

Self-Study of Graduate Programs
Electrical and Computer Engineering Department

This self-study is based on instructions from Vice Provost Jocelyn Milner to Dean Laura Albert and focuses on recent changes to the program, the student experience, and near future plans. It does not reproduce data from campus.

A. Introduction

The Electrical and Computer Engineering Department (ECE) has a long and distinguished history of graduate education. Master of Science and Doctor of Philosophy degrees have been awarded for the majority of the department's 127-year history. There have been significant changes to the M.S. programs in the department in the past few years to increase opportunities for students seeking accelerated options for professional preparation.

Effective Fall 2019 ECE will offer four named option M.S. programs:

1. Signal Processing and Machine Learning (SPML), a 12 to 16 month course-only program designed to prepare students for rapid entry into advanced careers in industry. The first cohort of students entered the SPML program in Fall of 2017.
2. Professional, a 16-month course-only program designed for students that seek advanced training in any area of electrical and computer engineering. The Professional program was recently approved and will be available to new students Fall of 2019.
3. Power Engineering Online, a course-only program for working professionals seeking advanced degrees in power engineering. This program began in the early 1980s. Its success is driven by the reputation and deep industry connections of ECE in this area.
4. Research, the traditional research-based M.S. program for students interested in a research career.

The course-only M.S. program is being phased out and will not accept new students beginning in Fall 2019.

ECE has a robust Ph.D. program and also offers a doctoral minor.

The M.S. degree learning outcomes are:

1. Demonstrate a strong understanding of mathematical, scientific, and engineering principles in the field
2. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
3. Apply the relevant scientific and technological advancements, techniques, and engineering tools to address these problems
4. Recognize and apply principles of ethical and professional conduct

The Ph.D. degree learning outcomes are:

1. Demonstrate an extraordinary, deep understanding of mathematical, scientific, and engineering principles in the field
2. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
3. Apply the relevant scientific and technological advancements, techniques, and engineering tools to address these problems

4. Recognize and apply principles of ethical and professional conduct
5. Demonstrate an ability to synthesize knowledge from a subset of the biological, physical, and/or social sciences to help frame problems critical to the future of their discipline
6. Demonstrate an ability to conduct original research and communicate it to their peers

B. Administrative Structure

The relatively large size of the program (typically 300-400 students) results in a significant administrative burden. Historically the program was led by multiple faculty committees with staff support. However, this model was found less than optimal due to the increasing complexity of the program and graduate education in general. Also, growing complexity in the department chair's role, increasing fund-raising/alumni relations, limits their time for day-to-day involvement in the graduate program. The department addressed these challenges in August of 2018 by creating an associate chair position to provide unified, department-chair level leadership and oversight of the ECE graduate program.

The Associate Chair for Graduate and Online Studies either chairs or works directly with the chairs of faculty committees relating to ECE graduate programs. The Graduate Recruiting, Admissions, and Fellowship Committee focusses on recruiting and admission of prospective students and stewards fellowship resources. The Graduate Curriculum Committee oversees all curriculum matters, including creation of named options and approval of course proposals. The Graduate Committee evaluates student petitions, organizes the Ph.D. qualifying exam and assesses Ph.D. student progress toward the degree.

The Associate Chair for Graduate and Online Studies also serves as the primary point of contact for student problem solving and advocacy.

A full-time Graduate Student Services Coordinator serves both prospective and current graduate students navigate the process of being admitted and ultimately satisfying graduation requirements. The ECE Payroll and Benefits Coordinator manages student appointments and assists graduate students manage their benefits. The ECE Communications Specialist helps with outward-facing content representing the program. The Department Administrator and Assistant Department Administrator support fiscal and other varied aspects of the graduate program.

C. Admissions

The ECE graduate student services coordinator is the first point of staff contact for prospective students. The Graduate Recruiting, Admissions, and Fellowship (GRAF) Committee makes admissions decisions for all M.S. programs. ECE is seeking to grow the new SPML and Professional named option M.S. degree programs to as many as 100 students total. These programs were actively marketed to ECE undergraduates during Fall 2018 as a realistic, one-year M.S. degree option, due to the ability to apply up to seven undergraduate credits to the 30 credits required. The Division of Continuing Studies is marketing these programs to external audiences. The Professional application did not go live until December 1, 2018 due to only receiving final approval in October, so growth in this program is likely to occur in future years. However, applications to SPML have been very robust. Our projection as of December 2018 is that we will admit 100 students for Fall 2019 with the expectation that about a third of admitted students will enroll.

