Academic Year 2004-05
Undergraduate Assessment

Self Study Report

for

Electrical and Computer Engineering

prepared by

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1 Overview

This report summarizes the ECE department status with respect to all of the assessment activities which are relevant to the next ABET accreditation visit in the fall of 2008. The detailed assessment which is conducted in seven ECE courses forms one important component of the overall assessment plan. The other assessment tools are also critical to this plan. The report concludes with recommendations for several changes in our assessment activities.

2 Changes in ABET Criteria

The Engineering Criteria for visits in 2005-06 (and later) contain a number of significant changes in wording as well as a change in location of some of the wording.

2.1 Criterion 2, Objectives

The wording in Criterion 2 has been revised and clarified in several places. It is now clear that ABET does not expect proof that every graduate accomplishes every Educational Objective and it is emphasized that the Program Outcomes (Criterion 3) should prepare graduates to achieve the Educational Objectives. There is no change in the intent of Criterion 2, but the new wording makes the intent more evident.

2.2 Criterion 3, Outcomes

Regarding Criterion 3, you will find that much of the wording regarding the major design experience (previously in Criterion 4) has been moved to item (c) in Criterion 3, with some revisions. Note in particular that now the list of design constraints is preceded by the modifier “such as” rather than “most of” and that the design abilities demonstrated in Criterion 3 need not be in the context of a “major design experience.” It is now also made clear that if the program lists outcomes in addition to 3 a-k, the program must demonstrate that students achieve these additional outcomes.

2.3 Criterion 4, Professional Component

Criterion 4 continues to contain reference to the “major design experience,” with a simplified wording: “Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.”
3 Program Educational Objectives Assessment

Following is the statement of the Objectives of the WPI Electrical Engineering Program:

The electrical and computer engineering department 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 we provide an education which is strong both in the fundamentals and in state-of-the-art knowledge, appropriate for immediate professional practice as well as graduate study and lifelong learning. Such an education also prepares students broadly for their professional and personal lives, providing the basis for effective leadership and informed citizenship. The curriculum embraces WPI's philosophy of education, and takes advantage of key components such as the Interactive Qualifying Project to develop technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work.

From ABET’s point of view there are three distinct aspects with respect to establishment and evaluation of Objectives:

1. The constituents of the program must be involved in determining the Objectives
2. The program must evaluate the success of the graduates in meeting the Objectives.
3. The evaluation results must be used to improve the program

While items one and three are not strictly a part of assessment, it makes sense to include them here.

3.1 Constituent Involvement and Review of Objectives

The current Objectives were established with significant involvement of the ECE faculty and the Advisory Board. It would be desirable to increase student involvement in the next review.

A special meeting of a subset of the ECE External Advisory Board was held on July 13, 2005 specifically to discuss strategic directions of the department with primary focus on undergraduate ECE education. The complete report is available from Prof. Fred Looft. Following is a summary of only those aspects of the session which represent potential changes from our current educational approach and content:

- New characteristics needed in future engineers
  - An understanding of complex systems and an ability to design such systems
  - Cross-disciplinary skills
  - Language and international skills (these are seen as desirable but of lesser importance)

- Changes needed in engineering education
  - More emphasis on reading and writing skills
  - More emphasis on ethics and professional responsibilities, including those related to intellectual property

- Emerging technologies which new engineers must understand
  - Nanotechnology
Life sciences and the emerging role of engineering in all the biosciences

- How corporations can help
  - Corporate representatives indicated their interest in providing summer internships. While the ECE faculty agree that internships are quite valuable, the faculty believe that corporate-sponsored MQPs can be even more valuable in helping students achieve the program outcomes in an integrated educational program. While there are some salient examples of corporate support for MQP work, in general it has been difficult to obtain and sustain corporate-sponsored MQPs.
  - The long-standing disconnect between the broadly-stated desires of industry for “well rounded” engineers versus the strong expectations of hiring managers for highly specific technical skills continues to exist.

