Oregon Institute of Technology
Computer Systems Engineering Technology Department
Embedded Systems Engineering Technology Program Assessment
2011-12

I. Introduction

The Embedded Systems Engineering Technology (ESET) program was proposed to OUS in spring of 2006 and approved in August, 2006. The curriculum for the ESET program is common with the hardware and software programs for the freshman year. The sophomore year of the ESET program has been constructed to mirror the track through both the Computer Engineering Technology (CET) and Software Engineering Technology (CET) programs, called the Dual Degree program. The ESET program junior year is when ESET students get instruction specific to topics of embedded systems engineering. These courses were taught for the first time in fall, 2008.

II. Mission, Objectives and Program Student Learning Outcomes

The mission of the Embedded Systems Engineering Technology (ESET) Degree program within the Computer Systems Engineering Technology (CSET) Department at Oregon Institute of Technology is to prepare our students for productive careers in industry and government by providing an excellent education incorporating industry-relevant, applied laboratory based instruction in both the theory and application of embedded systems engineering. Our focus is educating students to meet the growing workforce demand in Oregon and elsewhere for graduates prepared in both hardware and software aspects of embedded systems. Major components of the ESET program's mission in the CSET Department are:

I. To educate a new generation of Embedded Systems Engineering Technology students to meet current and future industrial challenges and emerging embedded systems engineering trends.

II. To promote a sense of scholarship, leadership, and professional service among our graduates.

III. To enable our students to create, develop, apply, and disseminate knowledge within the embedded systems development environment.

IV. To expose our students to cross-disciplinary educational programs.

V. To provide government and high tech industry employers with graduates in embedded systems engineering and related professions.

Program Educational Objectives

The Program Educational Objectives reflect those attributes a student of the ESET program will practice in professional endeavors.

A. Graduates of the embedded program are expected to understand societal impact of embedded systems and technological solutions.

B. Graduates of embedded degree program are expected to do hardware/software co-design for embedded systems. Graduates will continue to develop skills in analysis, approach, optimization, and implementation of embedded systems.

C. Graduates of the embedded program are expected to obtain the knowledge, skills and capabilities necessary for immediate employment in embedded systems. Embedded Systems is a profession increasingly driven by advances in technology, therefore graduates are expected to obtain the necessary life-long learning skills to enable them to be able to adapt to a changing environment.

D. Graduates of the embedded program are expected to develop a broad base of skills. These skills will prepare them for professional practice: 1) as embedded engineers, 2) participants in embedded development teams, and 3) effective communicators within a multidisciplinary team.

E. Graduates of the embedded program are expected to acquire knowledge of management and marketing of embedded projects and products and to prepare for series production.

Program Student Learning Outcomes

Embedded Systems Engineering Technology baccalaureate graduates will be engaged in:

1. Application of mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems (Objectives C, D, E).

2. Application of project management techniques to embedded systems projects (Objectives C and D).

3. Application of knowledge of embedded systems engineering technology, along with some specialization in at least one area of computer systems engineering technology. (Objective D)

4. A broad education and knowledge of contemporary issues necessary to reason about the impact of embedded system based solutions to situations arising in society. (Objective A)

5. Identification and synthesis of solutions for embedded systems problems. (Objective B, C)

6. Design, execution and evaluation of experiments on embedded platforms. (Objective C, D)

7. Analysis, design and testing of systems that include both hardware and software. (Objective B, D)

8. Documenting the experimental processes and to writing of satisfactory technical reports/papers. (Objective D, E)

9. Delivery of technical oral presentations and interacting with a presentation audience. (Objective D, E)

10. Recognition for and the motivation to further develop their knowledge and skills as embedded engineering advances occur in industry. (Objective C)

11. Working effectively, independently, and in multi-person teams. (Objective D)

12. Professional and ethical execution of responsibilities. (Objective A, D)

III. Three-Year Cycle for Assessment of Student Learning Outcomes

Assessment activities for the ESET program began Fall, 2008. Table 1 presents planned learning outcome assessment on a three year cycle. The rows of this table correspond to the PSLO. The entries in the cells corresponding to the year represent mapping from the row (PSLO) to the ISLO. The number in the cells of the table corresponds to the ISLO defined for the OIT assessment cycle:

- ISLO 1: OIT students will demonstrate effective oral, written and visual communication.
- ISLO 2: OIT students will demonstrate the ability to work effectively in teams and/or groups.
- ISLO 3: OIT students will demonstrate an understanding of professionalism and ethical practice.
- ISLO 4: OIT students will demonstrate critical thinking and problem solving.
- ISLO 5: OIT students will demonstrate knowledge and understanding of career development and lifelong learning.
- ISLO 6: OIT students will demonstrate mathematical knowledge and skills.
- ISLO 7: OIT students will demonstrate scientific knowledge and skills in scientific reasoning.
- ISLO 8: OIT students will demonstrate cultural awareness.