We anticipate students that historically chose the discontinued course-only M.S. program will make up some of the desired growth in the SPML and Professional named options. However, a very significant portion of the desired growth is expected from new student populations. Hence our net graduate student population should increase. Program revenue will be used to support additional sections of classes and administrative services to ensure this population of students is successful.

The Power Engineering Online program has had relatively stable enrollment in the 25-30 student range. No significant changes are planned while the SPML and Professional programs are being launched and grown.

We have made significant changes to the Ph.D. admissions process Spring 2019. Ph.D. students will not be admitted without a financial support commitment from a research advisor. Coupling of admissions and financial support was implemented to improve our recruiting competitiveness, facilitate long-term funding guarantees for all Ph.D. students (see *G. Funding*), and ensure every incoming student has a clear advocate/advisor from their first day on campus. Qualified Ph.D. applicants that do not have a long-term funding guarantee from a faculty member will be admitted to the M.S. research program and waitlisted for the Ph.D. program. Some of these may choose to enter the M.S. research program in hopes of securing long-term funding for the Ph.D. before completing the M.S.

ECE hosts an open house each March for recruiting purposes. Historically this event has served to facilitate match making between students and faculty. The relatively late timing of this match-making event resulted in our financial offers to prospective students being later than those of our peers and put us at a competitive disadvantage recruiting the best students. Now that we have changed to coupling admissions and financial support decisions, the open house is designed to convince students that ECE is the right place for their graduate studies. We expect this change to both improve our recruiting success and student success in the Ph.D. program.

Data from the US News and World Report rankings of colleges of engineering indicate that our peer (top 20 colleges of engineering) institutions have 4-5 Ph.D. students per faculty member. This is consistent with current enrollment in ECE (~44 faculty, ~220 Ph.D. students), so we are seeking to maintain a stable level of Ph.D. students.

D. Program Information

The ECE Graduate Student Handbook is the definitive source for program requirements, processes, and information to help graduate student succeed. (A substantial portion of program information is also available in Guide (guide.wisc.edu.) Current and recent past handbooks are available on a web site in pdf format for students, faculty, and staff. The handbook underwent a major revision during Fall of 2018 to reflect the changing structure of the M.S. programs and to expand the types of information provided to students. For example, the newest version (published in January 2019) has added sections on professional development and health/wellness. The handbook is updated approximately annually to reflect changes in requirements and procedures.

E. Assessment

Multiple methods are employed to assess the ECE graduate program and improve student experience.

Every graduate student is assessed on the program learning outcomes prior to graduation. Ph.D. students are assessed on each learning outcome by their committee immediately following their final defense. M.S. research students are assessed by their research advisor in their last semester. Students in course-only M.S. degree programs (SPML, Professional, and course-only Power Engineering) choose a 700- or higher level ECE course with their advisor and the advisor insures that the instructor of the course fills out the assessment form. The assessment data are reviewed and discussed annually in a faculty meeting. Compliance with completing the assessment form was irregular in the past. However, after a concentrated effort to increase awareness of the importance of this process, every graduating student has been assessed in the most recent reporting period.

The department's external advisory board has 20-30 members, typically from industry, and holds an annual three-day meeting in Madison to evaluate and advise the department. They are provided information about the state and direction of the department, meet with faculty and hold confidential discussion sessions with graduate students. One outcome of the visit is a series of recommendations. These are initially presented to the department's leadership team orally and later in writing to the department and the dean. Their feedback has been very helpful in identifying issues with and strategic direction for the graduate program.

In Spring of 2019 the College of Engineering is rolling out an online tool for annual academic progress assessment of all degree seeking Ph.D. students. The academic progress assessment follows this process:

1. A student self-report and assessment of academic progress.
2. A review prepared by the faculty advisor to focus on an assessment of degree progress and student strengths and areas of growth. A copy of this review will be given to the student.
3. The student will have the opportunity to discuss this review in person with their faculty advisor.

The ECE Department wholeheartedly endorses this initiative and expects that a required annual progress assessment will be of great value to our Ph.D. students.