Again, the focus above is intended to be only on what is new. The long-standing (for WPI) attention to communications skills, breadth of education, teamwork skills, and independent learning skills, as well as high technical competence, are not repeated above.

It is recommended that the department conduct a review of the current Objectives within the next twelve months with substantial student, corporate, and alumni involvement, and bring forth any recommendations for changes. One specific suggestion is that the Objectives be reworded to make them descriptive of alumni capabilities and accomplishments, rather than of the educational program.

### 3.2 Evaluation of Achievement of Objectives

We evaluate the achievement of our Objectives in three fundamental ways:

- Indirectly via data from our Outcomes Assessment process since our Program Outcomes should prepare graduates to achieve Educational Objectives,
- Via the 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. Note that this aspect of Advisory Board input is distinct from their input in *establishing* Objectives.

A continuing two-phase effort is needed with the ECE Advisory Board: first, a gathering of information on the extent to which our current graduates are demonstrating accomplishment of the Objectives as employees; second, recommendations from the Board for changes to the Objectives as their corporations’ needs change. As stated above, this second aspect has recently been addressed.

The Alumni Survey forms the heart of the evaluation of Criterion 3. The Provost’s office does not plan to conduct an Alumni Survey until the Fall of 2006. The last such survey was conducted in 2001. It is recommended that the ECE department consider conducting alumni surveys on a more frequent basis than WPI’s schedule. With nearly 5000 living alumni the ECE department could profitably be surveying a subset of its alumni on an annual or semi-annual basis using an automated web-based instrument. To encourage participation it would be desirable to integrate this with other forms of ECE and WPI communication with our alumni.
3.3 Summary Regarding Program Objectives

No new data are available to enable any conclusions at this time with respect to accomplishment of the Program Objectives. The Advisory Board input regarding desirable characteristics of new engineers provides valuable input to a review of our Objectives, which is recommended.

4 Course Outcomes Assessment

Course-based assessment is targeted toward the evaluation of seven ECE courses (ECE2011, ECE 2022, ECE 2111, ECE2201, ECE 2311, ECE 2799, and ECE2801), four that compose the “core” of our program of study (2011, 2022, 2111, 2311) and three (2201, 2799, 2801) selected from among the five courses that compose the “advanced core”. These seven selected courses represent the heart of the ECE program for all students and hence are critical to both the students’ education and our program assessment. Assessment of these courses is undertaken for two distinct but related reasons: (1) to monitor student accomplishment of the specific Learning Outcomes in each course; and (2) to provide data for assessment of overall Program Outcomes. The latter goal could be achieved with a less intensive course based assessment program than is now conducted.

A summary of assessment results for each course is presented in the following sections. For each course two graphs are presented:

1. A bar chart showing the percentage of students who achieved the given outcome at a performance level of 3 (“Applies appropriate strategy or concepts without significant errors”) or 4. (“Demonstrates a complete and accurate understanding of the important concepts”). Only students who passed the course are included.

2. A chart showing the percentage of students (only students who passed the course) who achieved the indicated percentage of the outcomes at a performance level of 3 or 4. Ideally, we would like 100% of the students to achieve 100% of the outcomes at a level of 3 (no significant errors) or above. Realistically, this will not be the case and the shape of this distribution can be informative. For instance if only a few students are successfully achieving most of the outcomes, some serious problem is indicated. This problem could lie in several areas, such as: (1) Inappropriate choice of outcomes; (2) Excessively high performance standards for the outcomes; (3) Unprepared students; and/or (4) Problems with the course delivery. On the other hand if most of the students are achieving all but one or two of the outcomes, then a specific area for teacher attention is indicated.

It was originally planned to include a third bar chart showing the average level of achievement of each outcome (on a four point scale) by students who passed the course. These charts correlate closely with the first chart described above, so little new information appears to be represented, and they have been omitted for reasons of space. These charts may easily be generated for anyone who is interested.