Table 1: Baccalaureate Outcome Assessment Timeline

#	**Learning Outcomes**	**08-09**	**09-10**	**10-11**	**11-12**	**12-13**	**13-14**
1	The ability to apply mathematics including differential and integral	**6**			**6**		

	calculus, probability, and discrete mathematics to hardware and software problems.						
2	An ability to apply project management techniques to embedded systems projects.		**2, 3**			**2, 3**	
3	Knowledge of embedded systems engineering technology, along with some specialization in at least one area of computer systems engineering technology.			**4**			**4**
4	A broad education and knowledge of contemporary issues necessary to reason about the impact of embedded system based solutions to situations arising in society.		**3, 8**			**3, 8**	
5	The ability to identify and synthesize solutions for embedded system problems.			**4**			**4**
6	The ability to design, conduct and evaluate the results of experiments on embedded platforms.	**7**			**7**		
7	The ability to analyze, design and test systems that include both hardware and software.	**7**			**7**		
8	The ability to document experimental processes and to write satisfactory technical reports/papers.			**1**			**1**
9	The ability to make technical oral presentations and interact with an audience.			**1**			**1**
10	The recognition for and the motivation to further develop their knowledge and skills as embedded engineering advances occur in industry.			**5**			**5**
11	The ability to work effectively independently and in multi-person		**2**			**2**	

	teams.						
12	An understanding of professional and ethical responsibility.		**3, 8**			**3, 8**	

To summarize, Table 2 shows the program learning outcomes (identified by number only) that will be assessed for each of the next three years.

Table 2: Summary of Assessment Timeline

Academic Year	Outcomes
2011-12	1, 6, 7
2012-13	2, 4, 11, 12
2013-14	3, 5, 8, 9, 10

Outcomes to be assessed are listed below:

1. Application of mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.
6. Design, execution and evaluation of experiments on embedded platforms.
7. Analysis, design and testing of systems that include both hardware and software.

Target courses where the assessment tools were to be applied for the 2011-12 academic year are summarized in Table 3.

Table 3: 2011 – 2012 Summary Courses of Assessment Application

Outcome	Courses	Term
1	CST 466 – Embedded Systems Security CST 417 – Embedded Networks CST 315 – Embedded Sensor Interfacing and I/O	Spring Fall Fall
6	CST 347 – Real-Time Operating Systems CST 455 – System on a Chip	Spring Fall
7	CST 345 – Hardware/Software Co-Design CST 204 – Micro Controllers	Winter Spring

IV. Summary of 2011-12 Assessment Activities

The following are the direct assessment activities that were accomplished during 2011-12 academic year. Each activity is introduced with a description of the activity followed by a table that summarized the rubric criteria along with the rubric application results. Where available, the rubric used for assessment is shown in Appendix A.

PSLO #1

The ability to apply mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.

CST 315 – Embedded Sensor and Interfacing IO: Fall 2011

The primary element assessed focused on graphical representation comprehension.

Data Collection Date: 09/14-19/2012 Coordinator: Claude Kansaku

Assessment Method 1: A question was given in the first exam of CST 315. The question presented a semi-log graph of the frequency response of a low-pass filter without identifying it as such. The student must be able to recognize the shape of the frequency response plot as that of a low-pass filter. Furthermore, the student must be able to use a linear y-axis decibel value to determine the corresponding frequency value from the logarithmic x-axis.

Assessment Method 2: A question was given in the first exam of CST 315. The question presented a problem that required students to setup and integral to compute the average value of a function.

The results are shown in Table 4.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Method 1: Recognize the semi-log template for a passive low-pass filter	Written question	Correct/incorrect	80% correct	10 of 12 83%
Method 1: Locate the cutoff frequency on the semi-log graph as defined by -3db of attenuation	Written question	Correct/incorrect	70% correct	2 of 12 17%
Method 2: Formulate the integral	Written question	Correct/incorrect	70% correct	10 of 12 83%
Method 2: Correctly derive the average	Written question	Correct/incorrect	70% correct	7 of 12 58%

Table 4 – CST 315: Embedded Sensor and Interfacing IO

Evaluation of results: Students were weak in the application of mathematical theory to practical applications. Students could successfully recognize and formulate solutions; however, in using the formulations to correctly solve the problem, students fell short of expectations.

Actions: Students need to be given more practice with the application of formulations to solve practical problems. This should be done in the addition of practice problems to assignments as well as additional instruction in class and during labs.

CST 417 – Embedded Networks: Fall 2011

The primary element assessed focused on problem formulation and application of calculus.