F. Diversity and Climate

The ECE Department has pursued multiple initiatives to foster an inclusive climate and community for all students. Each fall we hold a welcome and orientation event for all new students to introduce them to key faculty and staff and ease the transition to graduate school at UW-Madison. Several years ago, ECE created a new one-credit course (ECE610) that all graduate students are required to take in their first semester. They are introduced to faculty research areas, learn skills that will foster success in graduate school, and begin to form community through shared experience. A subsequent two-credit course (ECE611) is required for all Ph.D. students in their first spring semester. In ECE611 they continue to form community while learning key research and communication skills required to succeed as a Ph.D. student.

A student-led graduate student association (GSA) was formed about five years ago. The GSA initiates social activities and assists with various department events. For example, the GSA assisted with our fall new student welcome and recruiting events.

ECE adopted a parental leave policy to reduce academic and financial hardships for female graduate students during pregnancy, childbirth, and postpartum periods, and for any graduate student who is a new parent providing care for an infant.

ECE has actively sought out faculty role models for underrepresented groups in engineering. We have been very successful hiring female faculty, and as of Fall 2018 had one of the highest percentages of women faculty of any ECE department in the country. We are hopeful that our success recruiting women faculty will lead to a significant increase in women graduate students. We are also actively working on our outward facing messaging to create the impression of a welcoming climate for all underrepresented student groups.

The Department recently held a distinguished seminar series to celebrate its 125th anniversary. The series featured several prominent female and minority alumni as role models for current students.

The department hosted the WISELI workshop “Breaking the Bias Habit” on May 9, 2017 for faculty and staff. Approximately 75% of faculty and staff participated and learned how unconscious biases can create problematic climate. All faculty on search committees (we are currently leading or participating in six searches) are expected to participate in the WISELI “Searching for Excellence and Diversity” training.

The department is an active participant in College of Engineering supported programs designed to recruit and support targeted minority students. One program is the OPPS Conference held every November. College staff work with selected schools to identify students, match those students with the appropriate department, and then organize the two-day event. We are also active participants in the College of Engineering’s Graduate Engineering Research Scholars (GERS) program. GERS provides partial fellowship support for minority students. More importantly, GERS provides the supportive community that has been proven to help underrepresented students persist to graduation. Participation in minority recruiting and advising is widespread throughout the department – more than one third of our current faculty have made tangible contributions to advising or recruiting minority students.

The department’s priority is successful graduation of all students. Hence, we focus support systems that promote student success and on recruiting students that have the academic preparation for a rigorous graduate program. Our approach produces alumni that become leaders, role models, and that partner with us to identify/recruit new students. For example, Shakti Davis earned her ECE Ph.D. in 2006 as a GERS participant and was named “Most Promising Engineer or Scientist for 2010” at the U.S. Black Engineer of the Year Awards. Shakti regularly assists with our recruiting. She has been a keynote speaker at the OPPS Conference and during the Fall 2018 OPPS Conference spent an hour talking (via teleconference) with seven minority undergraduate students considering graduate studies in ECE. Juan Fernando Castillo is a current ECE Ph.D. student that travels each fall to the University of Texas El Paso (UTEP – a minority serving institution) to present the GERS program and ECE research to undergraduate students. As part of this initiative with UTEP, ECE invited and hosted

Professor Raymond Rumpf of UTEP in Madison to meet with our faculty to explore research and education collaborations. We are expecting to create an exchange where some of our undergraduates go to UTEP and UTEP undergraduates come to UW through the OPPS Conference and SURE program, and ultimately enroll in graduate studies. Daniel Cheverez is another former GERS program ECE Ph.D. that has sent his students (University of Puerto Rico) to UW.

Our approach of building reputation and strategic relationships requires substantial effort. Recruiting underrepresented students is a significant challenge due to many factors, including regional demographics and the relatively small number of minority undergraduates pursuing electrical engineering. However, the department is not content with the status quo and is committed to ongoing focus on recruiting and mentoring underrepresented graduate students. Some of our faculty are also working on increasing the pipeline of available students with outreach to elementary, middle, and high school students. Such efforts are critical even though they take a long time to make a difference at the graduate level.

G. Funding

ECE Department funding for graduate students is primarily based on a combination of teaching assistantships, research assistantships, and fellowships. With relatively few exceptions Ph.D. students are funded for the duration of their degrees. Many M.S. students are also funded. Historically some students had funding promised during the recruiting phase, while others chose to attend without up-front funding and attempted to secure funding once they arrived on campus. Ph.D. students arriving on campus without a research advising/funding commitment have sometimes experienced slow initial progress toward degree goals.

