– Master of Science in Engineering (MSE) – 2018-19 Assessment Report

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Contents

1 Program Mission and Educational Objectives

1.1 Program Mission

The mission of the Master of Science in Engineering (MSE) program at Oregon Institute of Technology is to prepare engineering professionals with advanced knowledge and skills in high-demand multi-disciplinary engineering fields who are ready to assume a broad range of technical and leadership roles.

The MSE program supports the university mission of offering *"innovative, professionally-focused undergraduate and graduate degree programs"* and providing *"a hands-on, project-based learning environment,"* with an emphasis on *"innovation, scholarship, and applied research."* It is an applied professional MS program in engineering, designed to allow maximum flexibility while maintaining academic rigor. The flexibility in the MSE degree ensures a relevant, up-to-date educational experience, and the ability to meet emergent industry needs in multidisciplinary technical fields. The program also aligns with the university core themes (*applied degree programs, student and graduate success, statewide educational opportunities, and public service*).

1.2 Program Educational Objectives

The following program educational objectives (PEO) reflect what graduates from the MSE program should be able to acomplish within a few years of graduation, and stem directly from the program mission.

- PEO1: Graduates of the program will excel as professionals in a broad range of technical and leadership roles within the various fields of engineering.
- PEO2: Graduates of the program will demonstrate an ability to apply advanced engineering methods to the solution of complex problems involving one or more engineering disciplines.
- PEO3: Graduates of the program will demonstrate an ability to acquire emerging knowledge and remain current within their field.

2 Program Description and History

2.1 Program Description

The MSE program is designed as a highly customizable and modular MS engineering degree, which enables students to choose coursework from multiple disciplines to design specialties typically not available in the classical engineering MS degrees. MSE students have the ability to customize the MSE to be highly relevant to their professional interests. The flexibility to design a specialized or multidisciplinary degree program, while maintaining practical focus and academic rigor, is the defining element of the program and is what makes it such a close match to the interdisciplinary environment in today's fast changing industries. This ensures a relevant, up-to-date educational experience, and the ability to meet urgent industry needs in multidisciplinary technical fields.

The MSE program offers several tracks or specialties (see Table 1) in differentiated areas that the faculty, in consultation with the Industry Advisory Board, have identified as high-demand fields. Depending on their interest and career goals, students can choose to complete a multidisciplinary, specialized, or a more classical MSE program. All of the tracks offer some degree of customization and they all have a mutidisciplinary element, with the track labeled *Multidisciplinary/No Specialty* being the most flexible.

Table 1: MSE Tracks/Specializations

Multidisciplinary
MSE (Multidisciplinary)
MSE in Systems Engineering
Specialized
MSE in Robotics, Autonomous Systems and Control
MSE in Embedded Systems Engineering
MSE in Optical Engineering
MSE in Power Systems Engineering
Classical
MSE in Electrical Engineering

2.2 Program Location

The Master of Science in Engineering (MSE) is offered at the Oregon Tech Portland Metro (PM) Campus, located in Wilsonville, on the south side of the Portland metropolitan area. The campus is situated in a wooded business park setting among several technology companies including Mentor Graphics, Rockwell Collins, and Xerox. The campus is conveniently located off Interstate 5 and a short walk away from the Wilsonville Station on the Westside Express Service (WES) commuter rail line that connects to Beaverton and the MAX Light Rail. Several core and elective courses are available in an online modality to provide increased flexibility and adapt to students' needs.

2.3 Program Brief History

The MS Engineering program originated in response to the increasing demand in technology companies within the state of Oregon for specific programs of study that do not fit the traditional engineering disciplines (e.g., electrical, mechanical, chemical, civil) but require a unique combination of coursework from these and other disciplines to address their particular workforce needs at the graduate level. With no similar programs in the Oregon University System (OUS), the program was designed to optimally complement the portfolio of M.S. degree programs in the classical engineering disciplines (electrical, civil, mechanical, etc.) offered by OUS universities.

In 2014, the Engineering and Technology Industry Council (ETIC) provided startup funding to develop the MSE program. The ETIC council included VP- and C-level leadership of key technology companies in Oregon including Intel, IBM Corporation, Tektronix, FEI, HP, Xerox, and others. ETIC identified an increasing market demand for this type of flexible multidisciplinary program, the lack of similar programs in the State of Oregon, and the alignment with the ETIC mission (serving urgent critical needs in engineering, upgrading existing talent, and producing new talent).