Data Collection Date: 11/05/2011 Coordinator: Eric Egalite

Assessment Method: Students were given a problem to perform a calculation on network packet loss given a mathematical model of the network and input parameters. Results are given in Table 5.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Understanding of Mathematical Model	Written Problem	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	4 of 4 100%
Application of Mathematical Model	Written Problem	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	3 of 4 75%
Derivation of Correct Outcome	Written Problem	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	3 of 4 75%

Table 5 – Assessment results for CST 417, Embedded Networks

Evaluation of results: Students performed at an acceptable level for this exercise.

Actions: No actions recommended.

CST 466 – Embedded System Security: Spring 2012

The primary element assessed focused on problem formulation and application of calculus.

Data Collection Date: 05/30/2012 Coordinator: Phong Nguyen

Assessment Method: Test questions were given related to GCD, Diffie Hellman and RSA key generation, encryption and decryption calculations. Answers to the questions were evaluated for accuracy.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Single Algorithm Use	Test Questions	Correct(3)/ Incorrect(1)/ Not Attempted(0)	Correct (3)	10 of 10 100%
Composite Algorithm Use	Test Questions	Correct(3)/ Incorrect(1)/ Not Attempted(0)	Correct (3)	7 of 10 70%
Algorithm Validation	Test Questions	Correct(3)/ Incorrect(1)/ Not Attempted(0)	Correct (3)	8 of 10 80%
Algorithm Aggregation for Problem Solving	Test Questions	Correct(3)/ Incorrect(1)/ Not Attempted(0)	Correct (3)	6 of 10 60%
Algorithm Analysis	Test Questions	Correct(3)/ Incorrect(1)/ Not Attempted(0)	Correct (3)	5 of 10 50%

Table 6 – Assessment outcome results for CST 466: Embedded Systems Security

Evaluation of results: Single and multiple input algorithm understanding is good as well as applying validation methods to determine correct algorithm outcome. The more complicated activities of aggregating multiple algorithm steps and outcomes to achieve a result were lacking as well as the ability the give an analytical description of an algorithm application.

Actions: More complicated examples of algorithms and how results can aggregate as input and output variable need to be presented to students. Students also need to have additional assignments where they give written analysis of complex algorithms after reading technical papers related to the algorithm being analyzed.

PSLO #6

The ability to design, conduct and evaluate the results of experiments on embedded platforms.

CST 347 – Real-Time Operating Systems: Spring 2012

The primary element assessed was the outcome of the real-time scheduling project.

Data Collection Date: 05/30/2012 Coordinator: Eric Egalite

Assessment Method: A project was given to the students related to the modification of a real-time scheduling algorithm in an existing real-time kernel. The goal was to achieve results for a new type of scheduling behavior through modification of the existing code base. The real-time scheduling project was collected and the outcome of the different scheduling paradigms was looked at to assess student understanding of experiment outcome hypothesis, test creation, system implementation, and outcome explanation. The results of this assessment are given in Table 7.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Hypothesis	Written Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	2 of 2 100%
Test Creation	Written Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	2 of 2 100%
Implementation	Written Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	2 of 2 100%
Outcome	Written Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	2 of 2 100%

Table 7 – Embedded experimentation assessment outcome results for CST 347: Real-time Operating Systems

Evaluation of results: Students were to successfully complete the assignment. The number of students in the sample space is small; however, there were no problems in successful completion of the assignment.

Actions: No required actions.

CST 455 – System on a Chip: Fall 2011
Although scheduled, assessment results were not received from this course.

PSLO #7
The ability to analyze, design and test systems that include both hardware and software.

CST 204 – Micro controllers: Spring 2012
Although scheduled, assessment results were not received from this course.

CST 345 – Hardware/Software Co-design: Winter 2012

The Hardware/Software Co-design course brings concepts of software and hardware design into a single activity resulting in more robust SOPC designs.

Data Collection Date: 03/29/2012 Coordinator: Ralph Carestia

Assessment Method: Junior level students in the ESET and CET program Hardware/Software Codesign class were given a laboratory problem where they had to develop an IP for a keypad and construct an interrupt driven keypad controller for PicoBlaze microcontroller, simulate the design and Test in the Xilinx ISE/Modelsim environment. They were to synthesize the design with Xilinx or Mentor Graphics Precision CAE tool, analyze and simulate the results with Modelsim. Finally they had to create the integrated logic analyzer (ILA and ICON core) and use ChipScope-Pro to analyze the results. Even though other learning outcomes could have been used with this problem, it was primarily evaluated, assessed and analyzed under learning outcome #2.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Knowledge	Lab Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	6 of 8 75%
Analysis	Lab Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	4 of 8 50%
Fabrication	Lab Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	8 of 8 100%
Testing	Lab Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	4 of 8 50%
Test Interpretation	Lab Assignment	No Proficiency (1)/ Some Proficiency (2)/ Proficiency (3)/ High Proficiency (4)	Proficiency (3)	4 of 8 50%

