SAINT LOUIS UNIVERSITY

Program-Level Assessment: Annual Report

Program Name (no acronyms): Computer Engineering	Department: Department of Civil, Computer and Electrical Engineering
Degree or Certificate Level: Undergraduate	College/School: School of Science and Engineering
Date (Month/Year): 11/2023	Assessment Contact: Dr. Kyle Mitchell
In what year was the data upon which this report is based collected? AY 22/23	
In what year was the program's assessment plan most recently reviewed/updated? AY 22/23	

1. Student Learning Outcomes

Which of the program's student learning outcomes were assessed in this annual assessment cycle? (Please list the full, complete learning outcome statements and not just numbers, e.g., Outcomes 1 and 2.)

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

Historical Outcomes:
(a) an ability to apply knowledge of mathematics, science, and engineering
(e) an ability to identify, formulate, and solve engineering problems implied.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

(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

Historical Outcomes:
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability implied.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

2. Assessment Methods: Artifacts of Student Learning

Which artifacts of student learning were used to determine if students achieved the outcome(s)? Please describe and identify the course(s) in which these artifacts were collected. Clarify if any such courses were offered a) online, b) at the Madrid campus, or c) at any other off-campus location.

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

ECE 3090 – Internal resistance of a battery design report

ECE 3130 – A question on the Final concerning Finding drawing the energy bandgaps in semiconductor structure.

ECE 3151 – Laboratory report on eliminating the echo from a voice signal

ECE4800 / ECE4810 – Final Design Reports.

(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

ECE4800 / ECE4810 – Final Design Reports.

All classes assessed were taught as onsite (St. Louis) lab classes with lecture session as necessary. These classes are not offered in Madrid, but will change in the coming years as they implement a CpE program.

3. Assessment Methods: Evaluation Process

What process was used to evaluate the artifacts of student learning, and by whom? Please identify the tools(s) (e.g., a rubric) used in the process and **include them in/with this report document** (do not just refer to the assessment plan).

Each of the artifacts were assessed by two faculty members from the program (due to the programs only having four faculty at the time of review). These assessments were collated and presented to the entire program faculty. The recommendations from these three assessments were discussed by the full program faculty and program improvements developed.

For each of the following assignments assessors are instructed to:

For each indicator, assess the three instances of each artifact presented. Give each instance an assessment a score from 1-3 based on the rubric. If the material does not seem to match the rubric then score the material a 1. Observations and recommendations are required for any material scoring a 1, they are recommended for any observations scoring a 2. Observations and recommendations are still welcome for those material scoring a 3.

Note: All rubrics are included at the end of this report.

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

Outcome 1 was assessed using a total of 11 samples from 4 assignments across 4 classes. These assignments were the Internal Resistance of a Battery Design Report from ECE 3090 Junior Design, A question from the final in ECE 3130 Semiconductors, The lab report from the echo cancelation lab from ECE 3151 Linear Systems Lab and the Final Design Report from ECE 4810 Senior Design.

(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

Outcome 2 was assessed using a total of 3 samples from 1 assignment. This assignment was the Final Design Report from ECE 4810 Senior Design.

4. Data/Results

What were the results of the assessment of the learning outcome(s)? Please be specific. Does achievement differ by teaching modality (e.g., online vs. face-to-face) or on-ground location (e.g., STL campus, Madrid campus, other off-campus site)?

There is no difference in teaching modality as the majority of these classes only have one section.

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

Outcome 1 Results Summary for ECE 3090 Battery Experiment Review – Indicator #1

Reviewer	Team	Rubric Score	Comments
1	1	1	Observations: There were no circuits presented. In either report.
	2	1	Recommendations: It is like the students do not realize they need to “present their solution.” This could be further addressed by more specific instructions in the assignment handout
2	1	2	Observations: The output has not been satisfied very well because the theoretical analysis is not complete. Team #2 gave a description of a problem that had to be solved (voltage on one leg of the wheatstone bridge) but did not show the analysis to solve it
	2	2	Recommendations: The teams are required to show the analysis of their method in the design report but the actual narrative is strongly deficient. Either they struggle with the analysis or it is not as evident in this particular material. The project notebooks might give more information about the problems solved. I recommend we use assess the material in the project notebooks. I recommend we reassess this measure using the project notebooks.