Following internal review and approval by the university's Graduate Council, an external panel was formed to evaluate the proposed Masters of Science in Engineering at the Oregon Institute of Technology as part of the Oregon University System (OUS) review process. The evaluation was conducted using criteria set forth in the IMD 2.015(2) for review of new academic programs. This review included an evaluation of the proposed program, faculty and resources associated to the program as well as the need for the new program. As part of this review, a site visit was conducted on the Wilsonville Campus of OIT on April 24, 2015. The results of the external review were positive, with the report concluding that *"[...] the faculty and staff at the OIT Wilsonville campus are more than capable to launch the defined Masters of Science in Engineering program immediately. The program seems well suited to the student population, builds off existing expertise, and responds directly to industry's needs in the greater Portland area."*

The launch of a new program for Oregon Tech, M.S. in Engineering (with Specialties) was approved by the Statewide Provosts Council (May 2015), the Oregon State Board of Higher Education (June 2015), and the Higher Education Coordinating Commission (HECC) on August 13, 2015.

The MSE program was subsequently launched in Fall 2017, with the first cohort of students graduating from the program in 2019. Table 2 provide the enrollment and graduation numbers for the last 5 years.

Table 2: MSE Enrollment and Graduation History

Academic Year	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Enrolment (HC)	–	–	–	19	33
Graduates	–	–	–	–	6

3 Program Student Learning Outcomes

3.1 Program Outcomes

Consistent with the program mission and objectives, the MSE program possesses specific measurable outcomes. The outcomes state specific knowledge, skills, and experiences that students should have attained by the time of graduation. Graduating students in the MSE program will demonstrate:

a an ability to conduct research and development involving one or more engineering disciplines.

b an ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.

MSE students who are graduating from the accelerated BS+MSE degree program are expected to also meet the program-level outcomes associated with their undergraduate program, as well as the institutional-level essential student learning outcomes (ESLOs). Information about these outcomes can be found in the corresponding report for the undergraduate program, and the ESLO university reports, available on the Oregon Tech's Essential Studies website (*https://www.oit.edu/faculty-staff/provost/academic-excellence/essential–studies*).

3.2 Assessment Methodology

The mission, objectives and outcomes for the MSE program are reviewed annually by the department at the fall retreat during Convocation. They are also reviewed periodically by the department's Industry Advisory Council (IAC). This periodic review ensures the continued alignment between the MSE program, the university mission, and the evolving industry needs.

Assessment of the program outcomes is conducted annually using both direct and indirect measures. Direct measures are collected by teaching faculty in core courses in the curriculum, typically via assignments or assessments that are integral to the course. Direct measures of attainment of all program outcomes is also collected in the MS thesis or project, as this represents the culminating product of the students' learning. Indirect assessment of outcomes is also performed annually by means of an exit survey that is distributed to all graduating students. As part of the survey, graduating students perform a self-assessment of their level of attainment of the different program outcomes.

The assessment results are compiled by the MSE Assessment Coordinator into a single document by the end of spring term. During the following fall term, faculty meet to review and discuss the assessment results of the previous academic year, in the annual Closing-the-Loop meeting. In these meetings, the faculty may identify particular results that fall below the expected level of attainment, or trends in assessment data that merit special attention. At this time, faculty may propose or discuss programmatic changes or changes to the assessment methodology as needed in order to increase the level of attainment beyond the set threshold, or to improve the quality of the assessment data.

4 Curriculum Map

The MSE curriculum map supports the development and attainments of the program outcomes. Table 3 provides a mapping of the courses in the MSE curriculum to each program outcome. The table identifies how each program outcome appears within the curriculum at the *Foundation* (Introduction), *Practice* (Reinforcement and Application) and *Capstone* (Synthesis) levels.

Table 3: MSE Curriculum to Outcome Mapping

Course	**Outcome A**	**Outcome B**
Graduate Research, Development & Innovation (Required for all MSE Tracks)		
ENGR 511 Research Methods I	F, P	–
ENGR 512 Research Methods II	F, P	–
ENGR 513 Research Methods III	F, P	–
ENGR 59X Graduate R&D/Project/Thesis	C	C
ENGR 59X Graduate R&D/Project/Thesis	C	C
ENGR 59X Graduate R&D/Project/Thesis	C	C
MSE in Electrical Engineering		
EE 5XX EE Specialty Course I	–	F
EE 5XX EE Specialty Course II	–	F, P
EE 5XX EE Specialty Course III	–	P
Engineering Electives (12 cr)	Varies	
MSE in Automation, Robotics & Control Engineering		
ENGR 520 Engr. Modeling	–	F
ENGR 524 Adv. Control Engr.	–	F, P
ENGR 523 Motion Control	–	F, P
ENGR 521 Automation for Robotics	–	P
EE 530 Linear Systems & DSP	–	F, P
Engineering Electives (4 cr)	Varies	
MSE in Embedded Systems Engineering		
EE 535 Embedded Systems I	–	F
EE 555 Embedded Systems II	–	F, P
EE 565 Sensors & Instrumentation	–	P
Engineering Electives (12 cr)	Varies	
MSE in Optical Engineering		
EE 548 Geometric Optics	–	F
EE 549 Optical Detection & Radiometry	–	F
EE 550 Physical Optics	–	F
EE 551 Lasers	–	P
EE 552 Waveguides & Fiber Optics	–	P
EE 553 Optical Metrology	–	P
MSE in Power Systems Engineering		
REE 529 Power Systems Analysis	–	F
REE 549 Power Systems Protection & Cntrl	–	F, P
REE 569 Grid Integration of Renewables	–	P
Engineering Electives (16 cr)	Varies	
MSE in Systems Engineering		
SEM 521 Foundations of Systems Engr.	–	F
SEM 522 Advanced Systems Engr.	–	P
SEM 525 Advanced Engr. Mgmt.	–	F, P
Engineering Electives (12 cr)	Varies	

