Institutional Effectiveness Report
2020-2021

Program: Computer Engineering BS

College and Department: College of Engineering – Electrical & Computer Engineering

Contact: Allen MacKenzie

Mission: "Provide quality undergraduate and graduate education and perform research in the areas of electrical and computer engineering to enhance the competitiveness of our graduates and contribute to economic, scientific, and social development."

Program Goals:

Within a few years following graduation, our graduates will have:

PG 1. progressed in their careers as indicated by promotions, positions of leadership, awards, recognitions, entrepreneurial activities, products or processes developed, patents, and/or publications;

PG 2. advanced their knowledge and expertise as indicated by continuing education, advanced degrees, and/or professional registration;

PG 3. contributed to the profession and society as indicated by research, national and international collaboration, professional service, community service, and/or public service.

Student Learning Outcomes:

Students will demonstrate:

SLO 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

SLO 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

SLO 3. an ability to communicate effectively with a range of audiences

SLO 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

SLO 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

SLO 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

SLO 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

Relationship of Student Outcomes to Program Educational Objectives.

Student Outcome		**Program Educational Objective**		
		i	**ii**	**iii**
1	an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	X	X	
2	an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	X		X
3	an ability to communicate effectively with a range of audiences	X		X
4	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	X		X
5	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	X		X
6	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	X	X	
7	an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	X	X	

Assessment Methods:

1. *The Capstone Assessment.* Written and oral final presentations of each senior capstone project are evaluated every semester. This evaluation has two components: a survey of the ECE Advisory Board is used to assess the attainment of SLO1, SLO2, and SLO3 on the basis of each team's poster and oral presentation; a longer written rubric, completed by the team's faculty advisor, a second faculty member, and an advisory board member for each team, is used to assess the attainment of all SLOs, except SLO6, on the basis of the final written report. Beginning in Fall 2021, this assessment method will be used to assess *all* SLOs. (See discussion under Modifications for Continuous Improvement.)

2. *The Final Exam Assessment (FEA).* Specific exam questions for specific ECE courses have been used to directly assess Student Outcome 1 each semester; this assessment tool was replaced with the broader *Student Outcome Assessment* in Spring 2021. (See below and discussion under Modifications for Continuous Improvement.) The FEA was conducted in ECE 3020: Discrete-Time

Signal and Systems, ECE 3130: Microcomputer Systems, ECE 3300: Electronics I, and ECE 3510: Electromagnetic Fields. (ECE 3510 is not required of BSCmpE students; the other three courses are.) This assessment is performed by the faculty member who administered the exam plus an expert in the field. Data is disaggregated for BSCmpE students.

3. *The Laboratory Assessment.* In academic year 2019-2020 and Fall 2020, a new direct assessment tool was introduced to measure the attainment of SLO6. The laboratory assessment was conducted in ECE 3060, and students performance was measured on specific tasks demonstrating the attainment of SLO6. In Spring 2021, this assessment tool was replaced with the broader *Student Outcome Assessment.* (See below and discussion under Modifications for Continuous Improvement.

4. *The Student Outcome Assessment (SOA).* Beginning with a trial in Spring 2021, the *FEA* (which focused on only SLO1) was replaced with this instrument. Each semester, some courses are selected (on a scheduled developed by the ECE assessment committee) in which to evaluated particular performance indicators associated with particular SLOs. During Spring 2021, SLO1, SLO6, and SLO7 were assessed; during 2021-2022, all SLOs will be assessed. After that, we plan to move to a cycle of assessing each SLO with this instrument during one semester every two years. The faculty member teaching the course in which the SLOs are being assessed is asked to use an assignment (homework, project, laboratory, or exam question) to evaluate the performance indicator, to report on the resulting measured attainment of the associated SLO, and to reflect on the results and needed improvement actions. Data is disaggregated for BSCmpE students. See further discussion under Modifications for Continuous Improvement.

5. *The Senior Exit Survey.* Each semester, both a written survey and a group oral interview of graduating seniors are performed. Students are asked a variety of questions about their experiences in the program, including being asked to rate their attainment of each SLO; this data is disaggregated for BSCmpE students. In addition to numerical feedback, comments are obtained regarding the overall ECE program experience, specific courses, and specific faculty and staff.

Attainment of Student Outcomes

The raw data from most tools is obtained on a 1-5 scale with 5 being the best score. For the final exam assessment, scores on selected exam questions are reported out of 100%. For comparability, we translate this into a 5 point scale with the formula X/20, this translates into an average grade of 60 on the selected exam problems receiving a 3.0, the threshold for acceptability on our 5 point scale.

Our target for each student outcome and each assessment tool is to achieve greater than 3.5 out of 5. We categorize the attainment of each outcome using each assessment tool as:

- Highly Satisfactory (HS) if the rating is 3.75 or above,
- Satisfactory (S) if the rating is between 3.00 and 3.74,
- Unsatisfactory (U) if the rating is less than 3.00.