Outcome 1 Results Summary for ECE 3090 Battery Experiment Review – Indicator #2

Reviewer	Team	Rubric Score	Comments
1	1	1	Observations: There were no equations derived. In either report.
	2	1	Recommendations: . We could find a place in the curriculum before this class where we ask the students to study an given circuit and “present” or “report” on analysis of the circuit, including modeling equations, their interpretation and overall function.
2	1	1	Observations: There is no analysis given in the design report.
	2	1	Recommendations: The project notebooks might give more information about the problems solved. I recommend we use assess the material in the project notebooks. I recommend we reassess this measure using the project notebooks.

Outcome 1 Results Summary for ECE 3090 Battery Experiment Review – Indicator #3

Reviewer	Team	Rubric Score	Comments
1	1	1	Observations: There were no calculations performed. In either report. From the design report I have no idea of what their design was.
	2	1	Recommendations: This could be done in the beginning of Linear Systems or somewhere in Electronics.
2	1	1	Observations: Same as #2 above

	2	1	Recommendations: Same as #2 above

Outcome 1 Results Summary for ECE 3130 Final Exam Question– Indicator #1

Reviewer	Student	Rubric Score	Comments
1	1	1	Observation: There is no real use of equations, there appear to be some assumptions stated and some answers drawn. --- There are some not well-organized equations and labeled plot --- There are some organized equation and a labeled plot
	2	2	Recommendations: I struggled to assess this due to a lack of understanding the calculations required.
	3	2	
2	1	2	Observation: Terselic: The energy band diagram appears to have some deficiencies. Hernandez: The energy band diagram appears correct. Ahn: The energy band diagram appears correct.
	2	3	Recommendations: It is hard to assess this when I don't know what the correct labeling should be. I recommend that the correct solution be given as part of the rubric.
	3	3	

Outcome 1 Results Summary for ECE 3151 Echo Cancelation – Indicator #1

Reviewer	Team	Rubric Score	Comments
1	1	3	Observations:
	2	3	Recommendations: Both plots are missing a legend
	3	3	
2	1	3	Observations: Teams 1 & 2 & 3: The data looks correct and the model looks appropriate.
	2	3	Recommendations: General recommendation: I think the correct solution should be explicitly given for all assessed works for the sake of those faculty who are not familiar with the material. I also think that the specific assessed material name (like program name) should be explicitly stated in our "assessment description" for each indicator.
	3	3	

Outcome 1 Results Summary for ECE 3151 Echo Cancelation – Indicator #3

Reviewer	Team	Rubric Score	Comments
1	1	3	Observations: They discuss a graph that Is not in their report
	2	2	Recommendations:
	3	3	
2	1	3	Observations: The construction of the estimation of alpha and the inverse impulse response look ok for all 3 teams.
	2	3	Recommendations:
	3	3	

Outcome 1 Results Summary for ECE 4800 Final Design Report– Indicator #1

Reviewer	Team	Rubric Score	Comments
1	1	1	Observations: The details shown in the FDR are limited, if they had included a flow diagram or a power analysis this would be higher There is evidence of design choices being based on measurements and observation, but no evidence of math tools used during design Beyond demonstration of iteration, there is no evidence of math or principles being considered
	2	2	Recommendations: Perhaps looking in a different place (notebook) would be a better place to look for this evidence
	3	1	
2	1	1	Observations: Teams 1 & 2 & 3: I don't see any mathematical analysis of a system using engineering principles in either the final report nor in the poster.
	2	1	Recommendations: I think we are more likely to find appropriate mathematics and/or engineering principles used in the project notebooks. This was stated as one of the assessment materials. This should be reassessed after looking at the project notebooks.
	3	1	

Outcome 1 Results Summary for ECE 4800 Final Design Report – Indicator #2

Reviewer	Team	Rubric Score	Comments
1	1	2	Observations: There is ONE example but it is very limited and not well explored, perhaps looking in a different place There is evidence of testing, but no evidence of models being used to inform design or testing There are examples of CAD being used to visualize placement of components prior to construction
	2	1	Recommendations: Perhaps looking in a different place (notebook) would be a better place to look for this evidence
	3	2	
2	1	2	Observations: I see plenty of modeling through block diagram illustrations of systems and subsystems. Team 1 seems a bit weak for this outcome
	2	3	Recommendations:
	3	3	