Table 8 – Assessment outcome results for CST 345 – *Hardware/Software Co-Design*

Evaluation of results: Students did well in their ability to understand the problem, gathering information. However the junior in the class struggled in developing a plan to solve, develop the Verilog code for the solution. They were able to fabricate the design however this was minimal in this class since most went inside the chip. They struggled in the area of being able test the design, at the junior level; however the seniors were able test appropriately due to having more experience in testing from the additional classes that they had. Juniors need to have additional instruction in carrying out procedure for testing and being able to interpret, evaluate results, and make changes from those results.

Actions: It appears that at the junior level students need additional work in testing – (it is assumed this happens in the senior year). Senior students in the class were able to handle this without a problem – the senior duals had software testing and hardware testing in classes prior to the CST 345 class.

V. Summary of Student Learning

PSLO #1

The ability to apply mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.

Action Items: Students perform at an acceptable level with respect to understanding mathematical constructs and formulation of solutions for single level mathematical aggregations. Issues occurred with more complicated problems and the application of formulations to produce solutions to problems. More material needs to be both presented and practiced related to composite mathematical constructs and use of formulations to produce results.

PSLO #6

The ability to design, conduct and evaluate the results of experiments on embedded platforms.

Action Items: In the activity students engaged in for this PSLO, there were no shortcomings. Due to issues with assessment understanding and timing, one of the assessment activities was not completed. In the next cycle, an assessment activity will also be performed in CST 455 – System on a Chip.

PSLO #7

The ability to analyze, design and test systems that include both hardware and software.

Action Items: In the assessment activity performed for this cycle, it was determined that more work needs to be done related to system testing prior to taking this course in which the assessment is being performed. It was clear that ESET students were deficient in testing knowledge as a result of issues in scheduling and staffing a testing course targeted specifically for embedded systems. Currently, ESET students are taking the Software Systems Testing course which does not cover all areas of knowledge required for ESET. Administration needs to allow courses to be taught with fewer than 10 students so the ESET program will have the ability to teach ESET students skills required of the degree. More teaching resources are required to fill this void.

VI. Changes Resulting from Assessment

THE FOLLOWING ACTION ITEMS WERE RECORDED IN THE 2008 – 2009 ASSESSMENT CYCLE:

PSLO #1

The ability to apply mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.

Actions: In the 2008-2009 Assessment report, a change was recommended for emphasis of the use of graphical representations of data for use in solving engineering problems to be done on both CST 162 and CST 315. This emphasis was done and students now have a better understanding of graphical representations. The deficiency now lies in the practical generation of results in more complicated mathematical formulations.

PSLO #6

The ability to design, conduct and evaluate the results of experiments on embedded platforms.

Actions: In the 2008-2009 assessment cycle, hypothesis creation and outcome analysis were cited as weak points for students, however, the data gathered provided inconclusive results. In this round of assessment, no deficiencies were detected.

PSLO #7

The ability to analyze, design and test systems that include both hardware and software.

Actions: In the 2008-2009 assessment cycle, the action item was for additional material to be developed on testing construction and execution for embedded systems. This was done. In this round of assessment, it was clear that the lack of a specific course for embedded systems testing was indeed impacting the ESET students. This shortcoming is not a curriculum constraint but a resource constraint.

Appendix A – Assessment Rubrics

PSLO #1

Application of mathematics including differential and integral calculus, probability, and discrete mathematics to hardware and software problems.

PSLO #6

Design, execution and evaluation of experiments on embedded platforms.

	Excellent **Score = 4**	**Good** **Score = 3**	**Fair** **Score = 2**	**Poor** **Score = 1**
Hypothesis	Hypothesis creation was clear and easy to understand.	Hypothesis had correlation to real-time systems; however, correlation was not clear.	Hypothesis was poorly formed.	Hypothesis had no correlation to desired real-time scheduling behavior.
Test Creation	Tests designed correlated directly to hypothesis assumptions.	Tests correlated to hypothesis; however, they were difficult to understand and results were hard to extract.	Tests partially tested hypothesis.	Test created did not test for hypothesis assumptions.
Implementation	Code written was easy to understand and performed designed tests.	Implementation worked and performed tests but code was pearly designed.	Implementation was buggy and performed sporadically.	Implementation was poorly done and did not perform tests.
Outcome	End results were analyzed and explained.	End results were analyzed; however, explanation did not draw from experimental results.	End results were enumerated with no real correlation to the hypothesis.	There was no analysis of outcome or explanation of results.

Table A1 – The rubric used in the assessment of PSL0 #6 in CST 347 – Real-Time Operating Systems