

2013-14 EE/CptE Student Work Course Assessment Report

K. Sivakumar (EE) and José Delgado-Frias (CptE)
Curriculum Committee Chairs

1. Background

For the 2013–2014 academic year the School of Electrical Engineering and Computer Science (EECS) follows the assessment plan outlined in the EECS assessment manual. The manual is intended to serve as the authoritative guide to our continuous assessment process for those responsible for carrying it out. The assessment process is a two-year cycle, which targets a subset of student outcomes in odd years (e.g., 2013-14 academic year) and a complement of the student outcomes in even years (e.g., 2014-2015 academic year). A set of courses has been identified in which periodic assessment of various ABET outcomes occurs. This assessment involves the gathering of student work related to the outcomes of interest. A panel then considers this work and the degree to which the students obtained the outcome. Together with this plan, a rubric, with corresponding “performance indicators,” was developed to facilitate the scoring on the students’ work. (Note that other assessment activities take place within the School, but this report is only concerned with this particular direct measure of student work.)

This academic year, three courses were targeted for assessment of student work: EE 214, Design of Logic Circuits; EE 321, Electrical Circuits II; and EE 416, Electrical Engineering Design (second semester of two-semester sequence). Instructors of these courses were asked to collect representative work that could be used to judge how well the students were obtaining the desired ABET outcome. In general, submissions from eight students selected as follows: One each from “high”, “medium”, and “low” performing students and five more selected at random. (For the “low” sample, instructors were asked not to provide work if it was anomalously low. Rather, low work should be representative of those toward the bottom of the class.)

The assessment committee (AC) consisted of Profs. Krishnamoorthy Sivakumar, Jose Delgado-Frias, and the course instructor. For each course it was decided to first inspect some of the student work and then decide which of the performance indicators were most closely aligned with the work. The AC met separately with each of the course instructors. After some initial discussion, the AC decided on the performance indicator(s) for each outcome and a specific artifact(s) to assess attainment of that outcome. Each member of the AC was asked to score the targeted outcomes, based on the appropriate set of performance indicator(s). AC members could score the individual artifacts and then average scores over all the artifacts or they could simply form a composite score directly after viewing all the artifacts. The approach was left up to the AC member but ultimately a simple composite score for each outcome was obtained. These scores are reported below. After scores were determined, the student work was discussed (the corresponding scores were discussed too). More detail will be provided below on a course by course basis.

The student work was scored on a four-point scale with the following definitions: 1) Unsatisfactory, 2) Needs Improvement, 3) Capable, and 4) Exemplary. (See the EE/CptE Performance Indicators and scoring rubric for more details.) The AC was free to give fractional

scores if the student work was thought to fall between these integer values. The material on which this assessment is based has been saved and is available on request.

2. EE 214, Design of Logic Circuits

EE 214 is a four-credit lecture and lab course. Mr. Clint Cole was the course instructor in Fall 2013 and Spring 2014 and provided samples of student work associated with a homework assignment, final exam, and a project (from Spring 2014 offering). The assessment plan calls for EE 214 to be used to assess outcomes A, B, C, E, and K. Professors Krishnamoorthy Sivakumar (chair, EE Curriculum Committee), José Delgado-Frias (chair, CptE Curriculum Committee), and Clint Cole (EE 214 course instructor) met in person on May 20, 2014, to assess achievement of student outcomes A and C. On May 22, the committee met again to assess achievement of student outcomes B, E, and K; this time Mr. Tinghui (Steve) Wang who was the lead TA during last academic year joined the meeting. Mr. Wang provided the committee access to student's Verilog code, as well as detailed spreadsheet of scores for each sub-task of the project for all students enrolled in the course.

