
</tbody>
</table>

Overview of the Curricular Development and Assessment Process

Structure

Development, implementation and assessment of the ECE program are the explicit responsibility of the ECE Undergraduate Program Committee (UPC) and Curriculum Committee (CC), and are managed by the ECE Department Head with the support of the Associate Head.

**UG Program Committee:** manages all non-course program issues including projects (assignments, management, support), academic advising day, minors, and project presentation day, etc.

**Curriculum Committee:** manages all aspects of undergraduate and graduate curriculum, courses, tracks, on- and off-campus offerings, course and project outcomes and assessment; course descriptions; implementation of strategic plan, etc.
These committees consists of the committee chair, the Associate Head ex-officio (for CC), and to the extent possible a representative of department emphasis areas (fundamentals, computer engineering, electromagnetics, communications and signal processing, power systems, analog microelectronics).

Both the UPC and CC appoint ad-hoc committees as appropriate to address specific topics. A long running example is the ad-hoc committee to review computer engineering courses, labs and projects (the Computer Engineering Review Committee - CERC) which monitors all aspects of the computer/digital area courses/projects and which meets sufficiently regularly to insure that the quality of the digital/computer engineering (D/CE) courses are kept up to date, that the associated course laboratories are well planned, supported, stocked and staffed, and that there are excellent resources available for project activities ranging from capstone (undergraduate) projects to MS and Ph.D. thesis and dissertation activities, respectively.

**Process**

Recommendations for changes in the undergraduate program for non-course related topics are first reviewed and voted by the UPC (curriculum topics are managed by the CC) and then discussed and acted on by the entire ECE faculty. Also, major changes are discussed with the departmental Advisory Board and with the students. Minutes of the UPC and CC meetings and ad hoc committee reports will be available at the visit.

The first step of our curriculum development has been to identify the kinds of skills and abilities we wish our students to exhibit when they graduate. We then plan for ways that our students could prepare for and then exhibit this evidence multiple times whenever possible. Here, by skills and abilities we mean both specific skills such as those that might be taught (for example) in a course on circuit theory (e.g. in-depth knowledge in a specific area) as well as broader types of skills and abilities such as good written and oral communication skills.

Our approach to assessment of what we deem desirable skills and abilities (within the context of our program outcomes) has been to provide mechanisms for determining student performance throughout their academic program, to report the findings in a timely and constructive way, to determine and obtain relevant comparisons for the data received, and to provide anonymity to students as they fill out survey tools. These mechanisms, in turn, provide ways to collect evidence of those skills and abilities. Finally, the evidence is used in a circular manner, once reviewed, to modify how we implement our program to foster those skills and abilities in our students so that i) we have high confidence that our students are actually obtaining those desirable skills and abilities (our outcomes) and ii) how we collect our evidence (our assessment mechanisms) so that we have confidence and efficiency in our data collection processes.

The overall departmental process for curricular planning, assessment and quality improvement is shown on the following page in **Figure 3.1 (also, Appendix G)** and is based on the department head (DH) and associate head (AH) reviewing collected assessment material and then, as necessary, discussing the evidence with appropriate committee chairs and establishing a plan for action. On occasion, an ad-hoc committee may also be formed to discuss the issue(s), formulate a solution, and monitor implementation. The bottom line is that the DH and AH manage the exchange of information among faculty (as committee members, course instructors, project advisors and academic advisors), students (in courses, on projects, as leaders, and during their extra-curricular activities), and the assessment tools (that address all of these aspects). The assessment tools are administered and the reporting done in a timely way so that the process is part of our culture, not appended to it.

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32 sabbaticals, leaves of absence, faculty departures, and other factors affect assignments to committees
Figure 3.1 - ECE Assessment Process
Outcomes Development and Assessment

Describe the process used for establishing and revising Program Outcomes. Describe by example how the evaluation team will be able to relate the display materials, i.e., course syllabi, sample student work, etc., to each Program Outcome.

The guiding principles for the work reported here are based on the following (slightly modified) steps for developing an assessment plan:

1. Identify goals and objectives
2. Identify desirable outcomes
3. Determine evidence needed to verify outcomes
4. Specify assessment methods to obtain evidence
5. Develop connections between evidence and assessment (particularly if indirect)
6. Determine feedback channels to provide for continuous improvement
7. Conduct assessments
8. Evaluate assessment results, determine opportunities and take appropriate action

Identify Goals and Objectives - Step 1

The result of this process can be found in the section on Criterion 2 of this report, where the Mission and Goals of WPI and the Objectives for the ECE program are stated.

Identify Outcomes - Step 2

Our program outcomes can be found in this Section.

Determine Evidence - Step 3

Much of our evidence is based on outcomes of coursework, MQPs, and IQPs, which in turn constitute degree requirements. Other evidence is provided through student surveys and internal reporting. A listing of the general evidence identified for each program outcome can be found in Table 3.3. Specific evidence is reviewed on pages 56-60. Briefly, Table 3.3 lists the sources of evidence such as courses, surveys and other tools that are used in different ways and with different emphasis to help us understand the extent to which we are achieving a specific outcomes. The information provided on pages 56-60 breaks down each outcome into different categories or aspects of each outcome and relates the category/aspect to specific evidence.

33 “Stepping Ahead: An Assessment Plan Development Guide,” Gloria Rogers, Jean Sando
Table 3.3 Assessment Matrix for Program Outcomes.

<table>
<thead>
<tr>
<th>ECE Program Outcome</th>
<th>Assessment Evidence Source or Tool</th>
</tr>
</thead>
</table>
| 1. Preparation for engineering practice, including the technical, professional, and ethical components. | • MQP and IQP review  
• alumni and EBI surveys  
• faculty MQP reviews  
• course outcome data |
| 2. Preparation for the future changes in electrical and computer engineering. | • audit of graduating senior transcripts for compliance with distribution requirements  
• alumni, exit and EBI survey data  
• MQP review  
• head and associate head reviews of data |
| 3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software. | • audit of graduating senior transcripts for compliance with distribution requirements  
• requirement for taking CS courses  
• course outcome data |
| 4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE. | • audit of graduating senior transcripts for compliance with distribution requirements  
• MQP inventories and biennial review data  
• EBI and alumni survey results  
• course outcome data |
| 5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills. | • 2799 course outcome data  
• MQP inventories and biennial review data  
• EBI and alumni survey results |
| 6. Demonstration of in-depth understanding of at least one specialty within ECE. | • audit of graduating senior transcripts  
• head and associate head review of data  
• MQP inventories and biennial reviews |
| 7. Demonstration of oral and written communications skills. | • biennial MQP and IQP reviews  
• MQP oral presentation evaluations  
• course outcome data (pri. 2799)  
• EBI and alumni survey data |
| 8. Understanding of options for careers and further education, and the necessary educational prep. to pursue those options. | • EBI, alumni and senior survey data |
| 9. An ability to learn independently. | • MQP inventories and biennial review  
• EBI, alumni and senior survey data |
| 10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI. | • WPI and ECE prog./dist. requirements  
• alumni survey data |
| 11. An understanding of engineering and technology in a societal and global context. | • EBI and alumni survey data  
• MQP inventories and biennial review data |

Specify Assessment Methods - Step 4
This section describes the assessment tools referred to in Table 3.3.
- **Educational Benchmarking Survey** - Performed at WPI and other schools in 2006 and 2007. Data is available from all of the schools that participated in the study. Charts are shown comparing WPI to "Select 6" (2006: BU, Northeastern, Rice, CMU, Kettering, Stevens - - 2007: BU, CMU, Dartmouth, Drexel, Northeastern, MIT)\(^{34}\) and "Carnegie Class" (2006: Dartmouth, George Mason, Texas A&M Kingsville, Florida Atlantic, Stevens, Texas Christian, U. Dayton, San Diego, Texas Dallas - - 2007: Cal State LA, Cal State Northbridge, Gonzaga, Loyola Marymount, National U., Santa Clara, U. Tenn. at Chattanooga, Villanova). EBI survey summary results for all departments participating in the survey are summarized in Appendix L.3.B. A sample of the EBI survey form is found in Appendix L.3.A. A full copy of the EBI results is approximately 600+ pages and will be made available to the ABET visitors if requested.

- **Alumni Survey** - Details of the alumni survey have been described previously (p.42).

- **Senior Survey** - Performed by the ECE department annually since 1996. An example of the form used and the results can be found in Appendix L.2.A and L.2.B, respectively. Changes over the years have reflected that a number of the questions have been answered by the EBI survey, and others have been added to provide a more complete assessment of the students’ experience.

- **WPI Teaching Evaluations** - includes data collected for the entire department, and results presented are the percentages of responses that are Strongly Agree or Agree. The total number of responses for each question have excluded Not Application (NA) responses for lab/facilities related questions. Values are for all ECE courses in an academic year, and are compared to courses from other WPI engineering departments in the same academic year. The return rates vary from one course offering to the next, but are generally fairly high because the forms are distributed during a lecture. An example of the form used and the results can be found in Appendix H.1.

- **Course Based Assessment** - refers to assessments done in ECE courses. Our department has targeted seven courses for course-based assessment (ECE 2011, ECE 2022, ECE 2201, ECE 2311, ECE 2111, ECE 2799, and ECE 2801). We developed a set of course outcomes which remain the same for each course offering. The actual coverage of material in each course is, however, more comprehensive than this set. Course instructors have the tasks of matching evaluated student performance (such as exam questions) to each course outcome and keeping student-specific data on performance. Summary data for all assessed courses is provided in Appendix I.3.

- **Faculty Two Page Course Review Sheet** - a relatively new and valuable per-course-offering review sheet filled out by faculty at the end of every ECE course offering. This review sheet, copies of which will be available and an example of which is found in Appendix J, seeks to determine whether a particular offering of a course is achieving the desired outcomes from the faculty perspective and how well the students are prepared for the course. As a result, this review sheet provides a viable way to determine the impact of individual course offerings, student quality, student preparation and to identify problems both on an individual course basis, as well as how courses flow together, and how possible problems ripple through our curriculum.

- **MQP Inventory and Assessment** - is done in a variety of ways and is appropriate given the importance of this degree requirement. Since 1999, the project advisor has been asked to complete MQP inventories near the end of each project. The current version of the forms can be found in Appendix K.1.C. Tabulations of some of the data collected can be found in Appendix K.1.D.

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\(^{34}\) Different universities use the EBI survey each year. As a result, WPI has to modify the ‘select six’ and “Carnegie Class” to match.
Separate from these inventories, a MQP review committee provides evaluations on a range of topics. The MQP review committees have been operating essentially biennially since 1997. A copy of their latest report can be found in Appendix K.2.

MQP teams are required to do an oral presentation, and these presentations usually occur on one of two department-wide project presentation days (fall, spring). Oral presentation skills are assessed during these days by faculty in attendance. An example of the form used and results can be found in Appendix K.3.A and a summary of the data can be found in Appendix K.3.B.

- ECE TA and Senior Tutor Evaluations - are completed by course instructors and collected by the department. An example of the form used and the results can be found in Appendix F.

Develop Connections - Step 5

There are two important layers of our assessment program:

1. The links between the outcomes and the ways in which students provide evidence that they have achieved the outcome.
2. The links between this evidence and assessment methods.
3. The links between the evidence and how the evidence is processed to create continuous improvement feedback paths.

It was agreed that there would be a framework for assessment so that any minor changes need not be approved by the ECE Curriculum Committee before being implemented. An important feature of this framework, shown in Figure 3.1 is that it describes which tool(s) are needed for each kind of evidence (and in turn each outcome). In order to specifically address connections between tools and evidence, the eleven ECE Program Outcomes are listed below, together with some of the evidences of achievement and the method by which the assessment takes place. The abbreviations used for assessment methods are: ALS (Alumni Survey), DAR (Department Head and Associate Department Head Review), EBIA (EBI Engineering Exit Assessment), OPA (Oral Presentation Assessment), MQPA (Senior Design Project Assessment), and SNS (ECE Senior Survey).

**Outcome 1: Preparation for engineering practice, including the technical, professional, and ethical components.**

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to demonstrate an understanding of the relevance of ethics, reliability, safety, and regulatory issues in the design process</td>
<td>ECE2799, MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>To be able to demonstrate a working knowledge of the financial, schedule, legal and other administrative elements in the design process</td>
<td>ECE2799</td>
</tr>
<tr>
<td>Ability to use modern engineering tools for engineering design and analysis</td>
<td>MQPA, EBIA</td>
</tr>
<tr>
<td>To be able to use computer software tools to model signals and systems and to solve problems.</td>
<td>ECE2311</td>
</tr>
<tr>
<td>To be able to demonstrate an understanding of the organizational issues associated with engineering design.</td>
<td>ECE2799</td>
</tr>
</tbody>
</table>
### Outcome 2: Preparation for future changes in ECE.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>An appreciation for and the skills to accomplish lifelong learning</td>
<td>MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>Membership and participation in professional societies</td>
<td>DAR</td>
</tr>
</tbody>
</table>

### Outcome 3: A solid understanding of the basic principles in electrical engineering, computer engineering, and the relationship between hardware and software.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to write and understand Kirchhoff’s current and voltage laws</td>
<td>ECE2011</td>
</tr>
<tr>
<td>To be able to solve for voltage, current and power in resistive DC circuits.</td>
<td>ECE2011</td>
</tr>
<tr>
<td>To be able to find Thévenin’s and Norton’s equivalents</td>
<td>ECE2011</td>
</tr>
<tr>
<td>To be able to model dependent sources and operational amplifiers in DC circuits.</td>
<td>ECE2011</td>
</tr>
<tr>
<td>To be able to determine the impedance of resistor-capacitor-inductor circuits.</td>
<td>ECE2011</td>
</tr>
<tr>
<td>To be able to use combinational/sequential logic circuits to perform a given task or operation</td>
<td>ECE2022</td>
</tr>
<tr>
<td>To be able to understand how a transistor is used for the implementation of Boolean algebra</td>
<td>ECE2022</td>
</tr>
<tr>
<td>Ability to solve problems within ECE that pertain to sets and functions of discrete variables</td>
<td>ECE2022</td>
</tr>
<tr>
<td>To be able to solve for the frequency response of first-order circuits</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to solve for the frequency response of a second-order circuits</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to explain the physics underlying the behavior of capacitors</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to explain the physics underlying the behavior of inductors</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to apply superposition to the solution of circuits</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to find the transient response of a first-order circuit</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to identify resonant behavior</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to understand basic principles of transmission lines</td>
<td>ECE2111</td>
</tr>
<tr>
<td>To be able to demonstrate and understand the fundamental semiconductor physical concepts and the performance of the pn junction</td>
<td>ECE2201</td>
</tr>
<tr>
<td>To be able to understand diode operation and performance</td>
<td>ECE2201</td>
</tr>
<tr>
<td>To be able to analyze diode circuits and to design and implement diode applications</td>
<td>ECE2201</td>
</tr>
<tr>
<td>To be able to understand field-effect transistor operation and performance</td>
<td>ECE2201</td>
</tr>
</tbody>
</table>
To be able to analyze field-effect transistor circuits and to design and implement field-effect transistor applications  

ECE2201

To be able to understand bipolar junction transistor operation and performance  

ECE2201

To be able to analyze bipolar junction transistor circuits and to design and implement bipolar junction transistor applications  

ECE2201

To be able to characterize and describe signals and systems using commonly-accepted terminology.  

ECE2311

To be able to relate frequency-domain descriptions of signals and systems to their characteristics in the time domain, and vice-versa.  

ECE2311

To be able to use frequency-domain techniques to solve input/output problems for linear, time-invariant systems.  