5 Assessment Cycle

The MSE student outcomes are assessed on an annual basis.

Direct assessment is performed according to Table 4. Outcome A is assessed in a core course required in all MSE tracks. Outcome B is assessed in a core course for each one of the MSE tracks. Both outcomes are also assessed in the graduate thesis or project, which is the culminating experience bringing together the different knowledge and skills acquired in the program.

Indirect assessment is conducted via a survey of graduating students, where the students rate their level of attainment for each of the program outcomes.

Table 4: MSE Annual Assessment of Student Outcomes

		Outcomes	
MSE Track	**Course with Direct Assessment**	A	B
All	ENGR 512 Research Methods II	√	
All	ENGR 59X Grad. R&D/Project/Thesis	√	√
MSE in Electrical Engineering	EE 501 Communication Systems		√
MSE in Aut., Robotics & Cntrl Engr.	ENGR 524 Adv. Control Engineering		√
MSE in Embedded Sys. Engr.	EE 555 Embedded Systems II		√
MSE in Optical Engr.	EE 552 Waveguides and Fiber Optics		√
MSE in Power Sys. Engr.	REE 549 Power Sys. Protection/Cntrl		√
MSE in Systems Engr.	SEM 522 Adv. Systems Engr.		√

6 Assessment Activity

6.1 Methodology for Assessment of Program Outcomes

Faculty in the MSE program perform direct assessment of program outcomes in their courses from Fall through Spring terms, according to Table 4. This assessment is performed using specific assignments or exam questions that target the particular outcome. A systematic, rubric-based process is then used to assess student attainment of the outcome based on a set of performance criteria. The rubrics are included in the Appendix. The results of all the assessment activities are then summarized in an annual assessment report. At the end of each academic year, the program faculty meet to review the assessment data at the annual Closing-The-Loop meeting.

Additionally, all graduating students are asked to fill out an anonymous exit survey. As part of the survey, students are asked to rate their level of attainment of the program outcomes. This provides an indirect assessment measure. The results of this indirect assessment are also included in the assessment report, and evaluated at the Closing-The-Loop meeting

The Closing-The-Loop meetings provide an opportunity to evaluate and compare assessment results, and discuss whether any changes are needed to the curriculum or to the assessment methodology in order to improve attainment of the outcomes or to improve effectiveness, objectivity, and consistency in the assessment methodology. By comparing assessment results over multiple years, faculty can also ascertain the effect of previous changes to curriculum or assessment methodology on outcome attainment or assessment results.

6.2 Summary of Direct Assessment for AY2018-19

The sections below describe the assessment activity and performance of students for each of the assessed program outcomes. The tables report the number of students performing at a 1-developing, 2-accomplished, and 3-exemplary level for each performance criteria, as well as the percentage of students performing at an accomplished level or above. The departmentally established objective is to have at least 80% of students performing at an accomplished level or better. If a smaller percentage of students is meeting this threshold in any of the performance criteria, this would be flagged as an area of concern and further action would be discussed at the Closing-The-Loop meeting.

6.2.1 Direct Assessment for Outcome a: an ability to conduct research and development involving one or more engineering disciplines.

This outcome was assessed in ENGR 512 Research Methods II and ENGR 597 Graduate Project, according to the performance criteria indicated in the Outcome (a) rubric, included in the Appendix.

Outcome (a) : ENGR 512, Winter 2019, Dr. Mateo Aboy

This outcome was assessed in a project where students needed to select a MS R&D topic, define the problem and its significance, conduct a literature review, evaluate related R&D work, and consider the methods and materials needed to carry out the project. Two performance criteria (a.1 and a.2) were evaluated (research & planning). The last performance criterion (a.3) cannot be assessed at this point, since students do not get to implement their projects until the subsequent completion of their graduate project/thesis.