It should be noted that all ECE courses now have learning outcomes which parallel those for the seven courses addressed here. These outcomes were presented in the 2003-04 Assessment Report. Some small modifications have been made in the original outcomes for these seven courses in the process of developing outcomes across the ECE curriculum.
4.1 ECE 2011

Learning Outcomes
Students who successfully complete this course should be able to:

1. Write and understand Kirchoff’s current and voltage laws,
2. Solve for voltage, current, and power in resistive dc circuits,
3. Find Thévenin’s and Norton’s equivalents,
4. Model dependent sources and operational amplifiers in DC circuits,
5. Manipulate complex numbers and phasors in the context of steady-state AC circuits,
6. Determine the impedance of resistor-capacitor-inductor circuits.

![Bar chart for ECE 2011 A04]

![Bar chart for ECE 2011 A04]
Learning Outcomes

Term B, 2004
For ECE 2022 in B term the newly approved course outcomes were assessed. Students who successfully complete this course should be able to:

1. Express numbers using different bases (binary, octal, hexadecimal),
2. Perform arithmetic operations using binary numbers,
3. Perform the basic operations of Boolean algebra,
4. Use combinatorial logic circuits to perform a given task or operation,
5. Demonstrate how a transistor is used for the implementation of Boolean algebra,
6. Manipulate and simplify logic equations (e.g., Karnaugh maps).

Term D 2005
An expanded set of course outcomes was used in D term of 2004-05.
At the completion of this course the students should achieve:
1. The ability to express numbers using different bases (binary, octal, and hexadecimal),
2. An understanding of how to perform arithmetic operations (addition, multiplication, subtraction) using binary numbers,
3. To perform basic operations of Boolean algebra,
4. An understanding of how to simplify logic expressions using Karnaugh maps,
5. The ability to design, build and test combinational logic circuits to perform a given task or operation,
6. To be able to consider the practical limitations of circuits (such as fan-out and propagation delay),
7. To understand the physical nature of logic design, specifically the interface between a logic circuit and other circuit elements,
8. To understand how a transistor is used for the implementation of Boolean algebra (inversion and the nand operation).
4.3 ECE 2111

Learning Outcomes
Students who successfully complete this course should be able to:
1. Solve for the frequency response of first-order circuits,
2. Solve for the frequency response of second-order circuits,
3. Explain the physics underlying the behavior of capacitors,
4. Explain the physics underlying the behavior of inductors,
5. Apply superposition to the solution of circuits,
6. Find the transient response of first-order circuits,
7. Identify resonant behavior,
8. Understand the basic principles of transmission lines,
9. Manipulate complex numbers and phasors in the context of steady-state AC circuits.
4.4 ECE 2201

Learning Outcomes
Students who successfully complete this course should be able to:

1. Demonstrate an understanding of the fundamental semiconductor physical concepts and the performance of the pn junction,
2. Understand diode operation and performance,
3. Analyze diode circuits and to design and implement diode applications,
4. Understand field-effect transistor operation and performance,
5. Analyze field-effect transistor circuits and to design and implement field-effect transistor applications,
6. Understand bipolar junction transistor operation and performance,
7. Analyze bipolar junction transistor circuits and to design and implement bipolar junction transistor applications.
4.5 ECE 2311

Learning Outcomes

Students who successfully complete this course should be able to:
1. Characterize and describe signals and systems using commonly accepted terminology,
2. Relate frequency-domain descriptions of signals and systems to their characteristic in the time domain and vice-versa,
3. Use frequency-domain techniques to solve input/output problems for linear, time-invariant systems,
4. Use computer software tools to model signals and systems and to solve problems.
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ECE2311 B04

Outcomes

ECE2311 B04

Percent of Outcomes Achieved

ECE 2311 D05

Outcome

Percent Achieving at 3 or 4

Percent of Class Achieving

Outcome

Percent Achieving at 3 or 4
4.6 ECE 2799

Learning Outcomes

Students who successfully complete this course should be able to:

1. Demonstrate knowledge of the steps involved with the system design process,
2. Demonstrate the ability to apply engineering design steps to the decomposition, solution, and implementation of an unbounded design problem,
3. Demonstrate an understanding of the organizational issues associated with engineering design,
4. Demonstrate an understanding of the relevance of ethics, reliability, safety, and regulatory issues in the design process,
5. Demonstrate a working knowledge of the financial, schedule, legal, and other administrative elements in the design process,
6. Demonstrate the ability to effectively use written communications to report project status and results,
7. Demonstrate the ability to use oral communications to report program status and results.
4.7 ECE 2801

Learning Outcomes

Students who successfully complete this course should be able to:

1. Demonstrate an understanding of digital number representations, fixed-point, and floating-point mathematics,
2. Ability to decompose a written problem statement into algorithms suitable for implementation in assembly language,
3. Demonstrate an understanding of assembly-language instruction sets and addressing modes,
4. Demonstrate an understanding of stack operations, procedure calls, and interrupt processing,
5. Demonstrate an understanding of operating-system operations and the use of operating-system services,
6. Demonstrate an understanding of variable scope and passing.
7. Demonstrate an ability to efficiently assemble, link, and debug a program.
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ECE 2801 A04

Percent Achieving at 3 or 4

ECE 2801 A04

Percent of Outcomes Achieved

ECE 2801 C05

Percent of Class Achieving 3 or 4
4.8 Observations Regarding Course Outcomes

4.8.1 Student Performance

No detailed analysis of the student performance data on course outcomes is undertaken here. Several observations may be made:

- Substantial variation in the average level of student performance is seen from course to course and from instructor to instructor in the same course. Several possible reasons for this variability exist, including:
  - Sampling error, in that a given criterion may only be evaluated by a single student response (such as an exam question),
  - Differing fundamental difficulty of the material,
  - Differing levels of performance expected by the instructor for a given score on the 4-point scale,
  - Differing student abilities,
  - Differing levels of teaching effectiveness.
- Given the above variability, in the absence of a significant norming project among courses and teachers, caution is urged in attempting to use the results to determine absolute student performance.
- Notwithstanding the above caution, an individual teacher should certainly be able to use the Outcome results to guide changes in successive course offerings.

4.8.2 Content of Course Outcomes

For some courses, there seems to be some level of disconnect between the catalog descriptions and Course Outcomes. For example, the ECE 2011 description is:

*The objective of this course is to expose new electrical engineering students (including first year students) to the broad field of electrical engineering, introducing basic concepts of circuits and systems and their applications. Experiments based on practical
devices are used to reinforce basic concepts and develop laboratory skills, as well as to provide system-level understanding. The use of circuit simulation tools for analysis and design is introduced.

None of this description appears to be reflected in the Course Outcomes. It should be noted that the Catalog description goes on to list topics:

Basic concepts of electrical circuits, linear circuit analysis, op-amp circuits, simple transients, phasor analysis, amplifiers, frequency response, filters.

This list is much closer to the Course Outcomes, but it still seems appropriate to inquire about the apparent disconnect between the course description and our desires for student learning as expressed in the Course Outcomes.

The relation of Course Outcomes to Program Outcomes is addressed in the next section. The Course Outcomes appear to address only a few of the eleven Program Outcomes. While the MQP and other aspects of the students’ education are quite significant, the apparent narrow focus of the ECE courses (which constitute the majority of the students’ ECE-specific education) seems somewhat surprising.

5 Program Outcomes Assessment

5.1 Assessment Tools

Following is a summary of the primary tools used for Outcomes Assessment together with their frequency of administration:

- Course Outcomes as described above (continuous),
- Biennial MQP reviews (summer of 2004, 2006, etc.),
- MQP completion surveys from faculty advisors (continuous),
- MQP oral presentation evaluations from faculty (annual),
- Student Course Evaluations,
- EBI Surveys (Spring, 2006, 2007),
- Other tools conducted on an irregular basis including: student surveys by Academic Advisors, IQP and Sufficiency Reviews, ad hoc studies by UPC or other faculty committees.