ECE2311

To show the ability to decompose a written problem statement into algorithms suitable for implementation in assembly or mixed C/assembly language  

ECE2801

To be able to demonstrate an understanding of assembly-language instruction sets and addressing modes  

ECE2801

To be able to demonstrate an understanding of stack operations, procedure calls, and interrupt processing  

ECE2801

To be able to demonstrate an understanding of parameter passing for mixed C/Assembly language programming  

ECE2801

To be able to demonstrate an understanding of the control and use of memory-mapped peripherals  

ECE2801

To be able to demonstrate an ability to efficiently assemble, link, and debug a program  

ECE2801

Outcome 4: An understanding of appropriate mathematical concepts, and an ability to apply them to ECE.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to apply mathematics, science and engineering knowledge</td>
<td>MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>Ability to analyze and interpret the resulting data</td>
<td>MQPA, EBIA</td>
</tr>
<tr>
<td>To be able to manipulate complex numbers and phasors in the context of steady-state AC circuits</td>
<td>ECE2011, ECE2111</td>
</tr>
<tr>
<td>To be able to perform basic operations of binary arithmetic</td>
<td>ECE2022</td>
</tr>
<tr>
<td>To be able to perform the basic operations of Boolean algebra</td>
<td>ECE2022</td>
</tr>
<tr>
<td>To be able to manipulate and simplify logic equations (i.e., Karnaugh maps)</td>
<td>ECE2022</td>
</tr>
<tr>
<td>Demonstrate an understanding of digital number representations, fixed-point, and floating-point mathematics.</td>
<td>ECE2801</td>
</tr>
</tbody>
</table>
**Outcome 5:** An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communication skills.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to demonstrate knowledge of the steps involved with the system design process</td>
<td>ECE2799, ALS, EBIA</td>
</tr>
<tr>
<td>To be able to demonstrate the ability to apply the engineering design steps to the decomposition, solution and implementation of an unbounded design problem.</td>
<td>EE2799, ALS EBIA, MQPA</td>
</tr>
<tr>
<td>Incorporate Economic Considerations</td>
<td>MQPA, EBIA</td>
</tr>
<tr>
<td>Incorporate Aesthetic Considerations</td>
<td>MQPA</td>
</tr>
<tr>
<td>Incorporate Sustainability Considerations</td>
<td>EBIA</td>
</tr>
<tr>
<td>Incorporate Manufacturability Considerations</td>
<td>EBIA</td>
</tr>
<tr>
<td>Demonstrate an understanding of the relevance of reliability</td>
<td>ECE2799, MQPA</td>
</tr>
<tr>
<td>Ability to design a system, component, or process to meet design criteria</td>
<td>MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>Perform Synthesis</td>
<td>MQPA</td>
</tr>
<tr>
<td>Ability to function within a multidisciplinary team</td>
<td>EBIA, ALS, MQPA</td>
</tr>
<tr>
<td>Ability to function on a team</td>
<td>MQPA, ALS, EBIA</td>
</tr>
</tbody>
</table>

**Outcome 6:** Demonstration of in-depth understanding of at least one specialty within ECE.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate knowledge representative of senior-level or graduate course material as part of an MQP</td>
<td>MQPA</td>
</tr>
<tr>
<td>Completion of the course(s) for at least one of the subdisciplines or completion of a ECE graduate course.</td>
<td>DAR</td>
</tr>
</tbody>
</table>

**Outcome 7:** An ability to communicate effectively in written and oral form.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to demonstrate the ability to effectively use written communications to report project status and results.</td>
<td>ECE2799, MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>To be able to demonstrate the ability to effectively use oral communications to report project status and results.</td>
<td>ECE2799, OPA, ALS, EBIA</td>
</tr>
</tbody>
</table>
**Outcome 8:** An understanding of options for careers and further education, and the necessary educational preparation to pursue those options.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive formal education after graduation from WPI</td>
<td>SNS, ALS, EBIA</td>
</tr>
<tr>
<td>Informed about programs, choices and opportunities available to you in graduate school</td>
<td>SNS, ALS</td>
</tr>
</tbody>
</table>

**Outcome 9:** An ability to learn independently.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to design and conduct experiments</td>
<td>MQPA, EBIA, ALS</td>
</tr>
<tr>
<td>Ability to use resource materials to support project work</td>
<td>EBIA, MQPA</td>
</tr>
</tbody>
</table>

**Outcome 10:** The broad education envisioned by the Plan, and described by the Goal and Mission of WPI. The only aspects of the Mission of WPI not already covered by other Program Outcomes is “civic contribution”.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate an understanding of the importance of civic contributions</td>
<td>ALS</td>
</tr>
</tbody>
</table>

**Outcome 11:** An understanding of engineering and technology in a societal and global context.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate Knowledge of Contemporary Issues</td>
<td>MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>Understand Impact of Work in Global, Societal Contexts</td>
<td>MQPA, ALS, EBIA</td>
</tr>
<tr>
<td>Participation in work abroad</td>
<td>ALS</td>
</tr>
</tbody>
</table>

Determine Feedback Channels - *Step 6*

Oversight of the assessment reporting is provided by the Department Head and Associate Head. As noted earlier, the DH and AH review the collected assessment material and then, as necessary, discuss the evidence with appropriate committee chairs and establish a plan for action. As noted in **Figure 3.1** and shown in **Table 3.4**, once the assessment data is reviewed by the DH and AH, it is forwarded to the appropriate individual(s) or committee and discussed. It is then the committee/individual(s) responsibility to review the material, determine the need and method for action, recommend a plan, and act on it in some manner.
Table 3.4: Assessment Reporting

<table>
<thead>
<tr>
<th>Assessment Method</th>
<th>Performed When</th>
<th>Reported To Whom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Head/Assoc. Head</td>
</tr>
<tr>
<td>Course Evaluations</td>
<td>compiled at end of every course</td>
<td>1</td>
</tr>
<tr>
<td>Course-based: ECE 2011, ECE 2022, ECE 2111, ECE 2201, ECE 2311, ECE 2799, ECE 2801</td>
<td>every term the individual courses are offered</td>
<td>1</td>
</tr>
<tr>
<td>Department Annual Report</td>
<td>annually</td>
<td>1</td>
</tr>
<tr>
<td>Alumni / EBI / Senior Survey</td>
<td>every year for alumni survey</td>
<td>1</td>
</tr>
<tr>
<td>IGSD Report</td>
<td>biennially</td>
<td>1</td>
</tr>
<tr>
<td>MQP Inventories</td>
<td>every B and D terms</td>
<td>1</td>
</tr>
<tr>
<td>MQP Review</td>
<td>biennially</td>
<td>1</td>
</tr>
<tr>
<td>TA and Senior Tutor Evaluations</td>
<td>every term for every course with an assigned TA and/or senior tutor</td>
<td>1</td>
</tr>
<tr>
<td>MQP Oral Reviews</td>
<td>every year</td>
<td>1</td>
</tr>
<tr>
<td>UPC/CC Reports</td>
<td>annually</td>
<td>1</td>
</tr>
<tr>
<td>Faculty Two-Page Course Reviews</td>
<td>end of every course/term</td>
<td>1</td>
</tr>
</tbody>
</table>

Conduct Assessments – *Step 7*

Table 3.4 shows the different assessment methods used and the schedule of their implementation.

Evaluate Results – *Step 8*

This section documents *some* of the results that have been attained through our process of assessment, reporting, and action.

- Assessment of the MQP in 2004 and 2006 showed a number of interesting trends and results when comparing the two surveys to each other.
  - all comments removed
- Senior Survey results are available for every year since the last ABET visit. Representative results noted below are from the 2008 survey of graduating seniors. In the following data the scale is ranked from 1=inadequate, 3=adequate and 5= excellent.
  - comments removed
- Oral presentation reviews (Project Presentation Day) comments showed that there was a marked improvement in the quality of the MQP presentations in 2008. In particular, we had observed presentation quality declined in 2007 compared to 2006 and it has been noted that the oral MQP
presentations seemed to need more faculty input to improve the quality. After a concerted effort by
the department head to remind faculty to rehearse their students and properly prepare them for their
oral presentations, it was noted (by the DH in an email to his colleagues) that the quality of the
presentations were improved in 2008 and that he had not attended a single presentation that was not
well done.

- Continuous **review of our curriculum** and courses highlighted opportunities for improvement in
both our early entry courses (first and second years) as well as our more advanced courses - a
bimodal concern by our students (exit surveys, senior surveys, alumni surveys). As a result, for
example, we i) implemented a new first year seminar ECE 1799 that we are still evolving and
optimizing, ii) have reviewed the content of our early circuits courses (ECE 2011, 2111) and are
making appropriate changes, iii) deleted a few courses in areas that are out of date or in need of
replacement and created several new courses in topical areas such as wireless networks, and iv)
looking at how to improve the flow between our upper level UG courses and our lower level
graduate level courses.

- Feedback from faculty member **two page course reviews** have revealed a disconnect between what
we want students to learn in our early circuits courses (2011, 2111) and what they seem to retain for
follow on courses. Representative issues include basic circuit analysis knowledge, the proper use of
simulators, and the ability to perform goal oriented design. As a result, we are making changes to
our early circuits courses and re-evaluating our laboratory goals to better reinforce course outcomes.

- The department has continued to support **student groups**, in particular contributing to the creation of
a new ECE student advisory board and providing funding for numerous student events (e.g. Spark
Party). Indeed, at the recent senior student banquet the DH received the outstanding student service
award for the year for his strong support of all ECE student groups and “having never said no to any
request from an ECE student group”.

**Achievement of Program Outcomes**

Explain the assessment and evaluation processes that periodically document and demonstrate the degree to which
the Program Outcomes are attained. Describe the level of achievement of each Program Outcome. Discuss what
evidence will be provided to the evaluation team that supports the levels of achievement of each Program Outcome.

This section looks at data and answers the question “**Is our program meeting its desired outcomes?**” This
analysis is documented below for each of the ECE program outcomes. References are made to assessment
results – which can be checked by looking at the appropriate appendix for the assessment tool or
appropriate outcome report.

Our assessment of MQPs by advisors is used throughout this section. This is done by examining the
**percentage of projects** that have a given quality at least to a “somewhat” level of compliance\(^{35}\) or
achievement, and the **percentage of students** judged to be on a level of 2 or higher out of 5\(^{36}\).

The following sections also show the corresponding ABET Criterion, listed at the beginning of the
appropriate paragraph. In some cases, the ABET Criterion are mapped to more than one of our ECE
program outcomes, as explained earlier in this section.

---

\(^{35}\) Levels range from “none” to “little”, “somewhat”, “much” and “very much”.

\(^{36}\) Levels range from “1” meaning a first year course knowledge/effort to “5” representing a graduate level effort/knowledge.
**Outcome 1: Preparation for engineering practice, including the technical, professional, and ethical components**

The ECE program outcome #1 is a combination of three streams: technical, professional and ethical.

**ABET K:** While the technical aspects are also parts of other outcomes, the assessments from the MQP advisors show that 73% in 2006 of our MQPs had the quality of using *modern engineering tools* for engineering design and analysis. Although this seems a bit low, one must be careful since the concept of a modern engineering tool has changed significantly in the past 10 years to encompass significantly more software based design of software which, for some, might not imply “engineering tools”. We note that the 2007 EBI survey (Electrical/Electronic and Computer) indicated that a higher percentage of WPI ECE students respond more positively (“system design” Q051 = 6.5) to the criterion 3C question than either select six (=5.71) or Carnegie (=5.18) class respondents and responded more positively to question 3K (tools, skills) at 6.12 than either the select six or Carnegie respondents (5.41 and 5.30, respectively). We believe that this sub-outcome is clearly met.

**ABET F:** Smaller percentages of the projects drew upon the quality *professional and ethical responsibility* (13% of projects in 2006). From the EBI survey (electrical/electronics) we find relatively low scores for WPI ECE students (5.41) yet higher than our select six or the Carnegie schools (5.16, 5.35 respectively). Although our results for EE2799 show that this sophomore-level course is not always resulting in appropriate student performance on professional and ethical components, the alumni survey data indicates that 61% of ECE students understand and apply the code of ethics to their profession. Appendix M also provides two representative notes on the coverage of ethics in two different classes.

In summary, our program experiences are allowing our students to meet these ECE program and ABET outcomes.

**Outcome 2: Preparation for future changes in electrical and computer engineering**

**ABET I (partial):** Through the EBI survey, seniors report favorably on the degree to which their engineering education enhanced their ability to recognize the need to engage in lifelong learning (ECE/WPI=6.12, select six=5.47, Carnegie=5.55). It is encouraging to see our graduating seniors committed to learning, the key component to preparing for future changes.

**Outcome 3: A solid understanding of the basic principles in electrical engineering, computer engineering, and the relationship between hardware and software**

**ABET A (partial):** We target seven of the ECE fundamental courses (ECE2011, ECE2022, ECE2111, ECE2201, ECE2311, ECE2799, ECE2801) as a way to measure the achievement of the ECE Program Outcome #3. Appendix I provides details of the learning outcomes for these courses and the collected assessment data. Each of these courses were offered two times in AY 2007-2008, and with the exception of ECE2111 in Term C08, the assessment data were collected for all the offering of these courses. The results are in 13 charts shown in Appendix L3. As can be seen in these charts, one can conclude that the ECE Outcome 3 has been achieved for a large majority of the students. We have also used these data for diagnostic purposes to detect problems and issues that require further attention.

In the course of reviewing the assessment data, we came to the realization that we needed more input from the course instructors to make a better evaluation of where there might be a problem that needs our attention. As a result, in the fall of 2007 we implemented a new assessment tool and asked all the course instructors to submit a two-page review for the courses they taught. A copy of a sample faculty report on the form used for this review is provided in Appendix J.

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37 A folder with all of the faculty review sheets will be available at the time of the visit.
In reviewing the assessment data and these two-page reviews, we realized there was a need for a focused discussion of the courses ECE2011, ECE2111, and ECE2201. This initiated a number of meetings and resulted in faculty reports that are included in Appendix M. The final outcome of these discussions and the resulting curricular changes are in **Section 4: Continuous Improvement.** Material related to these on-going discussions is provided in **Appendix M.**

In summary, we believe that this outcome is being met. The EBI results also support this conclusion.

**Outcome 4: An understanding of appropriate mathematical concepts, and an ability to apply them to ECE**

**ABET A (partial):** EBI “Electrical/Electronic Programs” data (2007) shows that WPI ECE students generally rated themselves higher, or only marginally lower than our select six or Carnegie groups for ABET(A) (6.97/5.91/5.53 for ECE/WPI and 6.09/5.86/5.78 for select six and 5.82/5.70/5.51 for Carnegie).

The MQP data shows that 100% of our MQP projects have satisfied ABET 3(A) and that the average math level was 2.1 (first year = 1, second = 2, etc). Further, our 2006 MQP review shows that 90% of our students perform measurement and analysis “much” or “very much” during their project work. Other results are also high, although mathematics is often assessed along with other qualities (such as science and engineering).

**ABET B:** Similarly, the MQP data for analyzing and interpreting data show that 100% of our MQP projects require that students perform these tasks. EBI survey data (2007, Electrical/Electronics) show that our students responded with much higher marks (6.38, Q50, analyze and interpret data) than either our select six or Carnegie comparison groups (5.77 and 5.44, respectively).

These results (along with others reported in Appendix K and L) demonstrate that our students are meeting these ECE program and ABET Criterion 3 outcomes at a fundamental level.

**Outcome 5: An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills**

**ABET E:** The results for EE2799 show that this sophomore-level course does not always result in demonstrating appropriate student knowledge of the steps involved with the engineering design process. By contrast, our MQP assessment shows that 100% of the MQPs demonstrated the ability to “identify, formulate and solve engineering problems.” Similarly, our student EBI data was nearly a point (range: 0.75-0.86) above the average scores of the select six and Carnegie schools on ABET 3E.

**ABET C:** Similarly, 100% of the MQPs required the ability to design a system, component or process to meet design criteria. ECE data from the EBI survey also indicated that except for “political issues”, our students were more confident in their abilities to design systems subject to select constraints (economic, environmental, sustainability, manufacturability, ethical, health and safety, social, political) than our select six or Carnegie comparison schools.

EBI data for ABET 3C for WPI ECE students was also significantly above the select six and Carnegie averages (ECE=6.50, select six = 5.71, Carnegie = 5.18) indicating that our students believe they were adequately prepared to “design a system, component or process to meet a desired need”.

**ABET D:** Approximately half of all WPI students complete their IQP off campus, and the majority complete their IQP as part of an interdisciplinary team, indicating that the IQP is satisfying our desire to provide a multidisciplinary experience for almost all of our students. As a result, our senior surveys (internal and nationally-normed) show that our seniors assess themselves very well on this quality (on average no less than 3 on a scale from 0 to 4, with 4 being the most positive).
Overall, these ECE program and ABET Criterion 3 outcomes are being met by a preponderance of our students.

**Outcome 6:** An in-depth understanding of at least one specialty within ECE

**ABET A and K (partial):** Appendix K.2 shows that the MQP experience along with our upper-level courses are providing ample opportunity for our students to demonstrate an in-depth understanding of at least one (and often more than one) specialty. Historical MQP review data from 2006 (MQP Review, 2006, Fig. 3) show that the level of capstone project activity is ~3.8 for the 2006 review, and 3.7 for the reviews in 1999, 2001 and 2004 – indicating that the capstone project (our MQP) represents a “culminating experience” level of activity corresponding to a fourth year (first year=1, fourth year=4) experience expectation.

**Outcome 7: Demonstration of oral and written communications skills**

**ABET G:** The MQP data (Appendix K.1.D and Figure 3.2) shows that the written communication skills were a major factor for 86% of our senior projects and that 53% of our projects (2006 review) were ranked as good or excellent in documentation quality. This ECE program (and ABET Criterion 3) outcome is being met.

**Outcome 8: Understanding of options for careers and further education, and the necessary educational preparation to pursue those options**

**ABET I (partial):** Appendix L data (alumni, senior and EBI survey data) shows that in terms of the options available in graduate school, We believe that we have some excellent opportunities for student development and engagement in this area.

**Outcome 9: An ability to learn independently**

**ABET B (partial):** Recent MQP review results showing that 100% of the 2006 projects were judged as requiring design and conducting experiments, and that 95% of students documented this ability in their project reports.