Results:

SLO 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Survey)	-	-	-	-	4.57	4.53
Capstone Assessment (Reviewer)	-	-	-	-	4.43	3.72
Final Exam Assessment (Through Fall 2020)	3.69	3.58	4.12	-	3.98	4.40
Student Outcome Assessment (Beginning Spring 2021)	-	-	-	-	-	4.23
Senior Exit Survey	4.52	4.07	4.17	4.06	4.50	4.22

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) for every assessment tool during the last two academic years, except for reviewer scores on the Capstone Assessment at 3.72, slightly below the "highly satisfactory" threshold. Unfortunately, the FEA was not conducted in 2018-2019. Although all indicators suggest strong attainment of this student outcome, we continue to monitor to ensure that the outcome is attained.

Numerous comments from faculty (via the student outcome assessment and course assessment instruments) and students (via course assessment instruments and the senior exit survey) have identified a lack of synchronization between lecture and laboratory courses (most laboratory courses are standalone) as a significant source of friction and a barrier to understanding the connection between theory and practice necessary to attain this student outcome. This is being addressed in the curriculum; see Modifications for Continuing Improvement.

SLO 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Survey)	-	-	-	-	4.52	4.51
Capstone Assessment (Reviewer)	-	-	-	-	4.13	4.00
Senior Exit Survey	4.22	4.06	4.04	3.78	4.29	4.11

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) for every assessment tool during the last two academic years. Although all indicators suggest strong attainment of this student outcome, we continue to monitor to ensure that the outcome is attained.

Comments from faculty and students across multiple courses and multiple assessment instruments (including course assessments and the senior exit survey) indicate that attainment of this SLO is hindered by students' relative weakness in programming. This is being addressed in the curriculum; see Modifications for Continuing Improvement.

SLO 3. an ability to communicate effectively with a range of audiences

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Survey)	-	-	-	-	4.52	4.53
Capstone Assessment (Reviewer)	-	-	-	-	4.19	3.75
Senior Exit Survey	4.22	4.03	4.31	3.94	4.21	3.78

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) for every assessment tool during the last two academic years. Although all indicators suggest strong attainment of this student outcome, we continue to monitor to ensure that the outcome is attained.

SLO 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Reviewer)	-	-	-	-	3.70	3.66
Senior Exit Survey	4.17	4.17	3.84	3.83	4.36	4.22

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) as indicated by the senior exit survey, but attainment is only at the satisfactory (S, 3.00-3.74) level as indicated by the capstone assessment, which is a direct assessment. As such, attainment of this SLO should probably be more closely monitored.

SLO 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Reviewer)	-	-	-	-	4.17	3.94
Senior Exit Survey	4.39	4.28	4.19	3.89	4.64	4.11

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) for every assessment tool during the last two academic years. Although all indicators suggest strong attainment of this student outcome, we continue to monitor to ensure that the outcome is attained.

SLO 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

	15-16	16-17	17-18	18-19	19-20	20-21
Laboratory Assessment (through Fall 2020)	-	-	-	-	3.84	4.46
Student Outcome Assessment (beginning Spring 2021)	-	-	-	-	-	4.08
Senior Exit Survey	4.61	4.33	4.19	4.11	4.43	4.33

As the table shows, attainment of this student outcome is highly satisfactory (HS, >3.75) for every assessment tool during the last two academic years. Although all indicators suggest strong attainment of this student outcome, we continue to monitor to ensure that the outcome is attained. In fact, the stronger measured attainment in 2020-2021 on the Laboratory Assessment and Student Outcome

Assessment (both conducted in ECE 3060) has been attributed to the pandemic, which forced students to complete laboratory exercises independently. As a result, an improvement action of maintaining some independent laboratory work post-pandemic has been adopted. (See modifications for continuing improvement.) This SLO, the only one that is currently *not* assessed with the capstone assessment, will be added to the capstone assessment in 2021-2022; see Modifications for Continuing Improvement.

SLO 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

	15-16	16-17	17-18	18-19	19-20	20-21
Capstone Assessment (Reviewer)	-	-	-	-	4.18	3.56
Student Outcome Assessment (beginning Spring 2021)	-	-	-	-	-	3.13
Senior Exit Survey	4.72	3.83	4.31	4.33	4.36	4.33

As this table shows, attainment of SLO7 is weaker than other student outcomes. Although the self-reported senior exit survey rates attainment in the highly satisfactory (HS, >3.75) range, the other indicators (capstone assessment and student outcome assessment) are both merely "satisfactory" (S, 3.00-3.74) in the 2020-2021 academic year, with the student outcome assessment being below the target rating of 3.5 or above.

Modifications for Continuing Improvement

Student Outcome Assessment (SLO1, SLO6, & SLO7)

A major overhaul of our program assessment methodology was undertaken during 2020-2021 to provide for more direct assessment of student learning outcomes. This resulted in replacing the FCA and the SCA with a broader direct assessment tool, termed the "Student Outcome Assessment (SOA)." Unlike the assessment tools that it replaced, the SOA will be applied to assess *all* student learning outcomes. After a trial in Spring 2021 on SLO1, SLO6, and SLO7, the SOA will be used to assess *all* SLOs during 2021-2022. After that, a biennial assessment process is envisioned that will apply the SOA to a select set of SLOs each semester while ensuring that every SLO is assessed at least once every two years.