Outcome 1 Results Summary for ECE 4800 Final Design Report – Indicator #3

Reviewer	Team	Rubric Score	Comments
1	1	2	Observations: There is ONE example but it is very limited and not well explored, perhaps looking in a different place There is discussion of multiple subsystems that complete a whole, but the details of design are very limited There is discussion of separate systems used to attain different functions of the design, but the discussion is very limited
	2	2	Recommendations:
	3	2	
2	1	3	Observations: I see plenty of diagrams that indicate that components have been synthesized to create a larger whole.
	2	3	Recommendations:

	3	3	

(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

Outcome 2 Results Summary for ECE 4810 Senior Design Final Design Report – Indicator #1

Reviewer	Team	Rubric Score	Comments
1	1	2	Observations: The constraints identified and used were user constraints, they were not distilled done to design metrics and measured
	2	3	Recommendations:
	3		
2	1	3	Observations: Teams 1 & 2 & 3: 3 All the teams had an awareness of the importance of realistic constraints for their design.
	2	3	Recommendations:
	3		

Outcome 2 Results Summary for ECE 4810 Senior Design Final Design Report – Indicator #2

Reviewer	Team	Rubric Score	Comments
1	1	2	Observations: There is a lot of discussion of choosing components to meet specification, but very little on designing to meet components
	2	3	Recommendations:
	3	1	
2	1	3	Observations: Team 1: 3 there are several places where this indicator is satisfied, GPS limitations and ranging sensor limitations Team 2: 3 there are several places where this indicator is satisfied, limitations of the human hand leading to quantitative design constraints. Team 3: 2 there are some places where this indicator is marginally satisfied – I think the justification for design choices was weak.
	2	3	Recommendations:
	3	2	

Outcome 2 Results Summary for ECE 4810 Senior Design Final Design Report – Indicator #2

Reviewer	Team	Rubric Score	Comments
1	1	2	Observations:
	2	3	Recommendations:
	3	2	
2	1	2	Observations: Team 1: 2 I see where the final design was assessed numerically, but I don't see where the quantitative design constraint is that relates to it.

			Team 2: 1 I see a lot of general remarks concerning design constraints but no real measurable design constraints. Therefore it is not possible to assess the design constraints quantitatively. I also don't see any comments regarding how the design constraints were measured at the end. Team 3: 1 same comments as for Team 2
	2	1	Recommendations: I'm not sure what to recommend here but something needs to be done to help the teams put down more quantitative design constraints so they have so they have something to assess at the end. Maybe this is a mentoring issue. Since the final design report was assessed, there should have been plenty of time to counsel each team each team on their design constraints.
	3	1	

5. Findings: Interpretations & Conclusions

What have you learned from these results? What does the data tell you? Address both a) learning gaps and possible curricular or pedagogical remedies, and b) strengths of curriculum and pedagogy.

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

Recommendations:

- It is like the students do not realize they need to "present their solution."
- This could be further addressed by more specific instructions in the assignment handout
- The teams are required to show the analysis of their method in the design report but the actual narrative is strongly deficient. Either they struggle with the analysis or it is not as evident in this particular material.
- The project notebooks might give more information about the problems solved. I recommend we use assess the material in the project notebooks.
- I recommend we reassess this measure using the project notebooks.
- We could find a place in the curriculum before this class where we ask the students to study an given circuit and "present" or "report" on analysis of the circuit, including modeling equations, their interpretation and overall function.
- The project notebooks might give more information about the problems solved. I recommend we use assess the material in the project notebooks.
- I recommend we reassess this measure using the project notebooks.
- This could be done in the beginning of Linear Systems or somewhere in Electronics.
- I struggled to assess this due to a lack of understanding the calculations required.
- It is hard to assess this when I don't know what the correct labeling should be. I recommend that the correct solution be given as part of the rubric.
- Both plots are missing a legend
- General recommendation: I think the correct solution should be explicitly given for all assessed works for the sake of those faculty who are not familiar with the material.
- I also think that the specific assessed material name (like program name) should be explicitly stated in our "assessment description" for each indicator.
- Perhaps looking in a different place (notebook) would be a better place to look for this evidence
- I think we are more likely to find appropriate mathematics and/or engineering principles used in the project notebooks. This was stated as one of the assessment materials. This should be reassessed after looking at the project notebooks.
- Perhaps looking in a different place (notebook) would be a better place to look for this evidence

(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

Recommendations:

- I'm not sure what to recommend here but something needs to be done to help the teams put down more quantitative design constraints so they have so they have something to assess at the end.
- Maybe this is a mentoring issue. Since the final design report was assessed, there should have been plenty of time to counsel each team each team on their design constraints.