All of the projects were assessed relative to student use of reference and resource materials to support project work. 97% of the project reports were judged to provide supporting literature reviews relevant to their capstone project. Therefore, these ECE and ABET Outcomes are clearly being accomplished.
Outcome 10: The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI

ABET H (partial): All of our graduates fulfill the degree requirements for the Sufficiency (pre-2006) or Humanities and Arts requirement (2006 and beyond), and IQP, providing them with a broad education. Furthermore, the relationship of the Mission of WPI (listed in Criteria 2) to our program outcomes revolves around preparation for careers, civic contribution, leadership, and lifelong learning. These aspects are discussed in all of the other outcomes – with the exceptions of demonstration of an understanding of the importance of civic contributions. 2007 EBI data shows that our senior student satisfaction with extracurricular activities and leadership opportunities within the engineering program is improving over time, and reported to be higher than at other institutions. This data, along with the wealth of information for the other outcomes, shows that this outcome is being met by our students as a group.

Outcome 11: An understanding of engineering and technology in a societal and global context

ABET H (partial): The EBI and comparable data presented in Appendix L shows that overall, the results are positive. For measurements of societal and global context, trends are increasing positively over time, and our students are having comparable experiences when compared to other students at WPI and better experiences when compared to students at other schools.

ABET J: Results on ‘a knowledge of contemporary events’ is improving, and are expected to continue to improve as the impact of our course adoptions are experienced. It is good to note that our students rate themselves (EBI) as more knowledgeable about contemporary events (5.45) compared to our select six (5.07) and Carnegie classification (5.01) comparison schools. Yet, the low value of these scores relative to other self judged scores means that we clearly have opportunities for improvement.
CRITERION 4. CONTINUOUS IMPROVEMENT

Actions to Improve the Program - Describe actions taken to improve the program since the last general review. Indicate why (the basis for taking action), when each action was implemented and the results of the implementation.

This section details i) the types of information used as a basis for continuous program improvement, and ii) specific actions taken since the last review to improve our program. While many improvements will be seen as directly related to ABET criteria, others will not – but will still be described for the simple reason that the ECE department at WPI takes a holistic approach to program improvement.

For the following discussion, it may be useful to follow the assessment feedback pathways illustrated in Figure 3.1 in the previous section.

Information Sources for Program Improvement

Information Used for Program Improvement - Describe the available information, such as results from the Criteria 2 and 3 processes, commonly used in making decisions regarding program improvements.

The information used for program improvement is of two types. The first is information from assessment tools that provides feedback regarding the Program Educational Objectives. This data source helps us determine whether our objectives continue to meet the needs of our constituent base. The second is information from assessment tools that provides data that can be used to evaluate our success in achieving our Program Outcomes. This source of data helps us determine whether our students are meeting the outcomes we have established for our program.

The following general sources provide the data we employ for program improvement. Each is directly or indirectly related to a specific constituency.

- current ECE students
- graduating ECE students
- ECE alumni (2 and 5 years out)
- ECE advisory board members
- corporate and industrial representatives
- ECE faculty and staff

Specific Data Sources

The specific sources of assessment and feedback data for our program educational objectives and program outcomes are listed below by category, not by constituency. However, for each source we provide a brief description of the source and the type(s) of data provided.

Committees

Curriculum This committee is responsible for all aspects of the ECE curriculum, meaning both the UG and Graduate courses we offer and the distribution requirements and rules and regulations (to the extent that the department has control over them) for program components (e.g. our implementation of the BS/MS program, the ECE minor requirements, etc). This committee regularly makes recommendations for new courses, courses to be deleted, changes to courses, changes to distribution requirements and so forth. The information collected by the committee is used for corrective changes (e.g. additions or changes to courses to improve the curriculum), or programmatic changes (e.g. modernization of courses, implementation of new tracks of
Sources of information for curriculum change include all of our constituencies.

**Undergrad. Program**
This committee is responsible for all aspects of the BS level degree program excluding courses. Responsibilities include project presentation day, project and oral reviews, student information and advising support (e.g. career opportunities, information on the BS/MS program, and support for various student events (e.g. spark party). The information collected and changes proposed parallel those of the Curriculum Committee but are not focused on curricular changes (e.g. mechanisms for preparing students for their oral project presentations, improving operational aspects of and delivery of our projects program, improved support for student events and groups).

**Internal Advisory**
This elected committee provides advice to the DH and also makes recommendations for faculty/staff policies, reviews and critiques program operations, often recommends changes to the department for continuous improvement, helps select special award winners, and in general provides a sounding board for the Dept. Head. The primary beneficiaries of the considerations of the IAC are i) our program (e.g. goals, objectives, outcomes, other recommendations), ii) students (e.g. indirectly through corporate funding, offering of internships and so forth), and iii) our faculty (though funding and other relationships developed to support research, student projects and similar broad activities).

**Ad-hoc Committees**
An example would be our Computer Engineering Curriculum Review committee (CERC) which has for many years i) held curriculum reviews with invited industrial and expert guests, ii) proposed and has overseen the implementation of numerous program improvements in the digital/computer engineering area, and iii) acted to insure that the D/CE courses are modern, appropriate, well equipped and structured, and in general provide the type of undergraduate knowledge and outcomes that are needed by industry and for continued education (graduate school, etc). Ad-hoc committees are generally formed as a result of constituency data from faculty and students that indicates a need for broad ranging improvements or review of particular ECE program components. The beneficiaries of the ad-hoc committee work is almost always our program students.

**Groups and Advisory Boards**

**IEEE Student Branch**
The IEEE student branch regularly interacts with ECE faculty and the DH to create and offer programs and activities for ECE students. In turn, the student branch officers provide feedback to the DH regarding student requests, desirable student programs and other student centric issues. Activities sponsored by the student branch, with the support of the department, include professional student engagement activities (e.g. a presentation and dinner with the President Elect of the IEEE Computer Society), corporate visits, our annual Spark Party (written up in the IEEE “Institute”, Jan. 7, 2008), various faculty and student awards, and other department activities.

**HKN Honorary Society**
The Etta Kappa Nu honorary society sponsors a weekly pizza lunch in ECE. This, in turn, provides an opportunity for students and staff to enjoy a common lunch time friendly event.
Women in ECE  WECE sponsors several events throughout the year, including resume workshops, afternoon teas, corporate on-site visits and so forth. The DH provides financial support for the WECE group and space for their activities (including the WECE lounge). An ECE faculty member is the advisor to ECE.

Student Advisory Board  The SAB is a new venture proposed several years ago by the DH but only recently initiated with the help of the campus student government association. It is expected that the ECE SAB will meet once a quarter to discuss student-department issues and advise the DH.

Advisory Board  A long standing board focused on advising the DH during their annual fall meeting. The board constituency is, of course, composed primarily of corporate and industrial representatives who provide their perspective of issues presented by the DH.

Curriculum

Course Evaluations  A new two-page review of courses was stated in the fall of 2007 as a result of i) discussions with other ECE Department Heads at the annual ECE DH Association meeting (ECEDHA) and ii) an identified need to ask faculty on a regular basis for information in a simple but usable format that addresses topics such as student preparation for a course, the need for changes in course outcomes, opportunities for course improvement, and long term tracking on the impact of courses upon each other in our curriculum. Unlike faculty evaluations (below) filled out by students and used to rate course and faculty factors, Course Evaluations are faculty perspectives of i) various student performance factors (e.g. pass/failure rates, preparation to take the course, observed issues with student ability to understand the material presented, etc) and ii) various course factors (e.g. appropriateness of the course outcomes, appropriateness of the course description, etc). The beneficiaries of changes made as a result of these evaluations include both the students (e.g. improvements to course material delivery) as well as the program (e.g. a course might be changed to improve a specific outcome statistic) and faculty (e.g. a change to improve preparation for a follow-on course). (I can provide you with a example of a two page course eval. form).

MQP Oral Evaluations  These evaluations are collected during Project Presentation Day and are used to judge the quality of oral project presentations and student preparation.

MQP Inventories  An MQP inventory is a two page evaluation of each and every MQP completed by a (primary) faculty advisor at the conclusion of an MQP. The inventory survey is designed to collect information on the extent to which a capstone project (the MQP) address the (a)-(k) components desirable for a culminating experience, and by review of the forms, and opportunities for improvement of our projects program (offerings, administration, advising, opportunities, content, expectations, etc). MQP Reviews These reviews occur about every two years and are a comprehensive evaluation of a multitude of factors and data related to the final MQP reports. These evaluations are well worth the time and effort to perform but usually require an entire summer to complete by two dedicated faculty members who read and critique every single ECE MQP completed in the past two years.
Numerous opportunities for improvement of the MQP process, program, structure and specific projects are typically identified.

**Course Assessment**

The department has for many years collected detailed data on seven (7) courses as a basis for i) understanding how efficiently we are delivering our course content, ii) how well the students are achieving the course outcomes, and iii) how well prepared students are for evaluated course as well the impact of the course on follow on courses.

**Program**

**ECE Goals and Objectives**

The ECE goals and objectives provide the framework for all of our assessment activities. In particular, they are aligned with the WPI goals and objectives and, as such, when reviewed provide a high level way to evaluate the alignment of the ECE program within the context of the WPI goals and objectives.

**Prog. Educational Objectives**

Statements of educational objectives that can be measured with appropriate review structures, surveys and data sources.

**Program Outcomes**

Statements of specific program outcomes that to the extent possible, each and every student should exhibit.

**Strategic Plan**

The ECE strategic plan was re-developed in the 2003 time frame and is provided in Appendix E.

**Dept. Head Annual Report**

The annual report is an academic year departmental summary of program changes, program and faculty accomplishments and opportunities and recommendations for program improvements or direction. Sources of data and information include most of those listed in this subsection. Numerous tables and data sets are provided, often in a historical context, so that trends can be observed.

**Faculty, Staff, Other**

**Faculty Annual Reports**

Faculty annual reports are used i) as a basis for the annual DH review of individual faculty performance, ii) as a source of material for the department annual report, and iii) occasionally as a way to document (by the faculty) their recommendations and requests for new courses, new program or department endeavors or initiatives.

**Faculty Teaching Reviews**

Summative teaching reviews are provided to the DH for all faculty and staff who participate in course instruction (full time tenure track, part time adjuncts, instructors, professor of practice). The DH reviews this data twice a year and makes appropriate changes, adjustments or comments to individual faculty to insure that the ECE courses are being offered in as high of a quality manner as possible.

**Staff reviews**

Staff are reviewed annually to insure the quality of support functions.

**TA per-course reviews**

TAs are used to manage labs, grade homework and exams, and hold help sessions. TAs are never used to deliver lectures. TAs are reviewed at the end of every course by the course faculty/instructor, and often by students, to insure high quality instruction and student support.
Tutor per-course reviews  Tutors (ECE second, third and fourth year students) are used to provide in-lab help with experiments, to grade homework, and to hold help sessions. Tutors are reviewed at the end of every course by the course faculty/instructor and often by students to insure high quality support.

Surveys

Alumni  The annual alumni survey of students 2, 5 and 10 years after graduation was changed to an on-line format in 2006 and improved in 2007. The information obtained from the survey has been useful for identifying how well our students are doing, what we have done well, how well the students believe we are meeting our published goals, objectives and outcomes, and which aspects of our program are likely in need of improvement. Alumni survey data is found in Appendix L.1.A and B.

Senior Exit  The senior exit survey is provided in Appendix L.2.A and B. The survey i) has relatively low overlap with the EBI survey, and ii) addresses student perception of specific WPI/ECE program factors, teaching, support, qualities and resources.

EBI  The EBI survey is self explanatory and well known (Appendix L.3). The data provides a way to compare self-reported student scores across a wide range of factors, outcomes, criteria and qualities.

WPI

IQP Biennial Review  The IQP is reviewed by the Interdisciplinary and Global Studies Division. The report data, while not directly pertinent to ECE program endeavors, is important in addressing our outcome #10 and #11 (broad education described by the WPI goals and objectives, and societal and global context, respectively).

Academic Support Programs  Specific student information provided by the WPI academic support services and programs (advising and planning office, campus computing center, etc) provide nuggets of information that can lead to ways to improve our program. Many of the pertinent academic support services that impact ECE are described in some detail in Appendix D, INSTITUTIONAL SUMMARY.

Student Degree Audits  These audits, an example of which was described in Section 1/Criteria 1, provides data to the academic advisor to help individual students i) individually achieve the broad education described by the WPI goals and objectives, as well as the department distribution requirements, and ii) review program and degree options that are best matched to individual student desires.

Graduation Audits  Every department is provided with the audits for all students graduating that year. In ECE, the Associate DH reviews these audits and determines whether each individual student is meeting the program and WPI requirements for graduation. The ADH also extracts from the audits data about our ECE students and their plans of study so that we can make decision on how to improve our program in subsequent years.

Obviously, in the above list some sources of information are more important than others, and some are used more regularly than others.
Program Improvement Actions

Process for Action

The process by which our objectives/outcomes are reviewed and validated has been discussed in Section 3/Criteria 3 (Figure 3.1). The implementation of the process used for program improvement is shown in the figure described in Appendix G.

The DH, and AH review the data collected from the constituencies noted in these sections/appendix via the mechanisms, surveys, groups, sources and entities and, primarily with the support of i) individual faculty, ii) small groups of faculty who are responsible for specific curriculum focus areas (e.g. computer, analog electronics, etc), iii) the Curriculum and Undergraduate Program Committee, and iv) as necessary an adhoc committee (e.g. computer engineering review committee - CERC), determine the need for change. Once the data is reviewed and acted on, formal changes result from i) a committee review and recommendation, ii) a review and recommendation by the DH or AH, iii) a review or recommendation by an ad-hoc committee formed (usually) to examine a particular problem, or even iv) an individual faculty member bringing an issue and recommendation to the faculty or a specific committee.

As shown in Figure 3.1 (Appendix G) and Table 3.4, the results from the various reviews and surveys are distributed to the appropriate committees or individuals, primarily by the DH and AH. It is the responsibility of the designated committee or individual to thoroughly review the data and clarify the area(s) of concern and, as appropriate, develop recommendations to address the concern. The committee/individual then presents their recommendations to the ECE faculty during a regularly scheduled faculty meeting for discussion and approval.

The approved solution is then implemented either through an appropriate committee, individual or even by all of the faculty associated with the course(s) affected. The process then repeats, usually over a period of years, so that data from more than one year or one course offering can be examined for trends and tweaking, and the process repeated. This process is shown in a simplified graphical form in Figure 4.1.

Figure 4.1 Assessment Feedback Loop

Actions to Improve the ECE Program

Specific actions are described in detail below which have been implemented to improve our program since our last ABET review. In each case, the relevant outcome(s) or objective(s) that were addressed by the action are noted. For ease of reference, our ECE program outcomes are summarized below.
**ECE Program Outcomes**

1. Preparation for engineering practice, including the technical, professional, and ethical components.
2. Preparation for the future changes in electrical and computer engineering.
3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software.
4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE.
5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.
6. Demonstration of in-depth understanding of at least one specialty within ECE.
7. Demonstration of oral and written communications skills.
8. Understanding of options for careers and further education, and the necessary educational preparation to pursue those options.
9. An ability to learn independently.
10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI.
11. An understanding of engineering and technology in a societal and global context.

**Action:** Comprehensive Review of ECE 2799 – Electrical and Computer Engineering Design.

**Rationale:** ECE 2799 is a critical course in the curriculum. Topics such as ethics, the engineering design process, teaming and scheming, proper lab notebook documentation, design by example, trade studies, setting measurable design objectives, and a mini-design project are used as a basis for teaching material critical to the successful completion of both subsequent course laboratories as well as the senior capstone project (our MQP). Over the years, data from our MQP reviews, exit surveys, student course and faculty reviews, and faculty observations have indicated that this course has varied from its original intent and perhaps not provide the foundation needed for subsequent courses and project requirements. Specific primary issues that have been identified include the following.

- lack of student adherence to a formal engineering design process
- lack of proper use of lab notebooks or fully understanding the rationale for doing so
- lack of student use of engineering and systems trade studies in selecting capstone project components or systems (as opposed to just “jumping in” and using what is familiar or available)
- too complex or involved ECE 2799 mini-project taking time away from other course components

**Implementation:** Several reviews of this course (Appendix M.10) have been implemented (two formally, several casually) since the last ABET visit. These reviews have reinforced the need for, and importance of this course in our curriculum, and have provided a sounding board for faculty and student concern regarding the course. In part as a result of a need for a long term “manager” to insure consistency for the course and in an attempt to standardize the curriculum and course methodology, a single faculty member (Prof. Bitar) has been assigned as the primary course manager/instructor. Although other faculty are assigned to assist with course content and delivery, this approach insures that there is consistency between course offerings and provides a single point of contact for addressing course changes or perceived problems which are conveyed to Prof. Bitar.

**Results:** Because many of the changes discussed above have been only recently implemented we have no hard data to indicate that they have resulted in a change in student achievement of outcomes.
Outcome(s) Impacted: (1) preparation for engineering practice; (3) solid foundation; (4) mathematical concepts and ability to apply them; (5) engineering design process; (7) communication skills; (9) ability to learn independently; (11) engineering in society;

Action: Implement a modern curriculum track in networks, including wireless networks.