We instituted a major change to our funding policy for Ph.D. students in fall of 2018 to improve our recruiting competitiveness and ensure funding/advising uncertainty does not hinder student progress to degree. Beginning with the current recruiting cycle (Spring 2019) Ph.D. students will not be admitted to the program without a faculty commitment to provide long-term funding and advise the student. Hence all Ph.D. students matriculating in Fall 2019 will have both a long-term funding guarantee and an advisor committed to their success from the day they arrive on campus. Ph.D. students arriving with a B.S. degree receive a five-year funding guarantee, while those arriving with a M.S. degree receive a three-year guarantee. The support guarantee is at the 50% level and may consist of a combination of fellowship, research assistantship, teaching assistantship, and/or external funds such as NSF Fellowships. A significant fraction of our students are/will be supported through research assistantships associated with external grants secured by the advisor. If premature termination or nonrenewal of a grant causes loss of funds for a research assistant, the Ph.D. student will be shifted to a teaching assistant appointment until the advisor has secured funding for the student. If timing is such that a teaching assistantship is not possible, e.g., a mid-semester loss of funding, the student will be supported initially as a research assistant using departmental discretionary funding until it is practical to appoint them as a teaching assistant.

Income from our non-pooled tuition accelerated M.S. programs is being set aside to help support students that encounter unexpected loss of funding.

We are explaining the funding guarantee as part of our financial offer to admitted Ph.D. students as a reason why they should choose Wisconsin. Most of our peers do not have explicit funding guarantees and we believe our guarantee will be a recruiting advantage.

Students in the online M.S. Power Engineering program, and the accelerated M.S. SPML and Professional programs are not eligible for ECE Department financial support of any form. The students in the online program are not local and are typically employed in an industry position. Financial support for students in the SPML and Professional programs is inconsistent with the accelerated and terminal nature of these programs. Such students need to focus full time on their studies and not be distracted with teaching or research duties in order to finish in a 12- to 16-month time frame.

Students in the Research M.S. program are eligible for departmental financial support. This group has lower priority than Ph.D. students for fellowship and teaching assistantship funds. Teaching assistantships and research assistantships are awarded when there is a match between student expertise and departmental needs in teaching or faculty needs in research.

Grader positions are also available for graduate students and typically used by students that have not secured other departmental support. Project assistantships are also available on occasion, but do not constitute a significant source funding.

H. Retention and Time to Degree

The ECE Department has implemented multiple initiatives in the past few years to improve retention and reduce time to degree:

1. We have initiated a comprehensive orientation program. It begins with an orientation event at the start of each fall semester. Then all incoming students are required to take ECE610 (1 credit) in their first semester. ECE610 introduces students to faculty and other departmental resources and teaches skills they will need to be successful in graduate school. All Ph.D. students are required to take the follow up course, ECE611 (2 credits) in their second semester. ECE611 teaches students research skills, such as reading papers and writing proposals. We fully expect that this systematic on-boarding process will improve student success as the initial cohorts continue to progress through our program.
2. Expected timelines for Ph.D. program milestones (coursework, qualifying and preliminary examinations) are explicitly articulated in the Graduate Student Handbook. In spring 2018 the department added a requirement that the preliminary exam be completed within three semesters of achieving advanced graduate standing, i.e., passing the qualifying exam. This change was motivated by the observation that some students were delaying their preliminary exam until the majority of their research was complete, and then scheduling their final defense within several months of the preliminary exam.
3. All assistant professors are now encouraged in mentor meetings and written annual feedback to schedule their student's preliminary examinations as soon as possible. This advice serves the dual purpose of helping their record for tenure and shifting the department culture in a way that reduces time to degree.
4. Long times to degree for Ph.D. students often correlate with difficulty finding a research advisor once students arrive on campus. Our new policy of requiring a funded advising

commitment prior to admission should improve retention and eliminate delays in time to degree due to student difficulty finding a research advisor.