6. Closing the Loop: Dissemination and Use of Current Assessment Findings

A. When and how did your program faculty share and discuss the results and findings from this cycle of assessment?

In a meeting on 10-3-23, the results of the assessment activities were discussed. The entire program faculty was present at this meeting. The observations and recommendations found during the individual assessments were discussed and used to determine actions.

B. How specifically have you decided to use these findings to improve teaching and learning in your program? For example, perhaps you've initiated one or more of the following:

Changes to the Curriculum or Pedagogies

- Course content
- Teaching techniques
- Improvements in technology
- Prerequisites
- Course sequence
- New courses
- Deletion of courses
- Changes in frequency or scheduling of course offerings

Changes to the Assessment Plan

- Student learning outcomes
- Artifacts of student learning
- Evaluation process
- Evaluation tools (e.g., rubrics)
- Data collection methods
- Frequency of data collection

Please describe the actions you are taking as a result of these findings.

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

Ind	Improvements
1	From 3090: In 1001 teach students to enter equations into MS Word In 2026, 2003 3226 - In week 1 teach formal writing exercise and have them practice this for their final project report From 3130: Append the rubric with material on how to assess certain material This needs an answer with explanation and supporting material From 4800: We need to assess the notebooks, after the instructors finds a few places with evidence
2	From 4800: We need "domain appropriate" math, models, subsystems
3	

(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

Ind	Improvements
1	As part of the PDR have them pick several design constraints and discuss how they are going to assess them
2	
3	

If no changes are being made, please explain why.

7. Closing the Loop: Review of Previous Assessment Findings and Changes

A. What is at least one change your program has implemented in recent years **as a result of previous assessment data**?

Work on developing program wide lab report format – Students were getting to their Junior year without being able to write a report that had correctly labeled, captioned and referenced – table and figures.

This change is to give students a consistent Lab Report format across the entire program. This will allow introduce students to expectations as freshman, allow them to practice with critique as sophomores and then be proficient as juniors and seniors.

B. How has this change/have these changes 7A been assessed?

A spot checking of a number of reports from different Junior classes was performed.

C. What were the findings of the assessment?

The inclusion of data in the form of tables and figures has gotten better. The reports from all students have improved. The good students are close to were they should be, but the reports from the lower students are not where we would like the minimum attainment to be.. The students have asked for a guide to getting these into Word easily.

D. How do you plan to (continue to) use this information moving forward?

We are planning of modifying our report format document to include instructions on how to format this type of artifact correctly in MS Word, while continuing to instruct students in how to produce good lab reports.

IMPORTANT: Please submit any assessment tools and/or revised/updated assessment plans along with this report.

IMPORTANT: Please submit any assessment tools (e.g., rubrics) with this report as separate attachments or copied and pasted into this Word document. Please do not just refer to the assessment plan; the report should serve as a stand-alone document.

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

Historical Outcomes:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (e) an ability to identify, formulate, and solve engineering problems
- implied. (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

TABLE 1 Student Outcome (1) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Ability to develop and analyze mathematical models for systems involving principals of science and engineering	ECE3090	Measure the internal resistance of a battery.
	ECE3130	Develop an energy band diagram of a semiconductor and calculate the carrier concentration.
	ECE3151	Develop a mapping function from an autocorrelation function estimate to echo gain.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to recognize the need for design refinement through performance observations.	ECE3090	Measure the internal resistance of a battery.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to solve an engineering problem using mathematics and/or engineering principles	ECE3090	Measure the internal resistance of a battery.
	ECE3151	Develop a software module that eliminates an echo from an acoustic signal.
	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

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This outcome refers to an ability to recognize that a problem needs to be solved, formulate the problem, carry out the solution using the techniques, methods, and concepts of mathematics, science and engineering. Further, an assessment of the correctness of solution should be performed using analytical techniques.