Rationale: The ECE department recognizes that there is a significant need for all students, and in particular ECE majors, to have a solid foundation in networks and, in particular, wireless networks. Our alumni (survey data) and advisory board members, as well as conversations with other corporate relations, clearly indicated that we needed to develop courses in the networking area so that essentially all ECE majors are presented with opportunities to learn about wired and wireless networks.

Implementation: Two new networking courses were discussed and created. The first course, ECE 2305: Introduction to Communications and Networking, is an introduction to the broad area of communications and networking. The course is organized as a systems approach to communications and networking and while originally developed primarily for ECE students, it is in fact available for other student majors to take. The second course, ECE 3308: Introduction to Wireless Networks, is intended for students interested in obtaining a systems-level perspective of modern wireless networks. Topics include an overview of computer networks, an overview of wireless network standards and products, radio channel modeling and medium access control, deployment of wireless infrastructures, and examples of voice- and data-oriented wireless networks using TDMA, CDMA, and CSMA access methods. We expect to expand our offerings in this area by cross listing a computer science course on general networks. However, the CS Department has undertaken a comprehensive review (spring, 2008) of their networking courses and we have, as a result, delayed our cross listing efforts until they have a firm plan for how they will either refocus their current course or, also under discussion, perhaps split the course into two courses in some manner.

Results: Both courses have been popular and well received by students (fall 2007, ECE 3308 enrollment was 29, spring 2008 ECE 2305 enrollment was 25. These numbers represent about 30% of the ECE students in each case.). Since both have been offered only a few times, it is perhaps too early to comment on how well we are meeting the respective course outcomes. What is clear, however, is that our alumni and advisory board members will no longer target the lack of networking courses as a significant opportunity for curriculum improvement.

Outcome(s) Impacted: (2) preparation for future changes; (6) specialty area in ECE; (10) broad education;

Action: Implement a bioengineering program track.

Rationale: Bioengineering has been recognized (along with ME) as one of the more attractive and fastest growing areas of interest to matriculating engineering students. While WPI has a strong Biomedical Engineering (BME) program, it does not mesh well with ECE faculty interests. Specifically, most of the BME program students and faculty are either in the biomechanical or tissue engineering tracks, not bioelectric or signals tracks that would be more in line with our department faculty interests. As a result, and in an effort to attract more students to the ECE side of BME, we considered it important to provide our students with both the option to take some BME courses as part of their distribution requirements as well as take a course focused on ECE areas of interest.

Implementation: A new ECE focus courses have been created in the bio-signals area. Additionally, several existing biomedical engineering courses have been cross listed for ECE credit. The new courses created were:

- ECE 443X, Applied Bioelectric Signal Processing
This new course is specifically designed to provide a comprehensive and rigorous study of bioelectric phenomena and signal processing, and EMG at the undergraduate level. The courses from BME that were cross listed were as follows:

- ECE/BME 2204. Bioelectric Foundations
- ECE/BME 3011. Bioinstrumentation and Biosensors
- ECE/BME 4011. Biomedical Signal Analysis
- ECE/BME 4023. Biomedical Instrumentation Design I, and
- ECE/BME 4201. Biomedical Imaging

**Results:** The cross listing of BME courses is only a recent addition to the ECE curriculum (AY 2007). As a result, there is insufficient data to assess the impact of these courses on our program and student course selections. Similarly, the new ECE course has only recently been developed and is scheduled to be offered in the near future. We believe that these course offerings and the development of the new track of study are consistent with our course review of other ECE programs which limit the offering of BME related courses within the context of an ECE curriculum, instead, on a strong companion program in BME.

**Outcome(s) Impacted:** (6) specialty area in ECE; (9) learn independently; (10) broad education; (11) engineering in society;

**Action:** Address the need to engage first year declared and un-declared matriculated students to consider ECE as their major degree path.

**Rationale:** WPI has seen an increase, often dramatic, in the number of matriculating first year students who are either “engineering undeclared” or simply “undeclared”; the former meaning that the students are fairly sure that they want to be engineering majors but are unsure of which specific major, while the latter are students who are unsure of their major in general. From conversations at ASME DH’s meetings (personal conversation with WPI’s ME DH) and our own conversations at ECE DH meetings (ECEDHA), it is clear that this is a national phenomena, not localized to WPI or similar smaller engineering schools. What this means is that engineering schools and departments need to engage first year students in new ways and to excite them sufficiently to consider (in this case) ECE as their declared major. Nationally this has translated into two types of first year engagement seminars; general university programs that engage all students regardless of declared or undeclared major status, and those that are department specific. Both types of seminars have been implemented at WPI/ECE.

**Implementation:** ECE has elected to implement a first year engagement seminar for both declared ECE majors as well as an enticement to those considering ECE as a major but are unsure what an ECE major does, what type of career paths are involved and so forth. A new course, ECE 100x Frontiers and Current Issues of Electrical and Computer Engineering, (recently changed to ECE 1799 as a regularly listed course) was created during the summer of 2006 and offered in the fall for the first time. This is a seminar based course intended for first year students seeking to understand the breadth of activities, career choices and technology that are considered today to

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38 Northeastern has 1 BME image processing course on record. CMU, Drexel, RPI, UMASS Dartmouth, and BU have no BME related courses on record.
comprise Electrical and Computer Engineering. Students considering ECE as a major, both those who are "decided" as well as those who are "undecided," are encouraged to enroll. This course is specifically designed to i) present an overview of the ECE profession, ii) engage students through presentation and discussion of current issues and new technology representative of the breadth and depth of ECE at a systems level, iii) challenge students to develop critically thinking skills through seminars, readings and discussions, iv) encourage good writing habits and media utilization, and v) provide a multitude of reasons why students should consider ECE as their major field of study while introducing them to our department's offerings and resources.

**Results:** Approximately 25 students enrolled in the course in 2006, followed by a similar number in the fall of 2007. General feedback comments indicated that although the seminar approach was interesting, the course was not sufficiently engaging. As a result, in 2007 a lab component was added that focused on the students building a small robot from a kit. This new component was well received by the students as judged by the course evaluation sheets and course survey data. As a result, the next offering (fall of 2008) will include more lab time to engage the students and to provide them with a hands-on introduction to several different areas encompassed by the ECE major.

**Outcome(s) Impacted:** (1) preparation for engineering practice; (2) preparation for future changes; (5) engineering design process; (7) communication skills development; (8) careers and education; (9) learn independently; (11) engineering in society

**Action:** Address the need for new forms of innovation throughout the curriculum.

**Rationale:** ECE is in the unique position of having an endowed fund targeted specifically for educational innovation. Traditionally, the proceeds from this fund have been used to support a single faculty member’s education innovation activities. The fund, however, has grown to a point where the department had an opportunity to change the awarding of proceeds from the fund in a manner that expanded opportunities for innovation.

**Implementation:** The Satin Fund was changed so that proceeds are distributed as follows (starting spring, 2008).

- a single yearly award of $25,000 to a young, educationally innovative ECE faculty member (selected by faculty vote and reviewed by the Internal Advisory Committee)
- a yearly solicitation from ECE faculty for proposals that address educationally innovative activities and that can be funded in the range of $5-10,000

**Results:** There were three proposals for this first solicitation. So far, two have been funded.

- Prof. Wyglinski – requested funding to support the development of a communications systems engineering laboratory course based on software defined radios (SDRs). Specifics include i) allowing students to apply their knowledge of comm./networks using SDR platforms, ii) developing five modules (mod/demod, sync/time recovery, equalization/channel coding, multi-hop routing and cooperative comm., wireless network security), iii) creating a demonstration prototype platform, experiments, software and so forth, iv) creating a specific course proposal to the curriculum committee, and v) creating a users manual, guide or other material as appropriate to encourage use of material in other courses.
- Prof. Makarov – requested funding to develop FDTD (finite difference time domain) models and educational materials for i) transmission lines with lumped loads (ECE2111, ECE2112, ECE3011),
ii) wireless signal propagation in urban environment (ECE3308, ECE3311), iii) semiconductor PN junction (ECE4902), and iv) to provide ECE faculty with simple, usable, and fully accessible FDTD codes.

Faculty who receive Satin funds are expected to make a department presentation at the conclusion of their funding period highlighting the results of their development efforts and to provide guidance to other faculty wishing to use or incorporate their new material into other courses.

**Outcome(s) Impacted:** (3) ECE foundation; (6) specialty area in ECE; (9) independent learning; (12) challenging and supportive environment.

**Action:** Continuously modernize labs and lab support structures

**Rationale:** Students often remark (exit surveys, alumni surveys, individual course surveys) on quality of the equipment available to them in ECE labs. Yet, students also remark on particular labs, computational needs and other aspects on the technology side of labs and support systems that, if changed or upgraded, would improve their educational environment.

**Implementation:** The following changes were made as a result of these types of requests and comments.

- As a result of student comments about the lab equipment and computers in our introductory course lab (AK 317A) and as part of an upgrade cycle, the lab physical environment was improved (painting, carpeting, projection system) and the computers and equipment were upgraded with, for example, multicore, high performance PC systems with flat panel displays.

- As a result of student comments about the availability of modern logic analyzers and the need for high speed oscilloscopes, all stations in our digital/computer lab (AK 113) now have modern logic analyzers and high speed digital oscilloscopes with USB memory stick up and download capability.

- As a result of student and faculty comments about our electronics lab equipment, we added 4 channel high frequency sampling scopes at all benches, upgraded the function generators, and upgraded the power supplies available in our studio/electronics classroom (AK 227). We also added a LabView input module so that students who take our ECE for non-majors course (primarily ME students) and who are use to using LabView in their own departments, will be exposed to it in our department as part of our ‘service’ course (ECE 3601). This improvement in laboratory capability was also a result of Professors McNeill and Bitar visiting NU, BU and MIT and surveying the equipment and programs at those universities (Appendix M). They then developed an NSF proposal which did not get funded, so the department paid for the upgrades.

- Finally, over a period of two years we added complete swipe card access to our building. Now, all labs are kept open 24 hours a day, 7 days a week for student access.

**Results:** The faculty and students that they are very pleased with the quality of the equipment and the 24/7 access to the building (the only teaching labs with such access on campus).
Outcome(s) Impacted: (3) ECE foundation; (5) engineering design;

**Action:** Address outcomes issues and knowledge issues in early ECE electronics courses.

**Rationale:** ECE 2011, *Introduction to Electrical and Computer Engineering*, is the first course taken by ECE majors and is offered twice a year. Over the past few years, we have identified two issues with this course. First, about 20% of the students taking either offering of the course fail the course. Second, assessment data indicates that course outcome #6 (knowledge of impedance and RLC circuits) is consistently a problem while outcomes #3 (knowledge of Thevenin and Norton equivalents) and #4 (source modeling) are not consistently met. The follow-on course, ECE 2111 (*Physical Principles and Applications in ECE*) is not taken by all ECE majors and has historically been a difficult course to teach because of the wide range of topics covered by the course.

**Implementation:** Two specific changes are being developed or have been implemented. First, we are specifically targeting outcomes improvements in ECE 2011 by adding specific homework assignments, targeted in-class examples and demonstrations, and targeted laboratory components. This approach has resulted in an improvement in outcomes #1 (KVL, KCL) and #2 (solving circuit problems). We are focusing on outcomes #6 and to a lesser extent #3 and #4 using a similar approach (focused homework, focused in-class examples, focused applications in lab, etc). We recognized, however, that as a single foundation course, and a critically important one at that, there is insufficient time to convey and insure that the students in this course have a firm foundation in the material presented and that all outcomes are being adequately met by a high percentage of the students.

As a result, the follow-on course, ECE 2111, was changed (spring, 2008) to focus more on foundation material that we believe our students need more exposure to. Specifically, ECE 2111 is now *Fundamental Principles of Electrical Engineering* and is focused on providing a firm foundation in the practical aspects of DC and AC circuit analysis. Students will gain a deeper understanding of foundation EE (as opposed to ECE) material including KVL and KCL, linear systems, RCL circuits, transients, phasors, impedance and other material that is crucial for a solid foundation needed by all ECE students.

**Results:** Addressing improvement in ECE 2011 student outcomes is continuous and improving. ECE 2111 is a newly revised course and has not yet been offered. However, we note that we will use our academic advising framework to strongly encourage all ECE students to take this newly revised follow-on course. The specific changes to ECE 2111 are provided in Appendix M.

Outcome(s) Impacted: (3) solid foundation; (5) engineering design process; (9) ability to learn independently;

**Action:** Address industry focus on HDL design, not VLSI

**Rationale:** With only 23 FTE faculty (*Appendix D, Table D.4*), it is difficult for the WPI ECE Department to offer the same breadth of courses as significantly larger departments and schools. One area that has been impacted by this is the teaching of VLSI design. While we have offered VLSI design in the past, the cost of maintaining a design expertise in this area at the UG level, as well as the various (not necessarily money) costs of maintaining a VLSI design and manufacturing capability, are not necessarily in the best interest of our students or department. Discussions with advisory board members and visits to local digital/computer focused industries has reinforced our understanding that what is important for undergraduate ECE students is a solid foundation in hardware description languages (HDLs), digital modeling and design, FPGAs and similar programmable devices, and of course a solid foundation in microprocessor systems and design (covered in a separate action item below).

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39 formerly, *Physical Principles of ECE Applications*
Implementation: To address student, advisory board and faculty comments and feedback on the need for a strong foundation and advanced topics in HDLs and related digital design issues, we refocused and improved our digital design courses so that students would have a solid foundation in VHDL and FPGA design. To do this we have made, and are in the process of making, the following improvements to our curriculum.

- removed all VLSI design components from our ECE 3810 (Advanced Digital System Design) course
- structured our digital design courses to support HDL design at all levels
  - revised ECE 3801 - Advanced Logic Design - to accommodate experiments using the Digilent\(^{40}\) Xilinx Spartan 3 FPGA board. This course introduces VHDL as the primary design language and, in particular, is focused on combinational design techniques.
  - refocused ECE 3810 exclusively on VHDL (not also VLSI) – this course now addresses primarily sequential design using VHDL and the Digilent FPGA board. A proposal has been sent to the curriculum committee (spring 2008) for action on modernizing the course description and outcomes. Action is expected this fall (2008).
- upgraded the digital/microprocessor laboratory (AK 113) as follows:
  - added new digital logic analyzers to all laboratory benches
  - added new digital high frequency oscilloscopes to all laboratory benches
  - upgraded the computers in the digital/computer lab
- At the graduate level we revised our ECE 574 (Modeling and Synthesis of digital Systems using Verilog and VHDL) course to cover both VHDL and Verilog and changed the syllabus slightly so that it flows naturally from our ECE 3810 undergraduate course.
- We added a new graduate course in Reconfigurable Computing with FPGAs.
- Although not particularly pertinent to his self study, the ECE department maintains a custom circuit design capability at the graduate level using Cadence software and the MOSIS fabrication capability.

Special Note: While the accreditation of our graduate program is not what is being considered here, we reference changes to our graduate program because i) we intend to merge courses and curriculum across the BS and MS level, and ii) we want to make the transition from undergraduate to graduate level courses seamless, and thus make it possible for our students to pursue studies of interest to them and to use to a MS level or beyond. This will, in turn, benefit our students since most companies will expect a BS level engineer to earn an advanced degree anyway and a seamless transition will impress on our students both the opportunities available to them (for continued education) as well as make it possible.

Results: Maintaining high quality digital design labs is a continuous problem given how quickly the technology changes. Although our students have not remarked positively on the lab changes (surveys, casual discussion), it is also important to note that they have not remarked negatively on the lab changes as they have in the past (for example, often remarking that there are either not enough or good enough logical analyzers in the lab).

Outcome(s) Impacted: (3) EE, CE and ECE foundations; (5) engineering design process; (6) in-depth area; (8) careers and further education;

Action: Address student and faculty concerns with use of a modern embedded processor for our embedded course.

\(^{40}\) http://www.digilentinc.com/
Rationale: The cost of embedding a high quality, low power, highly capable, usually RISC architecture processor is such that embedded processors can be found in nearly every electronic project imaginable. Perhaps 4 years ago, students were commenting (surveys) that the PIC processors we used at that time had insufficient processing power or memory to be useful in more advanced projects than the simple lab experiments used at that time. Further, faculty were concerned that the PIC development process (mostly in assembly language) was not representative of a modern embedded processor development process. In particular, students and faculty were looking for a faster, more capable system that was supported by commonly available and easily obtained mixed language (C+asm) development tools.

Implementation: The department selected the MSP 430 lower power RISC processor as the new target system for our embedded processor and design course. To ease the use of the Olimex board we selected, an ECE student designed a new interface board for a standard Olimex MSP 430 based system. The ECE designed board includes common IO components needed to teach embedded programming in a combined C+asm environment. For example, the board includes a keypad, AD and DA converters, LED lights, a power supply and DIP switch inputs.