After looking through the provided material, and with input from Mr. Clint Cole, it was determined that the Final Exam, a homework assignment, and a project would be suitable for this assessment. For each outcome, one or two performance indicators were selected. The list of outcomes and the associated targeted performance indicators (shown in bold) follows:

- A. An ability to apply knowledge of mathematics, science and engineering.
 - 1. **Chooses and implements problem solving strategies.**
 - 2. Analyzes and interprets information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words).
 - 3. Converts information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words).
 - 4. **Completes calculations using data, equations, and techniques.**
- B. An ability to design and conduct experiments as well as analyze and interpret data.
 - 1. Designs experiments for a purpose (e.g., to test a hypothesis, characterize components or devices, derive relationships, test performance, evaluate interactions, determine parameters, simulate use cases, etc.).
 - 2. Designs procedures within parameters and consideration of variables.
 - 3. **Obtains data for the implementation or analysis of a given design or experiment.**
 - 4. Generates mathematical/symbolic/graphical representations of the data for analysis, interpretation, and communication purposes.
 - 5. **Evaluates the results in comparison with the literature and/or theory.**
 - 6. Identifies limitations and recommendations for further experiments.
- 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.
 - 1. Identifies technical specifications and establishes parameters considering constraints and variables to develop a problem statement for the design project.

- 2. Decomposes the problem into a set of sub functions; a set of subsystems; and/or a sequence of actions.**
3. Generates multiple design concepts.
4. Evaluates the design concepts and selects the most promising concept.
5. Synthesizes the results of modeling, simulation, and prototyping to refine the design concept.
6. Recommends future work that seeks to improve the design while recognizing the limits and constraints placed on the project.

E. An ability to identify, formulate, and solve engineering problems.

1. Constructs a problem statement that articulates what constitutes a solution.
2. Identifies measurable parameters associated with both the problem and the solution.
3. Selects an approach or, as appropriate, approaches to solve the problem.
- 4. Implements the selected approach, or approaches, to obtain a solution.**
5. Validates a solution.

K. Have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

- 1. Uses modern engineering techniques, skills and tools (such as computer software, simulation packages, and diagnostic equipment) to make a choice, decision, or action.**
2. Combines use of engineering tools plus system operating information to monitor performance, find optimal operating conditions, and/or develop designs.
3. Evaluates which techniques or tools are most appropriate to complete a specific engineering task.

Comprehensive final exam included twelve problems with 120 minutes duration and was worth 15% of the course grade. Final exams for eight students were used to assess outcome A. The students were chosen as representative of “high”, “medium” and “low” performance.

The committee specifically looked at problems 3 and 7 in the final exam to assess the performance. In problem 3, a state diagram contained logic rule violations that needed be corrected. All students did well in this problem. Problem 7 asked for completing K-maps for a state machine. Students largely did well in the design problem. There were minor errors which were not significant conceptual errors.

Homework 6, which dealt with arithmetic circuits, was used to assess outcome C. In problem 5 students were asked to sketch a carry-propagate generate logic circuit for a 4-bit CLA. Again eight homework assignments were used as sample representing a broad range of student performance. Fifty percent of the sampled students got full marks; of the other 4 homework samples 3 students had the right approach but were not completely right. One student attempted to design the 4-bit CLA using logic gates (which was not required and needed a large number of gates). The majority of students have a grasp of the concepts –only one student might have misunderstood the question.

Project 6 was used to assess outcomes B, E, and K. This project was worth 7% of the course grade. For lab experiments in this course students used a Digilent Board (Nexys4, Nexys3, Nexys2, or Basys2), design tool software (Xilinx ISE Design Suit 14.7), a laptop or PC, and Windows or Linux OS. Six samples of this project were assessed; the committee considered the sample size to

be on the low side. There were three major parts in this project which were implemented using an FPGA: arithmetic circuits, counter and clock divider, and a VGA display controller. Students were provided with the fundamental theory and some Verilog code as foundations for the project. Students wrote Verilog code to implement the digital circuits/functions. The amount of software that students needed to add was considerable. Students gave a demonstration of their projects; in addition students were asked about their understanding of the project and underlying concepts. A number of items were evaluated in the projects; for this evaluation, instructor used the following scale: 4: Exemplary, 3: Complete, 2: Incomplete, 1: Minor effort, 0: Not submitted. Given the nature of this course and projects, students either got the correct results or they did not. An important component of this exercise was the questions at the end the student's demonstration; these questions provided a good indication of their understanding of the underlying digital logic theory and practice. TA/instructor verbally provided comments to each student of his/her performance.