- SLO1 – Complex Engineering Problem

  Data collected in the SOA from ECE 3010 (Signals and Systems) and ECE 3130 (Microcomputer Systems) and highlighted by comments made by instructors of those courses became the focus, and several areas where improvement is needed were identified. The ECE 3010 instructor found that students' lack of success on the provided instrument (an open-ended problem that required them to acquire and apply new knowledge) partly reflected a lack of mathematical sophistication and programming abilities. Thus, improvement of mathematics coverage for ECE 3010 (Signals and Systems) and ECE 3020 (Discrete-Time Signals and Systems) and improvement of programming background and abilities for ECE Students were identified as the primary revisions for SLO 1. To improve mathematics coverage in ECE 3010, an additional review (one week) of relevant mathematical topics, including relevant integration techniques and partial fraction decomposition, was added to the beginning of ECE 3010 starting in Summer 2021. To improve programming background and abilities, the ECE

Undergraduate Program Committee has been tasked with developing curriculum improvements to improve the programming abilities of ECE students, probably by requiring additional programming courses, especially for EE students.

- SLO6 – Experimentation and Data Analysis

  The Student Outcome Assessments of the ECE 3060 course have indicated that the analyzing and interpreting data construct has room for improvement as it has been rated just above the "acceptable" threshold. Thus, improvement of ability to conduct experimentation through solo work in ECE 2011 (EE Lab I) and ECE 3060 (EE Lab II), improvement in analyzing and interpreting data in ECE 3060, and improvement of curriculum through embedding laboratories were identified as the primary revisions for SLO 6. When following COVID-related social distancing requirements for independent lab work, instructors noticed a marked increase in the ability of students to complete the laboratory practical exam more quickly and successfully. Therefore, the improvement action for ECE 2011 and ECE 3060 is to continue to require significant solo work in the laboratories in future semesters, even after pandemic conditions subside. Additional exercises on data analysis will be introduced to ECE 3060 beginning in Fall 2021. In accordance with faculty requests and suggestions, the ECE Undergraduate Program Committee is preparing a major curriculum revision, a key component of which is the integration of theory courses and associated laboratories.

- SLO7 – New Knowledge

  ECE 3010 was targeted as assessing attainment of SLO 7, and SOA results have indicated room for further improvement in attainment of this learning outcome. The instructor of ECE 3010 noted in the SOA that students were not successful in acquiring and applying new knowledge to complete the assigned project. The specific action to improve students' ability to acquire and apply knowledge is to introduce some exercises requiring open-ended problem solving in earlier courses in the curriculum. ECE 2110 will be targeted as one such course.

Capstone Assessment (SLO1, SLO2, SLO3, SLO4, SLO5, SLO7)

In addition, the Capstone Assessment was previously used to assess the attainment of all SLOs *except* for SLO6. Beginning in the 2021-2022 academic year, the Capstone Assessment will be used to assess the attainment of all SLOs, including SLO6, ensuring that students are demonstrating the use of experimentation, data analysis and interpretation, and the exercise of engineering judgement in their capstone projects.

Appendices

1. Curriculum Map

Appendix 1: Curriculum Map

Course	Title	SO1	SO2	SO3	SO4	SO5	SO6	SO7
ECE 2001	Computer Aided Engineering in ECE	*					*	
ECE 2010	Electric Circuits I	*	*					
ECE 2011	Electrical Engineering Lab. I			*	*		*	
ECE 2020	Electric Circuits II	*	*					
ECE 2110	Intro. to Digital Systems	*	*	*		*		
ECE 3010	Signals & Systems	*	*					
ECE 3020	Discrete-Time Signals & Systems	*	*					
ECE 3060	Electrical Engineering Lab. II	*	*	*	*		*	
ECE 3130	Microcomputer Systems	*	*	*		*	*	*
ECE 3160	Digital Systems Lab.	*	*	*		*	*	
ECE 3300	Electronics I	*	*					*
ECE 3920	Professional Issues in ECE			*	*	*		*
ECE 4110	Digital System Design	*	*	*			*	
ECE 4120	Fundamentals of Computer Design	*	*	*		*	*	
ECE 4140	Embedded System Design	*	*	*		*	*	*
ECE 4961	Capstone Design I	*	*	*	*	*		*
ECE 4971	Capstone Design II		*	*		*	*	*
CSC 1300	Intro. to Problem Solving and Computer Programming	*	*					
CSC 1310	Data Structures and Algorithms	*	*					
CSC 2400	Design of Algorithms	*	*					
CSC 2500	UNIX Lab.	*						
CSC 4100	Operating Systems	*	*					
CSC 4200	Computer Networks	*						