Results: ECE has been using this combined system to teach embedded system design for the past few years. As a result of the ease of use of the system and the capabilities of the MSP 430 RISC processor, students often use the MSP 430 for their capstone design projects and, in some instances, for their ECE 2799 design course project.

Outcome(s) Impacted: (3) basic principles in CE and the relationship between HW and SW; (5) engineering design process; (6) specialty in ECE;

Action: Address student and faculty concerns regarding modern microprocessor system development tools, equipment, processors and architectures.

Rationale: Discussions with advisory board members, survey results and visits to local digital/computer industries also strongly supported the continued need for UG ECE students to have a solid foundation in the hardware and software design of computer systems. Similarly, our survey data of fresh-out engineers confirmed that we needed to insure that our microprocessor development laboratory was appropriately equipped to support modern architectures and design in our labs and lectures for students who wish to focus on the computer/digital design area.

One of the major problems we (and other ECE departments) face is that many of the processors and chips we wish to use are only available in surface mount configurations. Indeed, the availability of DIP configuration complex processors with externally available data, control and address busses is becoming very difficult to find except for relatively low end processors that we are not inclined to use (e.g. the 8088 which was what our microprocessor course was previously based on). Since this course was focused on modern processor system design, we needed to consider a new approach to the use of currently available technology.
Implementation: In the 2005 time frame, the ECE department undertook the design of a custom, ARM processor module for use in our ECE 3803, *Introduction to Microprocessor System Design*, course. This new ARM module includes sufficient functionality so that students have full access to the processor data, address and control signals necessary to design and build a custom, stand alone microprocessor system. Further, the board includes JTAG programming capability. To enhance the lab side of system development we upgraded the laboratory instruments available to the students (noted above) to include logic analyzers and new high speed digital scopes with USB up and down load capability on every student laboratory bench.

Results: Although lab intensive, students and faculty seemed generally pleased with the changes to a modern RISC like architecture with advanced capabilities. Further, most (or all) students generally finish the lab design project to implement some type of complete microprocessor system from basic components using the new ARM DIP module.

Outcome(s) Impacted: (3) solid foundation in CE and relationship between SW and HW; (5) engineering design; (6) specialty area;

Action: Address lack of student knowledge of the proper use of simulators and modeling of circuits and systems.

Rationale: Although simulation is an inherent part of engineering design, ECE has only in very limited ways incorporated simulation into standard course work. Conversations with advisory board members, students and colleagues highlighted that we needed to in some manner include simulation in our analog design courses (HDL simulators were common in our digital/computer design courses). Since the ECE department had a site license for Multisim\(^41\) it was not unrealistic to believe that simulation could be added to appropriate analog microelectronic design courses in a relatively easy way.

Implementation: Professors Emanuel and O’Rourke (fall, 2007) undertook a full integration of Multisim into ECE 2201, *Microelectronic Circuits I*. The simulator was used to generate input and output characteristic curves for diodes, FETs and bipolar transistors. Also, in the lab, students were asked to design circuits based on typical real-world practical situations. For the prelab component, students were required to simulate all designs and to have results available on their lab PC at the beginning of lab. Students then fabricated their circuits, measured circuit performance, and compared their lab results to the simulation results.

Results: It has been observed that the addition of Multisim in the 2201 class laboratory has resulted in a significant improvement in the ability of students to i) understand the value and use of a simulator and ii) understand the design and operation of basic circuits. An email outlining the use, advantages and results from introducing more in-depth use of Multisim in ECE 2201 is provided in Appendix M. We note, however, that this change of course format and coverage has only recently been accomplished and, as a result, no further outcome impacts are currently available.

Outcome(s) Impacted: (3) solid foundation in EE; (5) engineering design process; (6) in depth understanding of at least one area;

\(^41\) [http://www.ni.com/multisim/](http://www.ni.com/multisim/)
Action: Address student requests for more advanced level courses.

Rationale: Student exit survey data and alumni data was bimodal on course comments. Students often noted that there was not enough coverage of fundamental ECE material, and that there were not enough higher level, focus area courses.

Implementation: Three approaches are being taken to address this issue. First, significant changes are being implemented in our first and second year introductory courses (ECE 2011 and ECE 2111) to improve coverage of this critically important material, to engage students more fully, and to improve the percentage and level of students achieving the respective course outcomes. These changes have been described previously. Second, since our curriculum was heavy on the 2xxx and 3xxx level courses, we repositioned several courses at a higher level and modified the course curriculums to cover more detailed material appropriate for a 4xxx level course. In particular ECE 3901 (Semiconductor Devices) was renumbered and reconfigured as ECE 4904, and ECE 3703 (Real-Time DSP) was reconfigured as ECE 4703. Further, a proposal is being considered by the ECE Curriculum Committee to change the distribution requirements to require students to take a minimum number of 4000 level (or above) ECE courses (depth) as opposed to taken more 3000 level (or below) courses (breadth).

Results: An audit of all graduating (BS level) students showed the following statistics.

- All data removed

The most popular courses were ECE 4902 (Analog IC Design) and ECE 4703 (DSP) indicate that the change in level of the DSP course was beneficial for our students. The change of semiconductors (3901) from a 3xxx level course to a 4xxx level (4904) course was not evaluated (as it impacts graduating seniors) since the course will be taught the first time as a 4xxx course in the fall of 2008.

Based on this data, more than 2/3rd of our students took one or more additional 4xxx level course. In addition to continued advising of our students as a way to encourage them to take 4xxx level courses, we will continue to review alumni survey and graduate audit data in the next few years to determine what else we should do to encourage students to take advanced level courses.

Outcome(s) Impacted: (6) in-depth understanding of at least one area in ECE;

Action: Change distribution requirements as needed to account for new department and WPI initiatives.

Rationale: There are two sets of requirements that all students must satisfy to graduate from WPI with a BA or BS degree. The first are a set requirements that all students must satisfy regardless of declared major and include the IQP, MQP, credit requirement, HU&A requirement, and other university requirements. The second are the distribution requirements which are unique to each department. It is these latter requirements that must not only be kept up to date, but also reflect a sense of “continuous improvement” in that some distribution requirement changes are a result of new programs or changes not specifically in or by the ECE department.

Implementation:

- Robotics Engineering (RBE) courses were added to the list of courses that can be used to satisfy certain ECE distribution requirements.

- Discrete Math was added as a required math course for all ECE majors (in response to an ABET 2002 visit concern).

- Minor changes to the distribution requirements were made to accommodate courses added and removed from the program, adding a first year seminar course but not allowing it to be counted in the ECE distribution requirements, and other changes needed to accommodate both in- and out-of-
department program improvements (e.g. adding the cross listed BME courses that can be counted to meet certain distribution requirements).

**Results:** Results are self evident but, in general, are focused on i) enhancing the types and number of courses that can be used to meet degree requirements and ii) insuring that all ECE students leave WPI/ECE with a solid foundation in ECE as well as depth in one area of ECE.

**Outcome(s) Impacted:** (2) preparation for future changes in ECE; (3) foundation courses; (10) broad education;

**Action:** Address requests for support from ECE centric student groups (multiple actions).

**Rationale:** Over the course of an academic year students will make numerous requests to the DH or AH for support of various projects and endeavors, some professional and some simply for spirit building.

**Implementation:** A few of the team and professionalism building activities students have asked the department to support are indicated below.

- **new student advisory board** – will advise the DH and AH on issues of importance to students (primarily UG, but may also be expanded to graduate students), implemented with SGA (student government association) support in the spring of 2008.
- **Women in ECE (WECE)** – funds were provided for several activities including luncheons with guest speakers, soldering workshop, resume workshop and other various activities.
- **Student Branch of IEEE** – provided funds for the annual spark party, provided funds to support the construction of a (very) large telsa coil, provided funds for various meetings, events, luncheons, etc.
- **Support two professional events a year (joint with Worcester County IEEE section and student IEEE section)** including a guest speaker and dinner. Student participation is subsidized for dinner.
- **Support for department cookouts** – DH purchased and donated a grill, students schedule several cookouts in the spring and fall, DH covers grilling costs (gas, some supplies).
- In general, the DH and AH provide nearly all requested funding for ECE UG student events.

**Results:** The ECE students consistently note in exit and alumni surveys that the ECE department staff and faculty, facilities, and overall student support are by far the best on campus.

**Outcome(s) Impacted:** (10) A broad education.

**Action:** Address faculty teaching quality (multiple actions).

**Rationale:** Although a relatively infrequent comment from alumni and exit survey student evaluations (Appendix L), the department takes teaching quality very seriously. Students are encouraged to talk to the DH about teaching quality issues so that they can be resolved in a timely manner. Similarly, the DH monitors survey data and takes appropriate action when required.

**Implementation:** The WPI Committee on Academic Policy implemented a new teaching evaluation form (students fill it out at the end of every course) in 2004 (Appendix H.1). Each DH receives a summary report of student responses on questions #2 (“my overall rating of the instructor is...”), #1 (“my overall rating of the quality of this course is...”), and #9 (“relative to other courses I have taken, the amount I learned from this course was ...”) for each faculty member and each course.

**Results:** ECE teaching evaluations are generally well above the WPI averages. (data removed).

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**Outcome(s) Impacted:** (all) goes to quality of teaching;

**Figure 4.2 Faculty Teaching Evaluation Results**

**Action:** Respond to student and faculty requests and needs for computational and technical resources and capabilities (various forms and multiple actions).

**Rationale:** Over the course of an academic year there are many requests from students that fundamentally are focused on improving their ability to accomplish educational objectives.

**Implementation:** Examples of requests we have responded to in the spirit of continuous improvement include the following (obviously not exhaustive!).

- remote access improvements - students and faculty asked for faster, more capable, less delay remote access capability in order to be able to work from home
  - added four remote terminal servers (total of 5 now) to provide students and faculty with better off-campus connectivity
- students and faculty asked for faster, more capable, less delay Linux servers
  - added Linux computer server (total of 4 now)
- students and faculty were commenting that some research applications were using all available memory and, as a result, significantly impacting other application processing speeds
  - significantly increased server memory to improve overall network performance (now 20 or 32 G for all servers)
- upgraded network from 10/100 to 10/100/1000
- upgraded wireless from 802.11/b to 802.11/abg
- students and faculty were increasingly asking for more storage space
  - increased personal student/faculty storage space from 700GB to 3.1TB
- students and faculty were increasingly asking for more on-line support
  - deployed department WIKI server to encourage collaboration and provide more department information on services, systems and capabilities
- students requested SOIC soldering capability
- New soldering equipment and stations were purchased and installed specifically to handle SOIC and surface mount IC packages
- ECE shop facilities were upgraded with modern storage systems in support of student projects, student activities, faculty development, course laboratories, and graduate and faculty research
- The outer shop room was reconfigured for student project work.

**Results:** Faculty, staff, and students in ECE are very pleased with our computational facilities and technical support systems. Indeed, students from other departments often seek help from the ECE technical and computational support staff because of their friendly and supportive methods.

**Outcome(s) Impacted:** (all) goes to quality of work, collaboration and overall support.

**Action:** Improve the student casual space environment, information provided to students, and overall department displays to add pride to being an ECE student as well as provide information to visitors (various forms and multiple actions).

**Rationale:** Happy students make for a happy department.

**Implementation:** The department does what is necessary and reasonable to insure that our students have pleasant work and meeting space.

**Results:**
- New wall poster holders were installed to highlighting department activities
- Funds were provided to WECE to upgrade their lounge furniture
- Funds were provided to upgrade the IEEE lounge furniture
- The main student lounge area ("power panel lounge") is undergoing improvements for the second time in about 6 years
- Student requests for meeting space are honored to the extent possible

**Outcome(s) Impacted:** (all) goes to quality of work, collaboration and overall support.

**Summary**

The items noted above are in fact only representative of the types of actions taken on a regularly basis to continuously improve our curriculum and program. Indeed, as discussed at a recent ECEDHA meeting (San Diego, 2007, Open Forum), it is nearly impossible (or at least highly improbably) to capture all the different actions taken by faculty that relate to continuously improving a program.
**CRITERION 5. CURRICULUM**

**Program Curriculum**

Describe how students are **prepared for a professional career and further study** in the discipline through the curriculum and indicate how the curriculum is consistent with the Program Educational Objectives and Program Outcomes.

Provide evidence that the **minimum credit hours and distribution**, as specified in Criterion 5, are met.

The ECE program Distribution Requirements (Table 5-1, also Table 2.4 in §2), together with the WPI Degree Requirements (Table 2.3), implement an education in science, mathematics, engineering science, engineering design and general studies that meets or exceeds the expectations of the ABET criteria. The ECE Distribution Requirements mandate 4 units (12 courses) in mathematics and basic science, which is equivalent to slightly more than one year of study. Seven courses must be in mathematics. Physics must be included, with at least a two-course sequence. Finally, at least one course in either chemistry or biology must be included.

**Table 5-1 Program Distribution Requirements for the ECE Major**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units - Min</th>
<th>Semester Hour Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics (must include differential and integral calculus, differential</td>
<td>7/3</td>
<td>21</td>
</tr>
<tr>
<td>equations, discrete mathematics, and probability and/or statistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics (at least two courses)</td>
<td>2/3</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry and/or Biology (at least one course in either)</td>
<td>1/3</td>
<td>3</td>
</tr>
<tr>
<td>Additional Math, Physics, Biology or Geology</td>
<td>2/3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total Mathematics and Basic Sciences</strong></td>
<td><strong>4</strong></td>
<td><strong>36</strong></td>
</tr>
<tr>
<td>Electrical Engineering courses (from approved list)</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Computer Engineering courses (from approved list)</td>
<td>2/3</td>
<td>6</td>
</tr>
<tr>
<td>ECE elective courses (either in EE or Computer Eng.)</td>
<td>7/3</td>
<td>21</td>
</tr>
<tr>
<td>ECE Major Qualifying Project (MQP)</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>CS course at sophomore level or above</td>
<td>1/3</td>
<td>3</td>
</tr>
<tr>
<td>Engineering Science course outside ECE at sophomore level or above</td>
<td>1/3</td>
<td>3</td>
</tr>
<tr>
<td>Engineering related course in ECE, other engineering area, or CS</td>
<td>1/3</td>
<td>3</td>
</tr>
<tr>
<td>Capstone Design Experience (generally within the MQP)</td>
<td>0*</td>
<td>0*</td>
</tr>
<tr>
<td><strong>Total Engineering Science and Design</strong></td>
<td><strong>6</strong></td>
<td><strong>54</strong></td>
</tr>
<tr>
<td><strong>Total EE Distribution Requirements</strong></td>
<td><strong>10</strong></td>
<td><strong>90</strong></td>
</tr>
</tbody>
</table>

*Note: Capstone Design Experience is usually included in the senior project credit. If the senior project does not contain sufficient design experience, the student must register for additional design work for additional credit of at least 1/3 unit (3 credit hours).*
Six units, 18 courses, equivalent to one and one half years, must be completed in engineering topics, with at least five of those units (15 courses or course equivalents) in electrical and computer engineering topics. At least one course must be in computer science at the sophomore level or above, one course in engineering science outside ECE at sophomore level or above, and one course in an engineering-related area in ECE, other engineering areas, or CS.

Details on the ECE courses including catalog data, learning outcomes, topics covered, and their relation to ECE Program Outcomes are provided in the Appendix A. Table 5-2 and Figure 5.1 show how different courses support the ECE Program Outcomes. In addition to these curricular components Major Qualifying Project (MQP) supports most of the outcomes; the Interactive Qualifying Project (IQP) supports a number of outcomes including outcomes 1, 7, 9, 10, and 11; and Humanities and Social Science requirements supports outcomes 7, 8, 9, 10 and 11.

**Figure 5.1 - Relation of ECE Courses to ECE Program Outcomes**

![Figure 5.1](image)

**Prerequisite Flow Chart** - Attach a flow chart showing the prerequisite structure of program’s courses required or allowed towards the major.

Figure 5-2 shows the flow chart of ECE courses which is a primary academic advising tool. Noting that no ECE courses are specifically required, the faculty have designed the courses and their inter-relationships to provide student flexibility while assuring that sufficient breadth and grounding in the fundamentals is maintained.
Figure 5.2 - ECE Program Course flow Chart
Design Experience Component

Describe the culminating major design experience, including how it is based on the knowledge and skills acquired in earlier course work and how appropriate engineering standards and multiple realistic constraints are incorporated into the experience.