Indicator #1: This indicator refers to the ability to put a system into a mathematical form that illuminates its characteristics.

- ECE 3090: *Students will demonstrate the ability to use literature and engineering principals to develop to identify a method to find the internal resistance of a battery.*
- ECE3130: *Students will demonstrate the ability to present the energy band diagram of a semiconductor and calculate the position of the Fermi Energy Level given the impurity concentration level as evidenced by the final exam.*
- ECE3151: *Students will demonstrate an ability to develop a matlab function that extracts parameters from the autocorrelation function of an acoustic signal and use those parameters to estimate echo gain as evidenced by laboratory project reports.*
- ECE4800/ECE4810: *Students will demonstrate an ability to use mathematics or science/engineering principles to characterize a system as evidenced in the project notebooks, technical reports, or technical presentations.*

Indicator #2: This indicator refers to the ability to create a system model, which is an alternative form of the system that acts, to some degree, like the original system.

- ECE3090: *Students will demonstrate the ability to develop a model for and a procedure to measure the internal resistance of a battery.*
- ECE4800/ECE4810: *Students will demonstrate an ability to use mathematics or science/engineering principles to create a system model as evidenced in the project notebooks, technical reports, or technical presentations*.

Indicator #3. This indicator refers to the ability to synthesize, i.e. create or specify or implement, components/subsystems using mathematics and engineering knowledge to create a larger whole.

- ECE3090: *Students will demonstrate an to measure the internal resistance of a battery using the model and procedure developed for Indicator 2. Further they will demonstrate an ability to assess the accuracy and precision of their results..*
- ECE3151: *Students will demonstrate an ability to develop a matlab function that eliminates an echo from an acoustic signal as evidenced by a Matlab computer program.* This requires that previous components be synthesized in order to create a complete working system in the form of a computer program.
- ECE4800/ECE4810: *Students will demonstrate an ability to synthesize, i.e. create or specify or implement, components/subsystems using mathematics or science/engineering principles to create a larger whole as evidenced in the project notebooks, technical reports, or technical presentations*.

Students will demonstrate the ability to use literature and engineering principals to develop a model for and a procedure to measure the internal resistance of a battery.

The assessment rubrics are given in the following table

TABLE 2 Assessment rubrics for Student Outcome (1).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE3090			
1	There is little or no evidence that any engineering problems have been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.	There is evidence that one engineering problem has been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.	There is evidence that most engineering problems have been recognized as necessary to be solved to further the design of an experiment to measure the internal resistance of a battery.
2	There is little or no evidence that any engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that one engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.	There is evidence that most engineering problems to be solved as part of the design of an experiment to measure the internal resistance of a battery, have been properly and quantitatively modeled through an equation, appropriate numerical parameters, etc.

3	There is little or no evidence that any engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly carried out to a numerical solution.	There is evidence that one engineering problem to be solved as part of the design of an experiment to measure the internal resistance of a battery, has been properly carried out to a numerical solution.	There is evidence that most engineering problems to be solved as part of the design of an experiment to measure the internal resistance of a battery, have been properly carried out to a numerical solution.
ECE3130			
1	The energy band diagram is not correct or the labeling is insufficient.	The energy band diagram is correct and is properly labeled.	The energy band diagram is correct and is properly labeled. All calculations leading to the diagram are present and correct.
ECE3151			
1	Either the R[n]/R[0] measurement is incorrect, or the polynomial fit is either incorrect or seriously deficient in modeling the data.	The R[n]/R[0] measurement is correct, the plot of R[n]/R[0] versus alpha is correct, the number of plotted points may not be statistically relevant, and a reasonable polynomial has been fit to the data.	The R[n]/R[0] measurement is correct, the plot of R[n]/R[0] versus alpha is correct, the number of plotted points is statistically relevant, and a reasonable polynomial has been fit to the data.
3	The matlab function does not properly combine the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal.	The matlab function properly combines the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal. Either one or both the echo gain estimate and inverse filter are not well defined leading to a somewhat high mean square error between the echo-removed signal and the original acoustic signal.	The matlab function properly combines the echo gain estimation from the autocorrelation function measures with the inverse filter function in order to remove the echo from an acoustic signal. Both the echo gain estimate and inverse filter are well defined leading to a low mean square error between the echo-removed signal and the original acoustic signal.
ECE4800/4810			
1	There is not sufficient evidence of any examples where mathematics and/or science/engineering principles have been applied to characterize a system.	There is evidence of one example where mathematics and/or science/engineering principles have been applied to characterize a system.	There is evidence of multiple examples where mathematics and/or science/engineering principles have been applied to characterize a system. If mathematics are used, then the system is expressed using appropriate equations along with appropriate values.