In the present form, student's software and the grade sheet where TAs insert grades for both demonstration and verbal questions answered were made available for inspection. The committee found difficult to evaluate given that the software had too much code to examine and the grade sheet had only numeric evaluation of performance. With this caveat, the committee considered project 6 to be reasonably challenging and the students put in a considerable effort into it. Students got all the required deliverables and a good portion of them (80%) worked on some of the extra points. Overall, the student performance in this project was evaluated as being capable or better.

The table below presents the scores for the different outcomes --- a composite score was assigned based on all the artifacts and students examined:

	Performance Indicator and Outcome						
	A.1	A.4	C.2	B.3	B.5	E.4	K.1
Sivakumar	4	3.1	2.9	3.5	3.5	3.5	3.5
Delgado	3.5	3.25	2.9	3.5	3.5	3.5	3.5
Cole	2.9	3.1	2.9	3.5	3.5	3.5	3.5
Average	3.31		2.90	3.5		3.5	3.5

The provided coursework clearly showed that the students in EE 214 were meaningfully engaged in endeavors associated with each of the ABET outcomes this course is supposed to address. The worked was judged to be at "capable" level in the four outcomes; outcome C was slightly lower than 3.0 (2.9).

There are a couple of recommendations that the committee considers could help the assessment of this course.

- 1) The committee recommends that sample of lab/project student work to be larger than what was presented this time. The number of student work per sample is left up to the instructor; however, the goal is to provide a sample that is representative of typical weak, medium and strong work/performance.
- 2) The committee had difficulty evaluating project 6 with the provided documents. A valuable component of project evaluation is the questioning of student's knowledge of the subject matter. Due to the large class size (97 and 63 students in Fall 13 and Spring 14, respectively), documenting this would consume a considerable amount of TA time and,

therefore, it is impractical. A proposed solution is for this committee to attend TA/instructor evaluation of a randomly selected set of lab demonstrations which will include weak, medium, and strong lab work. This committee will assess achievement of student outcomes in “real-time.” Instructor will develop/modify a project that incorporates tasks that make possible to assess outcomes B, E and K.

3. EE 321, Electrical Circuits II

EE 321 is a three-credit lecture-based course. Prof. Tom Fischer was the course instructor in Spring 2014 and provided samples of student work (in electronic form) associated with one Test, Final Exam, and a course project. The assessment plan calls for EE 321 to be used to assess outcomes A, B, E, and K. Professors Krishnamoorthy Sivakumar (chair, EE Curriculum Committee), Jose Delgado-Frias (chair, CptE Curriculum Committee), and Tom Fischer (EE 321 course instructor) met in person on May 14, 2014, to assess achievement of student outcomes.

After looking through the provided material, and with input from Prof. Fischer, it was determined that the Final Exam and Course project would be suitable for this assessment. For each outcome, one or two performance indicators were selected. The list of outcomes and the associated targeted performance indicators (shown in bold) follows:

- A. An ability to apply knowledge of mathematics, science and engineering.
 - 1. **Chooses and implements problem solving strategies.**
 - 2. Analyzes and interprets information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words).
 - 3. Converts information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words).
 - 4. Completes calculations using data, equations, and techniques.
- B. An ability to design and conduct experiments as well as analyze and interpret data.
 - 1. Designs experiments for a purpose (e.g., to test a hypothesis, characterize components or devices, derive relationships, test performance, evaluate interactions, determine parameters, simulate use cases, etc.).
 - 2. Designs procedures within parameters and consideration of variables.
 - 3. Obtains data for the implementation or analysis of a given design or experiment.
 - 4. **Generates mathematical/symbolic/graphical representations of the data for analysis, interpretation, and communication purposes.**
 - 5. **Evaluates the results in comparison with the literature and/or theory.**
 - 6. Identifies limitations and recommendations for further experiments.
- E. An ability to identify, formulate, and solve engineering problems.
 - 1. **Constructs a problem statement that articulates what constitutes a solution.**
 - 2. **Identifies measurable parameters associated with both the problem and the solution.**
 - 3. Selects an approach or, as appropriate, approaches to solve the problem.
 - 4. Implements the selected approach, or approaches, to obtain a solution.