Design experience, particularly in large-scale projects, is central to the ECE program. A degree requirement for all WPI students is the completion of a senior project (“MQP”) equivalent in time and credit to three 3-semester hour courses. This project may be completed over the courses of the senior year in parallel with course work, or it may be completed in one term (one half semester) of full-time work, either on campus or at a project site. This senior project, together with the junior-level project (“IQP”) and Humanities requirements provide ample opportunities for student to both learn and demonstrate many of the ECE educational outcomes. A major biennial review of the MQP provides assessment data, analysis, and recommendations for this central component. An important aspect of this assessment is the degree to which all of the senior projects contain the desired components of engineering design. The most recent review (completed in February of 2007) presented the following conclusions and recommendations, the implementation of which is the task of the ECE Department Head and the ECE Undergraduate Program Committee:

CONCLUSIONS:

- The general educational goals of the MQP are being met.
- The design content of projects is high – as it should be – and is consistent with capstone-design expectations.
- Some elements of the design definition – namely, factors such as: safety, reliability, aesthetics, ethics, and social impact – are not currently emphasized as well as they perhaps should be.
- material and comments removed

RECOMMENDATIONS:

- All project advisors should expect that the members of the project team will have successfully completed ECE 2799, ECE Design.
- All project advisors should participate as faculty for at least one offering of ECE 2799.
- Every project team should be required to clearly establish a set of specifications and design objectives early in the MQP process. These specifications and objectives should be specific, measurable, and traceable to the phenomenology of the problem being solved.
- The faculty should make a concerted effort to maintain the number of corporate-sponsored projects.
- The faculty should be mindful that 1 unit of MQP credit is the equivalent of 3 courses for each student involved in the project.
- The faculty must ensure that issues such as economics, reliability, safety, ethics, and social impact are addressed in the MQP. While it is expected that our design course will increase student ability to address these issues, continued faculty vigilance is essential.
- The faculty must encourage students to fully document their projects from start to finish. This should include the original derivation of a solution, test plans and results.
- several other recommendations removed
These conclusions and recommendations are presented verbatim in this self-study to demonstrate that serious self-assessment is taking place. The fact that improvements are recommended does not imply that the current student outcomes fail to meet minimal standards!

Examples of these senior projects and biennial reviews, and student transcripts and transcript audits for the ECE graduates will be available for the visitors.

**General Education**

The “WPI Plan” integrates a broad college education with each student’s major area of study. A review of the Mission and Goal of WPI will demonstrate the importance given to what is typically called “General Education.” These goals are implemented with an extensive set of requirements in the Humanities and Social Sciences (separately), culminating in Humanities seminars and studies in technology/society (Interactive Qualifying Project, IQP) area. This latter project, the IQP, typically relates the student’s major area of study to an area of the humanities, with the emphasis on the human and social side, not the technical side. Examples include the politics of nuclear waste disposal, the tradeoffs between government expenditures on high-tech medical research rather than public health, and the value of a human life. Examples of these IQP reports will be available for the visitors. Equivalent semester hours of credit for these components are: Humanities: 18; Social Science: 6; IQP: 9, a total of 33 semester hours.

Beyond the substantial credit requirement, we feel that these components are well designed in themselves, and that they inter-relate in ways that multiply their value. For example, the study of language or Asian culture in the Humanities portion may be put to use by a student conducting his/her IQP in San Juan or Bangkok. It should be noted that ECE faculty are substantially involved as project center directors and advisors for the IQPs, both on campus at residential sites in the U.S. and abroad.

**Course Syllabi**

Attach course syllabi in Appendix A for each course used to satisfy the mathematics, science, and discipline-specific requirements required by Criterion 5 or any applicable Program Criteria. The syllabi formats should be consistent for each course, must not exceed two pages per course, and, at a minimum, contain the following information:

- Department, number, and title of course
- Designation as a Required or Elective course
- Course (catalog) description
- Prerequisites
- Textbook(s) and/or other required material
- Course learning outcomes / expected performance criteria
- Topics covered
- Class/laboratory schedule, i.e., number of sessions each week and duration of each session
- Contribution of course to meeting the requirements of Criterion 5
- Relationship of course to Program Outcomes
- Person(s) who prepared this description and date of preparation

The course and section size summary for ECE courses and a sample curriculum are provided in the following pages. Course descriptions and syllabi, per the ABET guidelines (red, above), are provided in Appendix A.
**Time and Attention**

Demonstrate that **adequate time and attention** are given to each curricular component, consistent with the outcomes and objectives of the program and the institution.

Described in the tables following.

**Cooperative Education**

Describe the provisions for any **cooperative education** that is used to satisfy curricular requirements. Include a description of the academic component evaluated by program faculty.

Few ECE students participate in the WPI COOP program because i) there are numerous off-campus and corporate sponsored project opportunities available to students (~50% of all ECE students complete their MQP in conjunction with a corporate sponsor or project center) and ii) there are numerous summer internships available to ECE students.

**Additional Material**

Describe the **additional materials that will be available for review** during the visit to demonstrate achievement related to this (design) criterion.

- Several MQP (and IQP) final reports will be available at the time of the ABET visit that illustrate off-campus or industry sponsored project activities and design.
- Copies of all ECE course folders with sample labs will be available.
### Table 5-2. Course and Section Size Summary for Electrical and Computer Engineering

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Sections Offered in Current Year</th>
<th>Avg. Section Enrollment</th>
<th>Lecture %</th>
<th>Laboratory %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 1799</td>
<td>First Year Seminar Intro to ECE</td>
<td>1</td>
<td>29</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 2011</td>
<td>Intro. to Electrical and Comp. Engineering</td>
<td>6</td>
<td>30</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 2022</td>
<td>Intro. to Digital Circuits and Comp. Engineering</td>
<td>6</td>
<td>23</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 2111</td>
<td>Physical Principles of ECE Applications</td>
<td>2</td>
<td>44</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 2112</td>
<td>Electromagnetic Fields</td>
<td>1</td>
<td>42</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 2201</td>
<td>Microelectronic Circuits I</td>
<td>4</td>
<td>22</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 2311</td>
<td>Continuous-Time Signal and System Analysis</td>
<td>2</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 2312</td>
<td>Discrete-Time Signal and System Analysis</td>
<td>2</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 2799</td>
<td>Electrical and Computer Engineering Design</td>
<td>6</td>
<td>15</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ECE 2801</td>
<td>Foundations of Embedded Computer Systems</td>
<td>6</td>
<td>21</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 3113</td>
<td>Intro. to RF Circuit Design</td>
<td>1</td>
<td>23</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 3204</td>
<td>Microelectronic Circuits II</td>
<td>4</td>
<td>18</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 3305</td>
<td>Aerospace Avionics Systems</td>
<td>1</td>
<td>36</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 3308</td>
<td>Introduction to Wireless Networks</td>
<td>1</td>
<td>29</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 3311</td>
<td>Principles of Communication</td>
<td>1</td>
<td>31</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 3501</td>
<td>Electrical Energy Conversion</td>
<td>1</td>
<td>22</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 3503</td>
<td>Power Electronics</td>
<td>1</td>
<td>29</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Table 5-2. Course and Section Size Summary for Electrical and Computer Engineering [con’t]

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Sections Offered in Current Year</th>
<th>Avg. Section Enrollment</th>
<th>Lecture %</th>
<th>Laboratory %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 3601</td>
<td>Principles of Electrical Engineering</td>
<td>5</td>
<td>40</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 3801</td>
<td>Advanced Logic Design</td>
<td>6</td>
<td>12</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 3803</td>
<td>Microprocessor System Design</td>
<td>4</td>
<td>9</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 3810</td>
<td>Advanced Digital System Design</td>
<td>3</td>
<td>11</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 4304</td>
<td>Communication Systems Engineering</td>
<td>1</td>
<td>13</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 4703</td>
<td>Real-Time Digital Signal Processing</td>
<td>1</td>
<td>26</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ECE 4801</td>
<td>Advanced Computer System Design</td>
<td>1</td>
<td>16</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>ECE 4902</td>
<td>Analog Integrated Circuit Design</td>
<td>1</td>
<td>44</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>ES 3011</td>
<td>Control Engineering</td>
<td>1</td>
<td>44</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Table 5-3. Sample Curriculum for Electrical and Computer Engineering

See notes at end of table on second page.

<table>
<thead>
<tr>
<th>Term (A, B, C, or D) and Year</th>
<th>Course (Department, Number, Title)</th>
<th>Category (Credit Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Math &amp; Basic Sciences</td>
<td>Engineering Topics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check if Contains Significant Design</td>
</tr>
<tr>
<td>A-1</td>
<td>Math 1021 - Calculus Differentiation. 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Physics 1110 - Mechanics 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>( )</td>
</tr>
<tr>
<td>B-1</td>
<td>Math 1022 - Calculus Integration 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Physics 1120 - E&amp;M 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>( )</td>
</tr>
<tr>
<td>C-1</td>
<td>Math 1023 - Calculus Series/Vectors 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Chemistry 1010 - Molecularity 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2011 - Intro to ECE 3</td>
<td>( )</td>
</tr>
<tr>
<td>D-1</td>
<td>Math 1024 - Calculus Multivariable 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2022 - Intro to Digital/Computer 3</td>
<td>( )</td>
</tr>
<tr>
<td>A-2</td>
<td>Math 2051 - Differential Eqns. 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Computer Science 1102 - Prog. Design</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2111 - Phys. Prin. of ECE 3</td>
<td>( )</td>
</tr>
<tr>
<td>B-2</td>
<td>Social Science Elective</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Computer Science 2301 - C Prog. 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2311 - Cont. Time Sigs/Sys 3</td>
<td>( )</td>
</tr>
<tr>
<td>C-2</td>
<td>Math 2201 - Discrete Math 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2801 - Embedded Systems 3</td>
<td>(✓)</td>
</tr>
<tr>
<td>D-2</td>
<td>ECE 3801 - Advanced Logic Design 3</td>
<td>(✓)</td>
</tr>
<tr>
<td></td>
<td>Physics 1140 - Oscillations and Waves 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Social Science Elective</td>
<td>( )</td>
</tr>
<tr>
<td>A-3</td>
<td>IQP (third year project)</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Math 2621 - Probability 3</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ES3011 - Controls Engineering 3</td>
<td>( )</td>
</tr>
<tr>
<td>B-3</td>
<td>IQP</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>( )</td>
</tr>
<tr>
<td></td>
<td>ECE 2799 - ECE Design (proj. based) 3</td>
<td>(✓)</td>
</tr>
</tbody>
</table>
Table 5.3. Sample Curriculum for Electrical and Computer Engineering  (continued)

<table>
<thead>
<tr>
<th>Term (A, B, C, or D) and year of program</th>
<th>Course (Department, Number, Title)</th>
<th>Category (Credit Hours)</th>
<th>Math &amp; Basic Sciences</th>
<th>Engineering Topics</th>
<th>General Education</th>
<th>Math &amp; Basic Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-3</td>
<td>IQP</td>
<td></td>
<td>( )</td>
<td>3</td>
<td>( )</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ECE 2201 - Circuits I.</td>
<td></td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE 2312 - Discrete Sigs/Sys.</td>
<td></td>
<td></td>
<td>3 ( )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-3</td>
<td>ECE 3803 - Microprocessor Sys</td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Humanities Seminar/Practicum</td>
<td></td>
<td>( )</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE 3204 - Circuits II.</td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-4</td>
<td>MOP (capstone project)</td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MA 2071 - Linear Algebra</td>
<td></td>
<td>3 ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ES2001 - Materials Engineering</td>
<td></td>
<td>3 ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-4</td>
<td>MOP</td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td></td>
<td>( )</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td></td>
<td>( )</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-4</td>
<td>MOP</td>
<td></td>
<td>3 (✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE4801 - Computer Arch.</td>
<td></td>
<td>3 ( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical Education (generally</td>
<td></td>
<td>( )</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>distributed over all years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-4</td>
<td>Optional Elective</td>
<td></td>
<td>( )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optional Elective</td>
<td></td>
<td>( )</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Optional Elective</td>
<td></td>
<td>( )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| TOTALS-ABET BASIC-LEVEL REQUIREMENTS    | 36   | 54   | 33   | 12   |
| OVERALL TOTAL FOR DEGREE               | 135  |      |      |      |
| PERCENT OF TOTAL                       | 27%  | 40%  | 24%  | 9%   |
| Totals must satisfy one set            |      |      |      |      |
| Minimum semester credit hours          | 32 hrs | 48 hrs |      |      |
| Minimum percentage                     | 25%  | 37.5%|      |      |

Note that instructional material and student work verifying course compliance with ABET criteria for the categories indicated above will be required during the campus visit.

The above program is typical, but does not represent the required schedule for any student since other than distribution requirements, there are no required courses at WPI. However, the amounts of credit in each column are required for each student, so that ABET requirements are certain to be met.
CRITERION 6. FACULTY

ECE Faculty

Faculty - Describe the composition, size, credentials, experience, and workload of the faculty that supports this program. Complete and include Tables 6-1 and 6-2.

The ECE department includes 20 tenured or tenure-track faculty positions. In addition, one position is vacant with a search planned for AY 2008-09.

ECE also make use of two full-time non-tenure track faculty and three part-time faculty in our undergraduate program. These non-tenure track faculty come from quite different backgrounds.

- specific faculty comments removed.

The heart of our program will always be the full-time, tenured/tenure track faculty, but these other faculty also make important and distinctive contributions.

Faculty Size

Faculty Size - Discuss the adequacy of the size of the faculty and describe the extent and quality of faculty involvement in interactions with students, student advising, service activities, and professional development. Attach as Appendix B an abbreviated resume for each program faculty member with the rank of instructor or above. The format should be consistent for each resume, must not exceed two pages per person, and, at a minimum, must contain the following information:

- Name and academic rank
- Degrees with fields, institution, and date
- Number of years of service on this faculty, including date of original appointment and dates of advancement in rank
- Other related experience, i.e., teaching, industrial, etc.
- Consulting, patents, etc.
- States in which professionally licensed or certified, if applicable
- Principal publications of the last five years
- Scientific and professional societies of which a member
- Honors and awards
- Institutional and professional service in the last five years
- Percentage of time available for research or scholarly activities
- Percentage of time committed to the program

The number of faculty is adequate to deliver the undergraduate program with the quality that we expect, as well as to deliver our graduate program, engage in research, and pursue professional development. Presently, our student-to-faculty-ratio is approximately 13:1 at the UG level and 3.4:1 at the graduate level (Appendix D).

Faculty Qualifications

Faculty Competencies - Describe the competencies of the faculty and how they are adequate to cover all of the curricular areas of the program.

The ECE faculty are well qualified to handle the development and delivery of our Electrical and Computer Engineering curriculum. However, the undergraduate program described by the WPI Plan places special demands on faculty. Not every person who would be appropriate for a traditional university faculty position is suitable for the faculty at WPI. Some of the necessary faculty attributes are:

- breadth of knowledge and interests to be able to span multiple areas of teaching, collaborative research and manage future change and innovation,
• a deep interest in both teaching *and* research,
• a strong interest in frequent interactions with students,
• a desire to support the global perspectives program and/or advise IQPs, and
• an interest and ability in practical engineering design as well as engineering science.

Fortunately, we have been quite successful at identifying, recruiting, and ultimately tenuring such individuals.

Our interview process includes a traditional research seminar as well as one-on-one visits between the candidate and as many faculty as feasible, for the benefit of both the candidate and his/her potential colleagues. The candidates also have a chance to interact in an informal environment with students for perhaps an hour during the interview day. Interestingly, our students regularly ask the candidate to ‘teach’ them something so that they can develop a sense of the quality of teaching they can expect. Finally, we have found that previous industrial experience has been extremely helpful to new faculty, both in the engineering knowledge which it provides, and in bringing a maturity of perspective.

A broad range of excellent undergraduate and graduate schools are represented by our faculty. There is also good diversity in such aspects as country or region of origin, previous academic experience, theoretical or practical orientation, age, and industrial experience. At present we have two female faculty members. We are working to add more women and minorities to the faculty.

The range of faculty expertise matches the educational program. However, it would be highly desirable to add more faculty in the analog electronics area. Following is a summary of the principal areas of expertise of the full-time faculty:

- Prof. Bitar: Fundamentals, analog electronics, design
- Prof. Brown: Communications, signal processing
- Prof. Clancy: Signal processing, biomedical engineering
- Prof. Cyganski: Signal processing, computer engineering
- Prof. Duckworth: Computer engineering
- Prof. Emanuel: Power systems, power electronics
- Prof. Hakim: Signal processing
- Prof. Huang: Computer engineering
- Prof. Jarvis: Computer engineering
- Prof. Klein: Communications, signal processing
- Prof. Labonte: Fundamentals, analog electronics, ECE design
- Prof. Looft: Computer engineering
- Prof. Lou: Computer and network security
- Prof. Ludwig: RF design, electromagnetics
- Prof. Makarov: Signal processing, numerical modeling, antennas
- Prof. McNeill: Analog and mixed signal design
- Prof. Michalson: Computer engineering
- Prof. Pahlavan: Wireless communications
- Prof. Pedersen: Signal processing
- Prof. Sunar: Cryptography, computer engineering
- Prof. Wyglinski: Communications

Most of the faculty have significant industrial engineering experience. This has been extremely helpful in bringing the “real world” of engineering into the classroom and project environments. Among our faculty, the number of years of teaching experience ranges from one to over 30. Overall, the faculty have a rather even distribution of experience within that range. There is also a good range of experience within each subarea of ECE, so that new faculty are generally not “starting from scratch” in their specialty area.
Historically, eight full-time ECE faculty (four currently on staff) have won the prestigious and competitive Trustees’ Award for Outstanding Teaching. Three present members of the ECE faculty have won the Trustees’ award for Outstanding Creative Scholarship. Two of them have won the prestigious Chairman’s Award. One (Emanuel) has won every individual Trustee’s and President’s award on campus (Advising, Scholarship, Teaching, Chairman’s) and is the only WPI faculty member to have won three, let alone all four of the campus awards for distinguished achievements. Dr. Jim O’Rourke, our facilities and technical support manager, was the first to win the Nicoletti Award for Community Service.