New data from the first four bullet items are available and are discussed in this report.

5.2 Relation between Course and Program Outcomes

The following table summarizes the relations among Course Outcomes and our ECE Program Outcomes for the courses assessed. “M” indicates a major relation between the two outcomes. “S” indicates some relation. It can be seen that almost all of the Course Outcomes relate to Program Outcome 3, “A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software,” with significant relation to another Program Outcome, “An understanding of appropriate mathematical concepts, and an ability to apply them to ECE.” It is not necessary to assess this many individual course outcomes to adequately demonstrate that students have achieved Program Outcome 3. The single exception is ECE 2799 which addresses different Program Outcomes.
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5.3 MQP Assessment Surveys

At the conclusion of each MQP the faculty advisor is asked to complete a brief and simple survey which asks for his/her evaluation of the achievement of the items in two categories:

- Program Outcomes, including:
  - Appropriate Use of Math/Science/Engineering Knowledge
  - Design of Experiments/ Data Analysis
  - Design to Specifications
  - Functioning Multidisciplinary Team
  - Identify/Formulate/Solve Engineering Problem
  - Ability to Communicate Effectively
  - Sensitivity to Global/Societal Context
  - Need for Life-time Learning
  - Sensitivity to Contemporary Issues
  - Use of Modern Engineering Tools and Techniques

- Engineering Design aspects, including:
  - Economic Considerations
  - Safety Considerations
  - Reliability Considerations
  - Aesthetic/Ethical/Social Impact (It is suggested that ethics be separated in the future.)
  - Analysis
  - Synthesis
  - Integration of Previous Course Work
  - Experimental Work

A simple binary decision on whether the given project demonstrates the indicated aspect or not is requested. This reflects the decision to keep the data collection process as simple and painless as possible for the faculty. Descriptions of each aspect are included so that all faculty have a consistent understanding of the criteria MQP Orals Assessment

Results of the surveys of Outcomes and Design aspects are presented below. The abbreviations for each item can be deciphered by reference to the lists above. It is important to note that the MQP is not expected to represent all of the Program Outcomes for every student, and also that not all design aspects are expected to be represented in each project.

The relatively low percentage of MQPs containing significant amounts of material addressing ethical, economic, safety, and reliability issues could perhaps be investigated.
5.4 MQP Oral Presentations

All MQPs receive an oral presentation. Some of these presentations occur off campus, but most happen on a single day in the Spring. At this event the faculty moderator at each presentation session is asked to complete an evaluation of the oral presentation skill of each student. Presentation Content, Organization, and Style are rated for each student on a five-point scale. Definitions of each aspect and the meaning each numerical grade are given to promote consistency of evaluation.

Following is the scoring key for the five-point scale:

- **1**: Seriously incomplete, serious errors (in content/organization/style).
- **2**: Somewhat incomplete, some errors (in content/organization/style).
- **3**: Generally complete and accurate, perhaps a few minor errors (in content/organization/style).
- **4**: Complete, accurate, meets all expectations (in content/organization/style).
- **5**: Excellent in all regards; exceeds expectations (in content/organization/style).

A score of 3 or higher is acceptable. From the charts it is seen that student performance is quite high, with fewer than 5 percent of the students scoring below a 3.

![MQP Presentations, 2005](image)

**MQP Presentations, 2005**

- **Content**: Average Score (4.2) ± Standard Deviation (0.5)
- **Organization**: Average Score (4.3) ± Standard Deviation (0.6)
- **Style**: Average Score (4.1) ± Standard Deviation (0.7)
5.5 Senior Survey

Seventy-two responses were received to the Senior Survey with a graduating class size of 126.