5. Validates a solution.

K. Have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

1. **Uses modern engineering techniques, skills and tools (such as computer software, simulation packages, and diagnostic equipment) to make a choice, decision, or action.**
2. Combines use of engineering tools plus system operating information to monitor performance, find optimal operating conditions, and/or develop designs.
3. Evaluates which techniques or tools are most appropriate to complete a specific engineering task.

Final Exam included eight problems with 120 minutes duration. It was comprehensive and worth 25% of the course grade. Final exams for eight students were used to assess outcome A. The students were chosen as follows: one each representing “high”, “medium” and “low” performance and five other students chosen at random. One student (among the eight) did not pass the course --- that student’s sample was not used for assessment.

The committee specifically looked at two problems --- a filter design problem and an Opamp circuit problem. Students generally did well in the design problem. There were no significant conceptual errors. In the Opamp circuit problem, two students had algebraic errors in deriving the transfer function of the given circuit.

The design project was an individual effort project worth 20% of the course grade. It involved two main tasks:

- (i) Analyzing a third-order circuit using a differential equation representation, state-space representation, and transfer function representation. Students were required to derive expressions for the different representations, and determine the step response, rise time, settling time, pole-zero locations. Matlab functions were used for obtain plots and numerically verify the theoretical values.
- (ii) Design a third-order Butterworth low-pass and high-pass filter by suitable choosing circuit parameter values to meet design requirements. Students were required to obtain frequency response plots and output waveforms for a sinusoidal input and verify the numerical values from the plots with theoretical results.

A formal project report detailing all derivations, calculations, plots, discussions, and code was required. Reports submitted by five students were collected to assess outcomes B, E, and K. The students were chosen as follows: one each representing “high”, “medium” and “low” performance and two others students chosen at random. Two students (among the five) did not pass the course --- those student reports were not used for assessment.

The committee considered the project to be reasonably challenging and the students put in a considerable effort into it. Two students did a very good work in the project and in presenting the results. A third student had errors in some derivations and plots. Overall, the student performance was evaluated as being capable or better.

The following table presents the scores for the different outcomes --- a composite score was assigned based on all the artifacts and students examined:

	Performance Indicator and Outcome					
	A.1	B.4	B.5	E.1	E.2	K.1
Sivakumar	3.2	3.5	3.5	3.5	3.5	3.5
Delgado	3.3	3.5	3.5	3.0	3.0	3.5
Fischer	3.3	3.2	3.2	3.2	3.2	3.2
Average	3.3	3.4		3.2		3.4

In all cases the work was judged to be at or above “capable.” The provided coursework clearly showed that the students in EE 321 were meaningfully engaged in endeavors associated with each of the ABET outcomes this course is supposed to address. The work was judged to be at “capable” level in the four outcomes.

The course instructor, Prof. Tom Fischer shared some thoughts and comments based on his observations throughout the semester:

1. **Quizzes not effective:** Quizzes were given, all previously announced, as a tool to increase student preparation for class and to provide feedback to the instructor regarding student retention of the material covered in lecture and homework. Quiz scores generally were poor, averaging about 10/20 over the five quizzes graded. The instructor found it remarkable how little the students retained of the examples covered in lecture or the problems completed in homework. Students appear to make little effort to integrate the topics covered into their retained understanding except in preparation for tests or the final exam.
2. Many students began the semester with poor understanding of how to derive differential equations for passive electrical circuits.
3. The teaching of EE 321 is independent of the teaching of EE 352 (the circuits laboratory course). It would likely help student learning to have the material in the two classes better coordinated.

4. EE 416, Electrical Engineering Design

EE 416 is the capstone senior design course. It is the second course in a two-semester sequence and is three credits. Teams consisting of four to five students work on large, “open ended” projects that are often sponsored by industry. The instructor for the past Spring semester, Pat Pedrow, provided access to all the course assignments for four teams judged to have performed at the “weak,” “medium_low,” “medium_high,” and “strong” level. The names assigned by the instructor to these teams were Tandoor, Michetta, Kulcha and Filone, respectively. Professors Krishnamoorthy Sivakumar (chair, EE Curriculum Committee), José Delgado-Frias (chair, CptE Curriculum

Committee), and Pat Pedrow (EE 416 course instructor) met in person on May 14, 2014, to assess achievement of student outcomes.