5. A parental leave policy was recently adopted by the department to reduce academic and financial hardships for women and their partners who choose to have children during their graduate studies.
6. We have been actively monitoring and adapting our accelerated M.S. programs to ensure students complete the programs in an appropriate time frame. For example, SPML was initially set up to require completion within twelve months. However, experience with the first two cohorts of students showed that completing 30 graduate credits in twelve months is unrealistic for the professionally oriented, terminal M.S. students the program attracts, especially foreign students with additional ESL requirements. We modified the program requirements to reduce the number of credits required per semester consistent with a 16-month completion time frame (three semesters plus summer) and now advertise the program as a 12- to 16-month degree. UW-Madison undergrads that transfer six credits into the program can realistically complete the program in 12 months. We also requested and received approval from the Graduate School to count up to seven credits of undergraduate work completed at ABET-accredited undergraduate institutions in order to expand the set of students that can realistically complete all degree requirements in 12 months. Finally, we are in process of setting up an advising system that will efficiently serve the expected growing enrollment in the SPML program. This will involve a combination of written materials, mandatory group advising sessions, and individual consultations as needed.
7. We expect the annual assessment process being rolled out by the College of Engineering in Spring 2019 (see *E. Assessment*) will improve retention and reduce time to degree and are enthusiastically participating in this new program.
8. Finally, restructuring of the program leadership model – establishing the Associate Chair for Graduate and Online Studies – was also motivated by desires to improve retention and reduce time to degree. The Associate Chair is responsible for strategic analysis of the graduate program with the goal of improving student outcomes. Many examples of program changes are described elsewhere in this self-study. Another example of the Associate Chair's proactive activity is promoting awareness of mental health issues and resources. The Associate Chair periodically emails faculty and students concerning mental health issues, and has arranged for UHS counselors to lead a discussion at the February 2019 faculty meeting to raise awareness of the prevalence of mental health issues amongst the graduate student population and inform faculty how to better support mental health in our students. The Associate Chair is also the dedicated point of contact for advocacy and problem solving to help students with challenges that arise during their studies, including health related issues, or problems with faculty. Improved student support and timely resolution of problems is expected to improve retention and reduce time to degree.

I. Professional Development

The department's graduate program supports professional development of ECE graduate students via a diverse range of mechanisms. Professional development beyond that provided by advisor mentoring has received increasing emphasis in the past several years. The Associate Chair now periodically emails all students to make them aware of the wide variety of campus resources that are available to them and encourages their use. The Associate Chair also communicates with

faculty periodically in both meetings and via email to remind them to encourage their students to undertake professional development activities. The latest version of the Graduate Student Handbook has a section devoted to professional development. The ECE610 and 611 courses required for all M.S. (610) and Ph.D. (610 and 611) students develop skills that not only help them succeed in their graduate careers, but also as professionals, such as engineering/technical communications, writing, ethics, and project management.

Recently we made a decision to provide teaching assistantship support of at least two semesters for any Ph.D. student that desires to obtain teaching experience. ECE offers the majority of its required undergraduate classes in active learning formats, many in WisCEL, so teaching assistants have the opportunity to apply research-proven best practices and obtain experience that prepares them to be innovative educators in their careers. We are currently investigating the possibility of requiring some sort of teaching experience of all Ph.D. students.

Most Ph.D. students are supported by their advisors to present their research at conferences and network with their external professional community. All dissertators are also eligible for department-administered travel funds to support conference travel.

A wide range of career outcomes are supported by the ECE graduate program. Ph.D. graduates typically establish careers in academia, private industry, or government laboratories. Our M.S. graduates typically take positions in industry, although some pursue Ph.D. or M.D. degrees. We recently responded to increasing industry need for engineers with advanced skills by creating the course-only SPML and Professional accelerated M.S. programs. The remarkable rate of technological advancement in the field has made it difficult to receive sufficient training for many industry positions in a four-year degree. Our accelerated M.S. programs are designed to provide students with these needed advanced skills in a short time frame. Our two programs are very new – the first cohort of SPML students graduated in August of 2018; we will accept the first Professional program students in Fall 2019.

Engineering Career Services provides extensive job-search support for our students, including: coordination of co-op and internship opportunities; hosting of career fairs and on-campus interviews; advice on resumes, cover letters, interviewing, and offers/negotiation skills.

J. Doctoral Minor

The Electrical Engineering Doctoral Minor continues to provide a valuable educational option for Ph.D. students in other departments. Our minor has served 113 students over the past 11 years (2007-2018). Mechanical Engineering (45 students), Computer Sciences (25 students) and Physics (22 students) make greatest use of this program. This is expected, as the disciplines of mechanical engineering, computer sciences, and physics have natural connections with electrical engineering.