5.5.1 Student Assessment of their engineering education

The first section of the survey asked the students to the extent to which their WPI education helped them to gain the listed skills using a scale of: (1) not at all; (2) very little; (3) somewhat; (4) quite a bit; (5) extensively. The skills are:

1. Apply math or science knowledge to solve problems
2. Apply engineering knowledge to solve problems
3. Design and conduct experiments
4. Analyze and interpret data
5. Design something to meet desired goals or needs
6. Work in teams with people of different backgrounds
7. Identify, formulate, and solve engineering problems
8. Understand professional and ethical responsibility
9. Communicate effectively in written form
10. Communicate effectively in spoken form
11. Understand the impact of engineering in a global societal context
12. Use modern computer software applications
13. Write computer software

The lowest score received on any item (global/societal issues) was above 3.5 which indicates a reasonable level of confidence.
### Section I

#### 5.5.2 Student Assessment of their overall education

The second section asked to rate, in retrospect, the educational value of the listed topics using a scale of: (1) inadequate; (2) marginal; (3) adequate; (4) good; (5) excellent. The topics were:

1. the **content** (subject matter, techniques, specific skills) of my IQP
2. the **process** (problem solving, teamwork, communication, general experience) of my IQP
3. the **content** (subject matter, techniques, specific skills) of my MQP
4. the **process** (problem solving, teamwork, communication, general experience) of my MQP
5. my humanities courses and sufficiency
6. my mathematics courses
7. my physical science (Physics, Chemistry, Biology) courses
8. my social science courses
9. my CS courses
10. my ECE courses
11. my ECE laboratory experiences
12. my interactions with ECE faculty
13. my interactions with other WPI faculty
14. my overall **ECE** education
15. my overall **WPI** education
All of these responses are above the 3.0 (adequate) level. However, a rather broad range of student perception of the educational value of the various aspects of their education is shown, and it may prove worthwhile to investigate those responses which lie below the 3.5 level. We would like our graduates to be well-educated, to have confidence that they are well-educated, and to understand the value in all facets of their education.

The distribution of student responses to the questions regarding the educational value of their overall WPI education and their overall ECE education is shown below.

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**ECE Undergraduate Assessment Report, Academic Year 2004-05**

Section II

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The distribution of student responses to the questions regarding the educational value of their overall WPI education and their overall ECE education is shown below.
The good news is the high percentage who rated their ECE and WPI educations as excellent (56% and 36% respectively). It is perhaps understandable that students would be more enthusiastic regarding their major than their overall education. Still, it would seem desirable to pursue the reasons for the disaffection of the small percentage of students who were unhappy with their WPI education.

5.5.3 Student Assessment of Professional and Lifelong Learning Aspects
The final section of the survey addressed several specific areas. The questions and the mean response values are summarized below.

**Further Study in ECE**
“What is the likelihood that you will pursue an advanced degree in electrical and computer engineering (or a related field) some time in the future? 1- highly unlikely; 2- unlikely; 3- uncertain; 4- likely; 5- highly likely”
Mean response: 4.04

**Value of Graduate ECE Education**
“How beneficial to your career do you think an advanced degree in ECE or a related field would be? 1- not at all; 2- somewhat; 3- uncertain; 4- quite a bit; 5- extremely”
Mean response: 3.95

**Further Study outside ECE**
“What is the likelihood that you will pursue an advanced degree in a field unrelated to ECE (e.g., business, law, medicine) some time in the future? 1- highly unlikely; 2- unlikely; 3- uncertain; 4- likely; 5- highly likely”
Mean response: 3.14

**Value of Graduate non-ECE Education**
“How beneficial to your career do you think an advanced degree in a field unrelated to ECE would be? 1- not at all; 2- somewhat; 3- uncertain; 4- quite a bit; 5- extremely”
Mean response: 3.44

**Level of Knowledge Regarding Graduate School**
“How informed do you feel about the programs, choices, and opportunities available to you in graduate school? 1- not at all; 2- a little; 3- quite a bit; 4- extremely”
Mean response: 2.49 (on a 4-point scale)

Overall the level of interest in further study, inside or outside ECE is reasonably high which is gratifying since this is in line with our Objectives. However, the level of student knowledge regarding graduate study is reported as low, which definitely indicates the need for attention to this area.