The assessment plan calls for the student work in EE 416 to be used to assess ABET outcomes A, C, H, and K. These outcomes, together with the performance indicators (shown in bold), that were targeted for assessment are:

- A. An ability to apply knowledge of mathematics, science and engineering.
 - 1. Chooses and implements problem solving strategies.**
 - 2. Analyzes and interprets information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words).**
 - 3. Converts information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words).**
 - 4. Completes calculations using data, equations, and techniques.**

- D. 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.
 - 1. Identifies technical specifications and establishes parameters considering constraints and variables to develop a problem statement for the design project.
 - 2. Decomposes the problem into a set of sub functions; a set of subsystems; and/or a sequence of actions.
 - 3. Generates multiple design concepts.
 - 4. Evaluates the design concepts and selects the most promising concept.
 - 5. Synthesizes the results of modeling, simulation, and prototyping to refine the design concept.**
 - 6. Recommends future work that seeks to improve the design while recognizing the limits and constraints placed on the project.**

- H. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
 - 1. Evaluates potential impacts of engineering solutions in global, economic, environmental and societal contexts to make a choice, decision, or action.**
 - 2. Evaluates stakeholder needs and perspectives in global, economic, environmental and societal contexts prior to implementing engineering solutions.**
 - 3. Analyzes risks and uncertainties associated with implementing engineering solutions in global, economic, environmental and societal contexts to make a choice, decision, or action.**

- K. Have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
 - 1. Uses modern engineering techniques, skills and tools (such as computer software, simulation packages, and diagnostic equipment) to make a choice, decision, or action.**
 - 2. Combines use of engineering tools plus system operating information to monitor performance, find optimal operating conditions, and/or develop designs.**

3. Evaluates which techniques or tools are most appropriate to complete a specific engineering task.

The scores were based on the overall degree to which the final report appeared to meet the stated outcome as judge from the perspective of the performance indicators (whether as a complete set or as some subset). It should be noted that, taken at face value, all the reports seemed to describe an impressive amount of work. However, the degree to which that work was properly documented was subject to variation.

The following table presents the scores for the teams.

Team	Outcome			
	A	C	H	K
Tandoor (weak)	2.77	2.85	2.75	2.68
Michetta (medium_low)	3.15	3.00	3.00	3.00
Kulcha (medium_high)	3.52	3.27	3.37	3.27
Filone (strong)	3.58	3.58	3.42	3.52

Team Tandoor project was to develop a system to buffer and route data transmitted serially from a mass spectrometry system, pass the data into a Graphics Processing Unit (GPU) which will perform various calculations on the data, and finally hand the data off to the PC for long term storage. This project was sponsored by Pacific Northwest National Laboratories (PNNL). The original goal was scaled back to implement three major blocks: the GTX Transceiver, the Storage System, and Data Conversion Block. The GTX block was verified; it provided correct decoding and alignment. The team used a Vertex 5 FPGA board to generate a test signal with a Texas instrument TLK2501 daughter card, to generate sample bursts of data. A memory controller was implemented as well. The Data Conversion Block was tested using a VHDL test bench. In the conclusion section the team reevaluated their approach and recommended modifications to the front end switch which would have the Data Conversion Block and take the data from the GTX. The team did demonstrate engineering competence (albeit in a limited way). The team did discuss some of the wider implications of the use of Liquid chromatography Mass spectrometry, especially in the context of the study of microbial systems as well as human and environmental health. The team used Xilinx on their ISE design tool set, Virtex 6 FPGA package, and MIG (Memory Interface Generator) IP core tool, the team was clearly competent in the use of techniques and tools for the practice.