2	There is not sufficient evidence of any examples where a system has been modeled as it relates to an engineering design solution or implementation.	There is evidence of one example where a system has been modeled as it relates to an engineering design solution or implementation.	There is evidence of multiple examples where a system has been modeled as it relates to an engineering design solution or implementation.
3	There is not sufficient evidence of any examples where components and/or subsystems have been synthesized to create a larger whole.	There is evidence of one example where components and/or subsystems have been synthesized to create a larger whole.	There is evidence of multiple examples where components and/or subsystems have been synthesized to create a larger whole.

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(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

Historical Outcomes:

- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- implied. (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

TABLE 1 Student Outcome (2) assessment indicators and descriptions.

Indicator	Course	Assessment Description
1. Awareness of and an ability to discern the importance of realistic constraints for a particular design or design component.	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
2. Ability to translate practical quantitative constraints to appropriate design constraints.	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.
3. Ability to implement a design and verify that it meets the constraints.	ECE4800/ ECE4810	Exhibit through technical details found in the Project Notebook, technical reports, or technical presentations.

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This outcome refers to an ability to conduct engineering design while meeting specific needs. These needs might lie outside the typical performance constraints established by a client and may include health, saftey and economic factors.

Indicator #1: This indicator refers to an awareness of practical and realistic constraints and an ability to discern which are applicable for a particular design.

- ECE4800/ECE4810: *Students will demonstrate an awareness of practical and realistic constraints and an ability to discern which are applicable for a particular design as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

Indicator #2: This indicator refers to an ability to assess practical constraints and put them in a quantitative form that directly relates to the technical aspects of the design solution. For example, the constraint that the design must be “safe” would need to be converted into quantitative technical aspects of the design solution which might include constraints such as maximum battery voltage, maximum robot speed, etc. All design constraints ultimately need to be put into a technical/quantitative form so that engineering design decisions can be made.

- ECE4800/ECE4810: *Students will demonstrate an ability to assess practical constraints and put them in a quantitative form that directly relates to the technical aspects of the design solution as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

Indicator #3: This indicator refers to an ability to develop and carry out testing procedures in order to verify that the design meets the required constraints. These testing procedures require, to some degree of formality, the development of an experiment that is carried out in order to draw an appropriate conclusion about constraint performance.

- ECE4800/ECE4810: *Students will demonstrate an ability to develop and carry out testing procedures in order to verify that the design meets the required constraints as evidenced in the project notebooks, the PDR/CDR/FDR technical reports, or technical presentations*.

This outcome refers to an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. Such tools can include PCB layout tools like *Eagle*, oscilloscopes, digital multi-meters (DMM), function generators, power supplies, Matlab, Xilinx software, the SDK500 development board, Multisim, etc.

The assessment rubrics are given in the following table

TABLE 2 Assessment rubrics for Student Outcome (2).

	Rubric		
Ind	**1 = Does not meet Expectations**	**2 = Meets expectations**	**3 = Exceeds expectations**
ECE4800/4810			
1	There is no evidence that any practical and realistic constraints have been identified as being applicable to a particular design component.	There is evidence that one practical and realistic constraint has been identified as being applicable to a particular design component.	There is evidence that multiple practical and realistic constraints have been identified as being applicable to a particular design component.
2	There is no evidence that any practical and realistic constraints have been quantified as they relate to a particular design component.	There is evidence that one practical and realistic constraint has been quantified as they relate to a particular design component.	There is evidence that multiple practical and realistic constraints have been quantified as they relate to a particular design component.
3	There is no evidence that any practical and realistic constraints have been applied to the solution of a particular design component.	There is evidence that one practical and realistic constraint has been applied to the solution of a particular design component.	There is evidence that multiple practical and realistic constraints have been applied to the solution of a particular design component.

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