The ECE faculty consistently perform research and publish the research results in high quality peer reviewed journals (see the two page Appendix B resumes for example). This activity, coupled with graduate student research advising, undergraduate project student advising, conference participation, and a range of other activities (review boards, ABET work, IEEE work, NSF reviewers, IEEE Fellows, elected to and serve on WPI campus committees, etc) clearly supports the idea that we have a dynamic and engaged ECE faculty.

specific comments removed

Management

Leadership - Identify and describe the leadership and management responsibilities of each leadership individual.

Authority and Responsibility of Faculty - 1. Describe the role played by the program faculty with respect to course creation, modification, and evaluation.

The department is led and managed by a Head and an Associate Head. The Head is responsible for overall management of all aspects of the department operation including strategic planning, faculty hiring and development, resource allocation, and staff supervision. The Associate Head assists the Head in a number of areas including course scheduling, assessment, catalog revisions, and transcript audits. As shown in Figure 6.1, the ECE Faculty are involved in the leadership and management of the department through a number of committees.

42 http://www.wpi.edu/About/Awards/presented.html
43 http://www.wpi.edu/Campus/Faculty/Awards/Advisor/
44 http://www.wpi.edu/Campus/Faculty/Awards/Scholar/
45 http://www.wpi.edu/Campus/Faculty/Awards/Teacher/
46 http://www.wpi.edu/News/Commence/Ceremonies/chairm865.html
47 http://www.wpi.edu/Campus/Faculty/Awards/Nicoletti/
The Curriculum Committee, in particular, is perhaps one of the most important at the UG level and is responsible for review of all proposals for course revisions, new courses, course learning outcomes and changes to ECE distribution requirements. CC recommendations need to be approved by ECE Faculty, WPI Committee for Academic Operation and WPI Faculty.

Table 6.1 provides a summary of ECE faculty workload in AY 2007-2008 and Table 6.2 provides an analysis of faculty background and activities. In AY 2008-2009 the following changes will take place:

- faculty notes removed
Administration’s Role and Support

2. Describe the roles played by others on the campus, e.g., Dean’s Office, Provost’s Office, with respect to these areas.

There are several individuals in the administration who support the ECE department and faculty in various ways. These include the following.

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provost</td>
<td>The Provost has oversight responsibility for all academic and academic-support departments.</td>
</tr>
<tr>
<td>Dean of UG Studies</td>
<td>Responsible for the quality and effectiveness of the undergraduate programs as well as oversight of student and faculty interests and directions for new program development. Specific responsibilities include undergraduate advising and first-year programs. This position is currently vacant since the Dean became the Provost (J. Orr).</td>
</tr>
<tr>
<td>Assoc. Prov. Grad Studies</td>
<td>Less impact on the UG program and accreditation, but critical for supporting our BS/MS program and other ways to enhance and support student knowledge of potential career paths.</td>
</tr>
<tr>
<td>Assoc. Prov. Acad. Affairs</td>
<td>Provides support for course assessment, outcomes evaluations, surveys and other aspects of curriculum quality control. Works with the department head to insure excellence in teaching.</td>
</tr>
<tr>
<td>Assoc. Dean 1st Yr. Exper.</td>
<td>Not a significant factor since ECE is not directly involved in the formal WPI first year program, but supports ECE as requested.</td>
</tr>
<tr>
<td>Academic Resource Center</td>
<td>Provides academic support services that are designed to enrich and enhance the learning experience of all WPI undergraduate students. Its student-based collaborative learning environment offers individualized assistance in a variety of subjects, as well as, a comprehensive peer tutoring program, seminars and workshops. Occasionally used by faculty to support course learning objectives.</td>
</tr>
<tr>
<td>Acad. Tech. Center</td>
<td>Supports i) technology for teaching and learning, ii) campus media services, iii) media production services, and iv) audio/visual systems engineering. Also supports the Teaching with Technology collaborative that several ECE faculty have been involved with. The Teaching with Technology Collaborative allows WPI faculty and staff to collaborate with the ATC to enhance student learning through the use of technology.</td>
</tr>
<tr>
<td>Dean of Students</td>
<td>Provides significant support for processing and guidance for academic honesty cases.</td>
</tr>
<tr>
<td>Academic Advising</td>
<td>Academic Advising is more than just helping student select courses. It is a mentoring relationship between the advisor and the student and involves offering career advice as well as degree planning. AA resources are designed to help advisors (ECE faculty) in their role as an advisor and as a mentor to ECE advisees.</td>
</tr>
</tbody>
</table>

48 http://www.wpi.edu/Admin/Provost/personnel.html
49 http://www.wpi.edu/Academics/Undergraduate/FirstYear/index.html
50 http://wpi.edu/Pubs/Policies/Judicial/
CEDA The Center for Educational Development & Assessment (CEDA) supports improvements in teaching and learning at WPI. CEDA’s principal functions are to:

- provide opportunities for undergraduate and graduate students, and WPI faculty to think reflectively and act to improve their teaching through participating in workshops and mentoring activities,
- assist faculty with educational proposals and proposals requiring assessment, and to
- support continuous improvement through structured and effective outcomes assessments of student learning.

IGSD - Dean and Staff The Interdisciplinary and Global Studies Division is responsible for overseeing two of the most successful educational innovations to emerge at any college or university in the past half century: the Interactive Qualifying Project (IQP) and the Global Perspective Program. ECE faculty regularly interact with IGSD faculty and staff to i) be trained for off-campus project center advising, ii) participate in various IQP activities, and iii) learn about opportunities for ECE participation in project activities not directly related to specific ECE curriculum goals and objectives.

Gordon Library The library partners with the WPI community in teaching, learning, and scholarship by providing resources and innovative services that anticipate and respond to changing information needs.

CCAC The mission of WPI’s Center for Communication Across the Curriculum is to improve the written, oral, and visual communication of WPI students and to promote writing as a tool for learning in all disciplines. The CCAC hosts a variety of faculty development workshops on writing and the teaching of writing, and it provides peer tutoring in writing, oral presentation, and visual design for undergraduate and graduate students. ECE faculty make regular use of the CCAC staff to help our students improve their oral and written communication abilities.

Course Quality and Consistency

3. Describe the process used to ensure consistency and quality of the courses taught.

- CC reviews all aspects of course issues and makes recommendations for improved quality and consistency.
- The DH and AH assess all course review material (student evaluations, faculty two page assessment forms, student comments, faculty comments) for issues related to quality and consistency.
- Teams of faculty work together to establish guidelines for specific courses in specific areas (e.g. digital/computer, communications/signals, analog/IC, etc) to insure consistency from term to term and offering to offering, as well as to insure a standard lab experience for both faculty and students.

51 http://www.wpi.edu/Academics/Depts/HUA/WC/index.html
• Students review teaching quality for every course offering. The DH then reviews a summary of that data and, with input from the Associate Provost for Academic Affairs, works with faculty who need to address specific identified teaching quality and/or methods issues.

Development

Faculty Development - Describe the plan that is in place for faculty development and the funding available to execute this plan. Provide detailed descriptions of professional development activities for each faculty member.

Faculty are encouraged to participate in development programs. Most faculty stay current by attending conferences, doing research, advising students and so forth. It is also not unusual for faculty to collaborate on projects, advising and research which, in turn, supports faculty development as faculty learn from each other.

The department head provides travel support, as needed and requested, for faculty development.
Table 6.1  ECE Faculty Workload for 2007-08 Academic Year

Table removed

Table 6.2  ECE Faculty Analysis

Table Removed
**Instructions**: Complete table for each member of the faculty of the program. Updated information is to be provided at the time of the visit. The level of activity should reflect an average over the current year (year prior to visit) plus the two previous years.

**Note**: "High" research activity represents regular publication of journal and conference papers, research funding, and advising of thesis students.

**Table 6.2** ECE Faculty Analysis (continued)

table removed
CRITERION 7. FACILITIES

Facilities Overview

Space - Summarize availability of program facilities and indicate how adequate they are for supporting the educational objectives and outcomes of the program.

The electrical and computer engineering program is housed in Atwater Kent Laboratories, a 44,000 square foot facility. The Electrical and Computer Engineering department has exclusive use of 36,000 square feet. This building was apparently the first building to be constructed in the United States (in 1907) specifically to house an electrical engineering program. It was completely renovated and substantially expanded in 1980. Within this building are 5,400 square feet of classrooms (used principally by the ECE department), and 15,000 square feet of teaching laboratories. The remaining space includes offices, conference and seminar rooms, and support space (including the electronics and computer shops.). This space is adequate at present, but tight. Given our project program and growing faculty research, the need for laboratory space continually increases.

The Atwater Kent building houses one lecture hall (200 seats), two amphitheater-style classrooms (~80 seats each), and one small classroom (~20 seats). The ECE department has also equipped all of its instructional laboratories with i) multimedia projection capabilities and ii) white boards for in-lab “studio classroom” style teaching if a faculty member elects to do in-lab instruction (most do).

Most ECE classes are taught in the Atwater Kent building. This is important to facilitate demonstrations, and also to maintain a sense of student-faculty community. In addition, several seminar and conference rooms are available for use by students and faculty to accommodate small-group meetings. There is also a variety of public lounge space, including one area dedicated as an undergraduate ECE student lounge. The student chapters of IEEE and Eta Kappa Nu are provided office space and computer support as well as the Women in ECE group (WECE).

Discuss the following: i) offices (Administrative, Faculty, Clerical, Teaching Assistants), ii) Classrooms, iii) Laboratories, and iv) Library.

Other points of note regarding space are as follows.

- All faculty have individual offices, including both of our senior technical supervisors (technical and computational).
- The ECE administrative office space is adequate and is currently being renovated (summer, 2008).
- All TAs are provided with office space if they are not able to work in the laboratory of the professor they are doing research for. RAs, by comparison, are generally located in the laboratory of the faculty advisor.
- Many faculty have individual or shared research laboratory space. Space is very tight for faculty laboratories.
- The library is housed in a separate building and as noted in the following section, library services are very good, both with respect to undergraduate needs, and those of the faculty and graduate students. The book collection is up-to-date, and the journal collection is quite substantial for an institution of our size. Also, the library has been quite pro-active in making available (at low or no cost) electronic searching and full-text retrieval. There is sufficient space in the library for student and faculty activities.
Computational Facilities and Software

Resources and Support - Describe the computing resources, hardware and software used for instruction. Specify any limitations that impact the student’s ability to achieve the program’s outcomes and the faculty’s teaching and scholarly activities.

Appendix C contains a list of the major software available to all undergraduate students. Students may access this software via our computer labs (the building is open 24:7 by card access) and over the WPI network from their own PCs. Appendix C shows the organization of software with regard to the design process, proceeding from initial design through simulation, schematic capture, and printed circuit board layout.

WPI and the ECE department have made a substantial commitment to computational infrastructure and resources. The WPI Computing and Communications Center (CCC) operates a high-speed backbone campus network with an extensive array of workstations and PC’s available to the campus community. Complete internet access is also provided based on both wired (offices, labs) and advanced, high speed wireless (full campus) connectivity. All rooms in the ECE building have both Category 5 and fiber media.

All WPI computer access is free to registered students (and faculty, staff). ECE computational resources are free to all registered ECE students (and faculty, staff). The ECE department provides over 80 PCs and a variety of Unix workstations for student use. Of course, many students own their own computers, and make extensive use of them (the residence halls are completely networked). In addition, WPI has made a commitment to make hardware and software resources available to all students. Particularly regarding professional-quality software, students could not be expected to purchase these resources. For example, WPI has a campus license for all Microsoft products. Also, many ECE licensed products are accessible off-campus to ECE students through one of our remote-access terminals (Appendix C).

For commodity Internet, WPI has a connection to ProSpeed at 40Mbps, Charter at 30mbs, and Sprint at 40mbs. The WPI campus is also connected to an NSF Internet2 site via an OC-3 link to the Abilene network. Internet2 is a high-speed research network that allows WPI students, faculty and staff to collaborate with other schools, government agencies, and corporations on high tech projects. WPI maintains and operates the Goddard GigaPoP for Internet2 which allows us to serve as a connector for other schools and businesses allowing them the same access.

Support Staff

Describe the type and number of support personnel available to install, maintain, and manage departmental hardware, software, and networks.

One full-time professional staff person and several part-time staff are dedicated to departmental hardware, software, and network support. Outside support from the CCC is available when the ECE professional staff is on vacation or otherwise not available. Overall, computational resources support within ECE and from CCC is excellent.

Process and Planning

Describe the laboratory equipment planning, acquisition, and maintenance processes and adequacy.

As has been previously discussed, laboratory education is an integral part of the ECE program. As a result, planning for laboratory facilities receives the same attention as the lecture components of the curriculum. Indeed, course content and lab facility revisions occur together. In addition, the Curriculum and Undergraduate Program Committees regularly review the facilities and support available to undergraduates for the experimental components of their project work.

The overall aspects of planning for laboratory instruction can be summarized as follows:

1. Determination of educational component needs, and facilities and equipment needs.
2. Integration of laboratory instruction with the overall undergraduate ECE program and maintenance of relevance to the modern practice of electrical and computer engineering.

3. Provision of appropriate space, laboratory furniture, etc.

4. Provision of resources for equipment acquisition.

5. Provision of staff and facilities for equipment maintenance.

6. Provision of faculty and teaching assistance for the delivery of laboratory education.

7. Assessment of level of quality of laboratory education.

Following is a summary of the responsible entities for implementation of this plan:

The Curriculum Committee (for courses) and the Undergraduate Program Committee (for projects and other program components) are responsible for determining the academic activities which require laboratory facilities, and for determining students project needs, primarily the MQP, respectively. This encompasses items 1 and 2.

The DH and AH are responsible for items 3 through 6, working with the ECE technical facilities and computational facilities managers regarding the details.

The DH and AH, in conjunction with faculty instructor feedback from individual courses, are responsible for item 7.

In general, the ECE department's philosophy is to integrate the laboratory experiences within the regular courses, rather than to offer free-standing laboratory courses. This course-laboratory integration provides a tight coupling between the lecture and laboratory material. Hence, in most cases laboratories are designed and redesigned along with the lecture material. Two good examples of this are the introductory ECE course sequence, and the Computer Engineering sequence. About 50% of the ECE courses contain formal laboratory components.

**Funding**

The department and the university understand the mutual responsibilities for provision of laboratory resources. Three general sources exist for laboratory resources:

- Regular ECE department funds.
- Institutional resources, provided as part of the annual capital budgeting process.
- Grants of various kinds, including corporate gifts in kind, government grant programs, and individual donations.

**Undergraduate Laboratory Facilities and Equipment**

**Major Instructional and Laboratory Equipment** - List major instructional and laboratory equipment and attach as Appendix C.

Integration of laboratory with classroom work is fundamental to the undergraduate ECE program. Indeed, of the 27 courses offered by ECE, 15 have labs. Of the 5 cross listed biomedical engineering courses, 3 have laboratories. Beyond scheduled lab sections, all teaching labs are open 24/7 to students with valid ECE swipe cards (for building access). Following is a summary of the major individual UG laboratory facilities and, in Appendix C, the equipment that can be found in each lab.
Basic ECE Lab (AK 317a: ECE 2011, 2022)

The intent of this laboratory is to provide an introduction to basic electronics instrumentation and measurement techniques, and to provide hands-on experience with real circuits and components. Modern basic instrumentation (digital oscilloscope, digital voltmeter, function generator, power supply) is provided at each student station (18 stations - 36 students, plus instructors station and multimedia capability). In addition, a Pentium PC with design software (Spice, Mathcad, Maple, C compiler, etc) is provided at each station. The instrumentation is completely adequate for this task.

Student Project Lab (AK 210, MQPs and ECE 2799)

The primary location of this lab is in AK 210. This lab consolidates facilities for student project work in an area adjacent to the ECE department Electronics Shop, for ease of supervision and assistance to students. Equipment (PC’s, development systems, schematic capture and printed circuit layout systems, cross-assemblers, logic analyzers, etc.) is provided to support a broad range of projects, with particular emphasis on computer engineering projects. The lab is well equipped (10 student project stations). The use of this lab space is being reconfigured during the summer of 2008 since many project students prefer to work in one of the other teaching labs.