5.6 Discrete Mathematics
In the major of Electrical and Computer Engineering it is required that students achieve an understanding of the principles and application of discrete mathematics. This can occur to some extent in the computer-related ECE and CS courses which our students take, but we instituted a requirement that students also complete a course in discrete mathematics. When this
requirement was added we agreed to monitor this approach to determine whether the required course approach was achieving its goals. The following table shows the results for ECE and CS students who took the Discrete Math course under either the Math2201 or CS2022 designation in the Fall of 2003 through the Spring of 2005. This course is dual-listed under the Math and CS numbers with no difference in the course content. Student may register for any offering under either number. Hence the registration designation (Math or CS) has no significance to this review.

<table>
<thead>
<tr>
<th>Student Major</th>
<th># students</th>
<th># NR’s</th>
<th>Average grade (NR=0, C=2, B=3, A=4)</th>
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<td>CS</td>
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The conclusion is that ECE students are doing well in the Discrete Math course, both with respect to the NR rate and grade distribution. Further study will be needed to determine how well this course is meeting student and curricular needs.

5.7 Summary with respect to Program Outcomes

Following is a brief summary of status with respect to each of the ECE Program Outcomes, referring to the data presented above as well as to other studies. In some cases the results are framed as an expectation, pending completion of the relevant study.

5.7.1 Preparation for engineering practice, including the technical, professional, and ethical components

Data from course assessment, validated by the MQP Advisor Survey, and expected to be supported by the 2004 MQP Review demonstrates achievement of the “technical” aspect of this Outcome. The “professional” component is validated by the high level of student performance on large projects, particularly the MQP and performance in ECE 2799 as well as student self-reporting of a moderately high level of confidence in this area. The ethical aspect is directly addressed only in ECE 2799, and via self-report in the Senior Survey. This area merits consideration for strengthening.

5.7.2 Preparation for the future changes in electrical and computer engineering

The achievement of this outcome is validated by:

- The strength of the ECE education in both breadth and depth
- High level of planning by seniors to continue their education
- Ability to learn on their own as demonstrated in the MQP surveys and review.

5.7.3 A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software.

The achievement of this outcome is validated by:

- For the basic principles of electrical and computer engineering overall, the course outcomes in all of the courses assessed
• For hardware/software relationships in particular, the course outcomes in ECE 2801, Foundations of Embedded Computer Systems;
• Responses by Seniors to questions 12 and 13 in Section I of the Senior Survey (although the response is somewhat lower than desired to the question regarding their confidence in their ability to write (rather than to use) computer software).

5.7.4 An understanding of appropriate mathematical concepts, and an ability to apply them to ECE

The achievement of this outcome is validated by:

• Level of mathematics expected to be found in the MQP Review.
• Senior Survey response regarding student confidence in their ability to apply mathematics and science to engineering problems.
• Student performance in the many mathematics-related course outcome aspects.

5.7.5 An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.

The achievement of this outcome is validated by:

• MQP Review
• High value of the response to the “Design to specifications” question on the MQP Advisor survey
• High level of confidence in their ability to do design as reported in Question 5 of Section I of the Senior Survey.

5.7.6 Demonstration of in-depth understanding of at least one specialty within ECE

The achievement of this outcome is validated by:

• A transcript review demonstrating that students complete advanced ECE courses
• The MQP Review

5.7.7 Demonstration of oral and written communications skills

The achievement of this outcome is validated by:

• For written skill, the MQP Review
• For oral skills, the MQP presentation survey results
• Questions 9 and 10 of Section I of the Senior Survey

5.7.8 Understanding of options for careers and further education, and the necessary educational preparation to pursue those options

This outcome is achieved at a basic level as demonstrated by:

• The high number of seniors who plan to pursue further education
• The achievement of the solid BS-level education as demonstrated via accomplishment of the other outcomes

However, there is a need for improvement as demonstrated by the relatively low (2.5/4, which lies between “a little” and “quite a bit”) response to the Senior Survey question, “How informed do you feel about the programs, choices, and opportunities available to you in graduate school?”
5.7.9 An ability to learn independently
The achievement of this outcome is validated by:
- Demonstrated performance on degree requirements, including the Interactive and Major Qualifying projects, which require independent learning for success

5.7.10 The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI
No single measurable can address this broad Outcome. Rather, the curriculum and degree requirements of the WPI approach to education require breadth (as demonstrated by requirements such as the Humanities Sufficiency, substantial coursework in both the humanities and social sciences, and the breadth of the ECE portion of the curriculum) and the Senior Survey indicates that students are quite satisfied with both their ECE and their overall WPI education.

5.7.11 An understanding of engineering and technology in a societal and global context
The achievement of this outcome is validated by:
- The response of Seniors to Question 11 of Section 1 of the Senior Survey.
However the response is not as strong (3.6/5) as we would like. Many students, though not all, pursue this aspect via personal experience at our off-campus project centers. We are working to assure that those students who do not go off-campus also receive a strong understanding of the societal and global context in which they will practice their profession.

5.7.12 ECE Outcomes vs ABET Outcomes
The Outcomes presented above are those adopted for the WPI ECE program. Their organization and wording is slightly different from the ABET Outcomes which we must demonstrate that our students meet. The significant differences are:
- Multidisciplinary teams: The WPI Outcomes do not explicitly mention “multidisciplinary.” With our students’ experiences with IQPs as well as MQPs, and broad education, it is possible to demonstrate achievement of this aspect.
- The placement of the “professional and ethical responsibility” aspect is not as prominent in the ECE Outcomes as in the ABET list.
- The “contemporary issues” aspect of the ABET list is absent in an explicit form. However, our references to “preparation for future changes in the profession,” “broad education,” and “understanding of engineering and technology in a societal and global context” provide opportunities for our students to learn and demonstrate this aspect.

6 Recommendations
Overall the ECE program is in performing well and is in good condition for the next ABET visit. Several recommendations are made to increase efficiency as well as to improve the overall assessment process:
1. For the purpose of verification of program Outcomes, the amount of course-based assessment may be reduced. In particular, assessment of the courses ECE 2011, 2022, 2111, 2201, and 2311 could be eliminated since the Outcomes measured for these courses
may be adequately verified by other means. However, it must be noted that Program Outcomes assessment is not the only reason for conducting assessment in an individual course. Assessment is valuable in the course itself, to guide change and improvement. Assessment of ECE 2799 should continue since this course holds a key position with respect to Program Outcomes. Also, since computer engineering aspects are less comprehensively addressed compared to electrical engineering aspects, it may be appropriate to continue assessing ECE 2801.

2. Some minor changes should be made to the Senior Survey, particularly the addition of questions related to plans immediately after graduation. Also, separation of the important question regarding Ethics from the aesthetic and social aspects seems appropriate.

3. It is time for a review of Educational Objectives, taking constituent input into account. It is recommended that the department conduct a review of the current Objectives within the next twelve months and bring forth any recommendations for changes. One specific suggestion is that the Objectives be reworded to make them descriptive of alumni capabilities and accomplishments, rather than of the educational program.

4. The following Outcomes are achieved to a relatively low level and the educational activities which are intended to lead to these outcomes should be reviewed for possible strengthening:
   a. Ethics and professional responsibility occupy a relatively small place in the program. A review is recommended, both with regard to educational content and assessment aspects.
   b. Students self-report a relatively low level of confidence in the following aspects:
      • Understand professional and ethical responsibility
      • Communicate effectively in written form
      • Communicate effectively in spoken form
      • Understand the impact of engineering in a global societal context
   This relates to item (a) and merits investigation.