Team Micheta's task was to analyze the spillway gate system at Avista's Little Falls hydro project in terms of existing control logic, equipment and power systems for the spillway gate. This project was done for Avista. The team's model consisted of: i) hardware, where a DC power supply, two SEL-421 relays and a user interface were designed and constructed; ii) software, where the control logic was modified to simulate the portions of the system that were not implemented in hardware. The interface included toggle switches and push buttons for inputs along with LEDs for outputs. The considered competing solutions and discussed why they made the choices they did (three options were considered for the One Line Design.) The team clearly did a good amount of work. The report had all the figures in appendices; this in turn made difficult to read and see the figure. They discussed, in some detail, broader impacts of their solution for instance the dam impact on

the new Native American fish hatchery. The team was obviously able to use the (advanced) tools at their disposal to obtain a working model. They did recognize some shortcomings of their design and provided suggestions for improvements. This was a sound work.

Team Kulcha’s project objective was the prevention of damage to induction motors and extended power outages along the Bonneville Power’s 115kV line during events where the Cold Creek substation experiences high residual voltages. The work was done for Benton County Public Utility District (BPUD). The team considered alternatives such as isolating the motors or the substation serving them. Team used PSCAD™/EMTDC™, an industry accepted transient modeling program developed by the Manitoba HVDC Research Centre. The team did a remarkable amount of work with technical work incorporated in the report. The team clearly documented how their work on the beta implementation. They discussed the broader impact of their solution (induction motors being damaged and economic benefits). They did recognize the shortcomings of their design and provided suggestions for improvements.

Team Filone designed, implemented, and tested an unmanned aerial system power system. This project was sponsored by Washington State University’s (WSU) Unmanned Aerial System (UAS) Club. The beta prototype implemented a system to provide energy to the UAS from two different sources: Lithium-Polymer batteries and a hydrogen fuel-cell. The hydrogen fuel-cell provides energy for cruise-flight and the battery-bank assists the power demands for in-flight maneuvers and takeoff. It appears the team did a remarkable amount of engineering. The team used a variety of tools to design and test the prototype. Team discussed broader impacts on a number of commercial, industrial, and agricultural sectors. There is brief mention of a positive impact on the environment. The team recommended some improvements such as the use of the novel IGBTs instead of MOSFETs; this in turn shows that students are aware of advances in transistor technology. The team was capable of using the modern engineering tools necessary to tackle challenging design problems. This was very solid work.

In conclusion, averaging the scores above (where there is more than one score for a particular outcome) yields:

	Outcome			
	A	C	H	K
Average	3.25	3.18	3.13	3.12

Senior design work was judged to be above “capable” for the four outcomes.

All the teams seem to implement designs that largely met the stated goals. All the teams appeared to have done solid engineering work; final reports do not necessarily document that work as fully as might be hoped. However, one should point out that students have multiple meetings with the course instructor, mentors, and faculty members. Students give a presentation in the form of a poster session with project demonstration. In conclusion, there is nothing in these reports that cause concern in terms of the technical abilities of the students.

5. Conclusions

Averaging the scores above (where there is more than one score for a particular outcome) yields:

	Outcome					
	A	B	C	E	H	K
Average	3.28	3.45	3.04	3.35	3.13	3.34

If one assigns equal weight to each outcomes and averages over these scores, the overall result is 3.27, i.e., slightly above “capable.” Indeed, all the outcomes assessed are achieved at or above the “capable” level. Compared to the course assessment in the last two academic years, the scores are comparable and there is no major concern about any particular outcome.

A summary of recommendations/action items:

1. For EE 214 projects, it is recommended that the assessment committee assess achievement of student outcomes in “real-time.” This activity must be coordinated with the course instructor/TA.
2. (Suggestion from Prof. Tom Fischer, EE 321 instructor): Create a student culture of professionalism. Encourage the IEEE student chapter of be actively engaged in this process. Specifically, have the ABET criteria A through K relevant to a course, and the respective performance indicators, given to each student at the beginning of each semester. Each student must then verify their individual successful accomplishment of each listed indicator, with the date of accomplishment submitted as part of the course record. This could be done on-line. Accomplishment must be verified by the TA or Instructor. Accomplishment could include such things as acceptable score on a test problem or project. The goal would be to better connect the criteria and performance indicators with student work and accomplishment. This is an action item for all EE courses. This will be discussed with the entire EE/CptE faculty at the next Faculty retreat.