Computer Engineering Course Lab (AK 113: ECE 2801, 3801, 3803, 3810)

Each station in this lab is equipped with a Pentium class PC with interfaces for JTAG programming of microprocessor and embedded systems, both custom and commercial. Equipment includes a modern logic analyzer, a multi-meter, power supply and high frequency oscilloscopes. In addition, software appropriate for course needs are available on every PC (HDL compilers, C and ASM compilers and loaders, etc). This lab is more than adequate for course needs (15 stations - 30 students, plus instructors station and multimedia capability) but, because of the quickly changing nature of digital electronics and computer engineering in general, is perhaps the lab that is most intensely scrutinized for modernization on a regular basis.

Studio Classroom (AK 227, ECE 2201, 3204, 3601, 4703, 4902)

This laboratory space combines a modern AV classroom with laboratory facilities including PCs and standard laboratory instruments (digital oscilloscopes, digital multimeters, power supplies) in a comfortable learning environment. Both traditional 3-hour lab sections and combined lecture-lab courses are taught in this room (25 stations - 50 students, plus instructors station and multimedia capability). Other courses often taught in this space include our DSP course and our basic ECE for non majors course (3601) because of the recent installation of LabView on all lab PCs and the availability of an ADC/DAC interface (to the LabView SW).

Specialized Laboratories

Following are brief summaries of specialized laboratories operated by individual faculty or faculty groups. These labs are very much available to undergraduate students, particularly for their senior projects. Below, a few of these labs are described. A complete listing of labs and centers can be found here: www.ece.wpi.edu/Research/index.html
**Antenna Laboratory**

The Antenna Laboratory in the ECE Department is a small-scale laboratory with emphasis on numerical optimization and prototyping of selected antenna types.

**Cryptography & Information Security (CHRIS) Laboratory**

The CRIS Laboratory conducts research and development in cryptography and its applications. Lab personnel work on fast software algorithms and efficient hardware architectures. The lab is equipped with industry-standard development tools for ASIC and FPGA target hardware. Another focus is the integration of cryptography and data security into new communication networks, including the design and implementation of security protocols for wireless networks, with an emphasis on wireless LANs.

**Center for Wireless Information Networking Studies (CWINS)**

The Center for Wireless Information Network Studies (CWINS) is a major facility for modeling and performance analysis in all aspects of wireless networking. The core competence of the center is in indoor radio channel propagation measurement modeling and in the development of testbeds and tools for design and performance monitoring of wireless indoor networks.

**New England Center for Analog and Mixed Signal IC Design (NECAMSID)**

NECAMSID has been established as a complete integrated circuit design and test environment to serve multiple needs of graduate and undergraduate students and research sponsors. The facilities include comprehensive high-speed (up to 2.5 GHz) analog test and measurement equipment, which can be used to characterize a wide range of devices and circuits.

**Embedded Computing Laboratory**

The research focus of the embedded computing labs is on the theories, architectures, and applications of embedded computing. The term "embedded computing" has been used for decades to describe the computational property embedded in a physical component or system, or within the constraints of a physical system. The radical transformation that we envision comes from networking these devices with reconfigurability. The challenge of the circuits and systems design is to achieve high performance computing at lower power consumption with added flexibility.

**RF Electronics and Image Analysis Laboratory**

The mission of this laboratory is the development of RF/MW electronic systems and all aspects associated with computer-driven data acquisition, network communications, numerical analysis and processing, and visualization. The lab is equipped with numerous SUN, SGI, and Compaq workstations. Network analyzer, LCR meters, power sources, and associated equipment is available for RF development work. The lab has access to commercial, academic, and public domain software in RF circuit design, image analysis and display.

**Wireless Innovation Laboratory**

The Wireless Innovation Laboratory (WI Lab) was founded in August 2007 by Professor Alexander M. Wyglinski in order to advance our understanding of technologies and algorithms that can help improve society's usage of radio frequency spectrum for a wide range of wireless applications.

**Wireless Networking and Security Laboratory**

The mission of the Wireless Networking and Security Lab (WiNetS) is to explore the novel concepts and ideas related to the protocols and systems of wireless and mobile networking, and to design scalable architecture and efficient and secure protocols for the next generation wireless networks. Our current research interests are i) security in wireless mesh/sensor networks, ii) energy efficient routing,
cooperative communication in wireless sensor/ad hoc networks, and iii) intelligent transportation system.

**Laboratory Equipment**

Modern hardware tools range from 20 GHz Spectrum Analyzers to facilities for working with surface-mount components in student project work. **Appendix C** lists equipment available to students in ECE - along with an indication of the major equipment additions over the past few years:

**Planning and Support**

Describe the type and number of support personnel available to install, maintain, and manage laboratory equipment.

discussion of staff removed
CRITERION 8. SUPPORT

WPI is blessed with a straightforward administrative structure, and these positions are occupied by persons who understand and value engineering education - and the associated costs in terms of actual budgets and personnel, both within the department and external to the department. Our Provost, in particular, is not only an engineer but has also a long history of working at WPI and, thus, is intimately familiar with the operations of the school, has an understanding of its history and legacy, and knows the faculty and organization of the school very well.

At a university, leadership comes from the faculty as much as from the administration, and WPI has a strong tradition of faculty governance in academic matters. The vision of combined faculty and administrative leadership was clear 30 years ago when the WPI Plan was created, adopted, and implemented. Over the past 30 years the leadership necessary to continue the implementation, revise the details as necessary, and maintain the fundamental educational objectives, has always been present. Finally, the leadership and administrative structure has a tradition of stability; the present president, provost, and ECE department heads have held their positions for 4, 152, and 553 years respectively.

Department Budget

Program Budget Process and Sources of Financial Support - Describe the process used to establish the program budget and provide evidence of continuity of institutional support for the program.

WPI was founded as an engineering college, and that tradition and sense of commitment to engineering is strong today as well, even though the institution has broadened itself considerably over the past 140 years. More details are provided below in specific categories. Appendix D provides a summary of the major categories of departmental expenditures over the past three years.

Sources of Financial Support - Describe the sources of financial support including both “hard” and “soft” monies.

Budget sheets will be available to the ABET visitors that list all resources available to the department. The two major sources that data will be provided for are the annual department budget and the department accounts. The former are on a year to year basis while the latter are “roll-over” accounts and represents donated money, special funds for department programs, overhead return accounts and so forth.

Adequacy of Budget - Describe the adequacy of the budget.

While more resources are always desirable, adequate finances are available in all major areas (faculty and non-faculty personnel, space, facilities, and equipment). Indeed, the DH works closely with his faculty and staff to insure that all reasonable needs for support and program are met in a timely manner. Further, the WPI Provost encourages Department Heads to speak with him about special needs and has often been able to support unusual or otherwise meritorious requests that fall outside the ability of a department to cover the costs for.

Faculty

Support of Faculty [and] Professional Development - Describe the adequacy of support for faculty professional development, how such activities are planned, and how they are supported.

Resources to enable the faculty (and students) to do its work (in both teaching and scholarship) are almost as necessary as the faculty themselves. Specifically, these take the form of funds for equipment (for teaching and research), supplies (components, copying, telephone, etc.), support services (secretarial, technician), and travel. All of these are adequate. For example, sufficient funds have always been available to support faculty and student travel to conferences where a paper was to be presented, or for other specific purposes. Sufficient funds are available to provide secretarial support, copying, telephone

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52 removed.

53 removed
usage, etc., for faculty without the necessity of an accounting and charging bureaucracy. Funds have also been provided to undergraduate students to attend conferences, particularly IEEE student development meetings.

With respect to attracting new faculty, our compensation, as demonstrated by external surveys, is competitive. We provide start-up funding for laboratory equipment, travel, and summer support. A review of the resumes of our faculty will demonstrate that they are quite well-qualified. It also demonstrates substantial stability of the faculty, as well as a healthy range of years of experience and time at WPI.

**Facilities and Support**

**Support of Facilities and Equipment** - Describe the sufficiency of resources to acquire, maintain, and operate facilities and equipment appropriate for the program.

**Adequacy of Support Personnel and Institutional Services** - Describe the adequacy of support personnel and institutional services necessary to meet program needs.

WPI maintains a program of continuous upgrading of laboratories and classrooms through its capital budget. Equipment budgets (both capital and expensed) are maintained by departments and the Provost. Faculty are also quite successful in achieving donation and grant funding for laboratories and equipment. A description of campus-wide resources and computing equipment is supplied in **Appendix D - INSTITUTIONAL PROFILE**.

The department employs 7 full-time support personnel: 3 secretaries, 2 senior engineers (one supervising the electronics shop and one supervising the computer operations), one junior engineer, and 1 technician. In addition, approximately 2 FTE in part-time employees (primarily UG hourly students) are utilized. These persons support all of our activities: undergraduate, graduate, and research. The undergraduate program is our largest activity, and is adequately supported by this team. However, they are busy to say the least!

Major institutional services include: Computational facilities, Library resources, Registrar, Instructional Media Center, and Physical Plant Services. All of these are described in **Appendix D** and all are of vital importance to the ECE department.

With regard to computation, the ECE department provides most of the student computational needs. These are supplemented with PCs and UNIX workstation in the campus computer center (CCC). The most vital aspect of the computer center’s services are the network infrastructure (both hardware and software) and the internet access which the CCC provides. The infrastructure is constantly upgraded to meet growing network traffic, and to replace obsolete equipment. WPI is connected to both the commodity Internet and to Internet2.

Library services are very good, both with respect to undergraduate needs, and those of the faculty and graduate students. The book collection is up-to-date, and the journal collection is quite substantial for an institution of our size. Also, the library has been quite pro-active in making available (at low or no cost) electronic searching and full-text retrieval.

The Registrar (technically the department of Projects and Enrollment Services) has a formidable job, with five terms per year (four during the academic year, one in the summer), a major off-campus program, and many individualized projects. Student transcripts at WPI carry rather detailed descriptions of student projects, since they represent such a substantial component of each student’s education. These services are carried out quite well.

The division of Plant Services is responsible for cleaning, maintenance, and renovations to all WPI buildings and buildings. All of these functions are extremely important to maintain an efficient and productive educational environment, and they are carried out quite well.

Clearly, there are numerous other services and support structures in place in support of the university and individual department missions. There are none that are lacking from the viewpoint of the ECE department.
CRITERION 9. PROGRAM CRITERIA

ABET Program Criteria
According to the ABET guidelines (excerpted and bold added):

<table>
<thead>
<tr>
<th>PROGRAM CRITERIA FOR ELECTRICAL, COMPUTER, AND SIMILARLY NAMED ENGINEERING PROGRAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>These program criteria apply to engineering programs that include electrical, electronic, computer, or similar modifiers in their titles.</td>
</tr>
<tr>
<td>The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program.</td>
</tr>
<tr>
<td>The program must demonstrate that graduates have: knowledge of probability and statistics, including applications appropriate to the program name and objectives; and knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.</td>
</tr>
<tr>
<td>Programs containing the modifier “electrical” in the title must also demonstrate that graduates have a knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.</td>
</tr>
<tr>
<td>Programs containing the modifier “computer” in the title must also demonstrate that graduates have a knowledge of discrete mathematics.</td>
</tr>
</tbody>
</table>

This section is organized to respond to each section of the Electrical and Computer Engineering Program Criteria.

ECE Program Requirements
The fundamental basis for meeting the ABET Program Requirements is that all students earning the WPI ECE BS degree must meet the ECE program distribution requirements. These requirements are shown below and are taken from the most recent WPI undergraduate catalog (2008-09). Key points to note in the listed program distribution requirements are as follows.

- Ten units of work are required to meet the ECE distribution requirements (30 courses).
- Mathematics and basic sciences represent 12 of the 30 required program courses.
  - Discrete math is required (a “computer” and “electrical” program modifier requirement).
  - Calculus, differential equations and probability and/or statistics are required of all ECE program students (an “electrical” program modifier for a typical program).
    - All graduates took one or the other. A few (=8) took both.
- Physics (2 courses) and chemistry or biology (1 course) are required of all ECE program students.
- ECE focus courses are required of all students (3 minimum from a specified list).
- ECE focus courses are required of all students (2 minimum from a specified list).
- A minimum of 1 CS course is required at the 2000 level or above\(^\text{54}\):  
  - 32% of the recent graduates took 2 or more CS courses at the 2000 level or higher. Also, 14 out of 87 graduates in the 2007-08 academic year - including both fall and spring graduates - minored in CS.
- All ECE program majors must take at least 1 engineering science course at the 2000 level or above.

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\(^{54}\) Distribution Requirement “E”, below.
Breadth and Depth

Given WPI’s policy of avoiding prescriptive curricula, this requirement cannot be satisfied by giving students a list of required courses. Rather, the number of electrical and computer engineering courses called for by the distribution requirements, the number (relatively small) of courses offered by the department, the topical organization and structure of the offerings, and the requirement for the culminating design experience of the MQP, assure that students will study at least one area of electrical and computer engineering at an advanced level, and gain exposure with less depth to several areas of electrical and computer engineering. A review of the ECE program course flow chart (Figure 5.3) will show that all paths end in courses that reflect a 4xxx standing for material offered.

The depth requirement is addressed and assessed specifically as Program Outcome 6. The section on Criterion 3 describes the assessment process and results. The breadth requirement is addressed by Program Outcomes 1, 2, 3, and 5, each addressing a different aspect of this important component of the students’ education. Outcome 1 addresses breadth in the context of professional practice, including aspects ranging from ethics to knowledge of modern engineering tools. Outcome 2 addresses the breadth necessary to understand and participate in the continuing technical change process that is implicit in electrical and computer engineering. Outcome 3 specifically addresses the necessary knowledge across the basic principles of electrical and computer engineering. Outcome 5 relates to the design process, in which a broad understanding of electrical and computer engineering is needed to produce a useful product.
The importance of mathematics to electrical and computer engineering is indicated by its status in the distribution requirements, where seven courses in mathematics are required. Some students take more than this minimum. Our requirements do explicitly state that students must complete courses in differential and integral calculus, differential equations and discrete math. Most students complete the requirement with four Calculus courses, one Differential Equations course, a probability/statistics course, and then a selection among courses in Linear Algebra, Vector Calculus, Complex Variables, and Numerical Analysis. Within these mathematics courses there is substantial emphasis on engineering applications; several of them also have a computer laboratory component, generally based on Maple.

Following is a summary of the specific application of mathematics topics (beyond differential and integral calculus) that are integral to electrical and computer engineering courses. Some examples of the specific applications are given:

- **ECE 2111** Differential Equations (circuit analysis with energy storage)
- **ECE 2112** Vector Calculus (electromagnetics)
- **ECE 2312** Discrete Math
- **ECE 2799** Statistics (system performance specifications)
- **ECE 3113** Complex Variables
- **ECE 3305** Probability and Statistics (error probability)
- **ECE 3803** Statistics (system performance over range of parameter variations)
- **ECE 4304** Probability (noise, probability of error)
- **ECE 4904** Probability and Statistics (quantum effects, energy level distribution, etc.)

MQPs: Specific projects include advanced math topics appropriate to the project. In addition to those topics listed above, data security MQPs include number theory and abstract algebra.

The mathematics component of the student project work is significant. The most common math component of the Interactive Qualifying Project is Statistics. For the MQP, each biennial review measures the amount and level of mathematics used in these projects. From the most recent MQP Review (2006) it was determined that most MQPs made reasonable use of advanced-level mathematics as indicated in the figure shown here from the final MQP review report (2006). As noted in the report; “the mathematics content of MQPs was estimated to be 2.1, the same as that observed during the previous review. [...] The view here is that the lack of mathematics [incorporated into the MQP] continues to be a result of incomplete discussions of the phenomenology associated with the project topic and to the incomplete documentation of the theoretical justification of the design solutions.”

A review of transcripts will verify that students complete the required mathematics courses. The ability to apply knowledge and techniques from these courses is verified but the ECE department will continue to work toward improving the application of the ABET required learned material to, in particular, our capstone project experience (the MQP).

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55 1=first year level, 4=fourth year level and so forth
Science

Most students complete three or four courses in Physics, and a growing number are including a course in Biology. Similarly, all students complete course work in the engineering sciences in three general areas: electrical and computer engineering, computer science, and one or more aspects of mechanical engineering. The design course, EE2799, and the senior project (MQP) provide substantial experience with design of complex systems. This is verified via the Course Based Assessment and the MQP reviews.

Design

Design is an important component of the ECE program. The biennial senior project ("MQP") reviews specifically address aspects of project magnitude and the technical content and level with respect to expectations for an entry-level engineer. Refer to the most recent MQP review in Appendix K.1.D. An appropriate level of both breadth across the design process and depth in accomplishing a given set of design objectives is assured via the combination of the design course (EE2799) and the team-based senior project.

Summary and Comments

- Our ECE program meets all of the General and Program Criteria.
- The ECE program is not the concatenation of an Electrical Engineering program with a Computer Engineering program. It is by its nature broader and less deep than either of these more narrowly-focused programs would be. We believe that for our students, the appropriate place for that specialization is an MS program.
- The ECE program contains sufficient breadth requirements to address two concerns: that students interested in Computer Engineering receive sufficient breadth across electrical engineering, and that students on the electrical engineering side receive sufficient exposure to computer engineering, which in our view is now essential to all those entering the profession.