In total 13 students were assessed and 92.3% performed at an accomplished level or above in all assessed performance criteria. The results are summarized in Table 5.

Table 5: Outcome (a) : ENGR 512, Winter 2019, Dr. Mateo Aboy (N = 13)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
a.1 - Research	1	6	6	92.3%
a.2 - Planning	1	7	5	92.3%
a.3 - Implementation	–	–	–	–

Outcome (a) : ENGR 597, Spring 2019, Prof. Allan Douglas

This outcome was assessed in ENGR 597 - Graduate Project, in Spring 2019. The Graduate Project is a year-long (three-term) project that students typically complete in their final year of the MSE program, which involves a major design experience encompassing knowledge and skills gained through the program.

Students worked as a team to develop an underground remotely operated vehicle. Each student was responsible for design and implementation a different subsystem as well as integration of their subsystem into the complete project. Subsystems included user interface, power distribution, software architecture and framework, 2D LIDAR, and 3D LIDAR. This project required significant research, development, time management, and the use of advanced engineering concepts to implement.

A total of 5 students were assessed in Spring 2019. The results of this assessment are presented in Table 6

Table 6: Outcome (a) : ENGR 597, Spring 2019, Prof. Allan Douglas (N = 5)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
a.1 - Research	–	1	4	100%
a.2 - Planning	1	3	1	80.0%
a.3 - Implementation	–	5	–	100%

6.2.2 Direct Assessment for Outcome b: an ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.

This outcome was assessed in one of the required courses for each track of the MSE program, as well as ENGR 597 Graduate Project, according to.the performance criteria indicated in the Outcome (b) rubric, included in the Appendix.

Outcome (b) : EE 501, Spring 2019, Dr. Scher

This outcome was assessed in EE 501 - Communication Systems in Spring 2019 by a project in which students design audio modems for encoding and decoding PSK31 messages. Students were expected to implement the modem using a "software defined acoustic radio" in the form of a laptop running Simulink to read and write samples to the computer's audio devices for encoding and decoding messages in real time. Students were asked to demonstrate their design using a laptop transmitter to send digital text messages via modulated audio signals from laptop's speakers. A second laptop receives the audio signals via its microphone to demodulate and decode the signals to retrieve the original text message.

The project is open-ended in the sense that there are multiple engineering solutions and approaches. Success was defined as a modem that could communicate with a standard "off-the-shelf" software modem that can decode/encode RTTY/PSK31 packets (such as cocoaModem). Students were also expected to submit a report that contains a history, description, application, and use of PSK31 digital modes in amateur radio. The report was also required to contain a description of the Simulink modem and test results, including a characterization of the performance of the modem. This assignment relates to the outcome because it requires students to apply engineering concepts, methods, and principles learned in class to solve a technical problem of adequate complexity.

Table 7 summarizes the results of this targeted assessment. The results indicate that the minimum acceptable performance level of 80% was met on all performance criteria for this program outcome.

Table 7: Outcome (b) : EE 501, Spring 2019, Dr. Aaron Scher (N = 2)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	–	2	–	100%
b.2 - Design	–	2	–	100%
b.3 - Evaluation	–	2	–	100%

Outcome (b) : ENGR 524, Winter 2019, Dr. Melendy

This outcome was assessed in ENGR 524 - Advanced Control Engineering during the Winter 2019 term via (1) a problem set; (2) a lab simulation.The purpose of assignments (1) and (2) was to assess student's advanced mathematical and control engineering knowledge base and methods to solve a variety of problems relevant to discrete-time control systems.

Both the problem set and lab simulation consisted of problems that required the application of series calculus, stability concepts from control system engineering, differential equations, and Matlab programming.

Students were expected to apply their conceptual knowledge of differential equations, series calculus, classical control systems, and Matlab programming to solve and simulate a small variety of complex transformations, as well as understanding how to use Matlab to plot a discrete impulse response h(n) of a discrete system suitable for implementation in a control system.Table 8 summarizes the results of this assessment.

Table 8: Outcome (b) : ENGR 524, Winter 2019, Dr. Robert Melendy (N = 5)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	1	–	4	80.0%
b.2 - Design	1	–	4	80.0%
b.3 - Evaluation	1	–	4	80.0%

Outcome (b) : EE 555, Winter 2019, Prof. Douglas

This outcome was assessed in EE 555 - Embedded Systems II during the Winter 2019 term. Students were asked to design software to implement a machine vision embedded system using a modern nVidia graphic processing unit (GPU). This project consisted of 8 separate labs and spanned the entire academic term.

This project is very complex and required application of advanced engineering concepts, methods and principles to implement the solution. Each student had a unique approach to solving the technical challenges. Nine students were assessed. Table 9 summarizes the results of this assessment.

Table 9: Outcome (b) : EE 555, Winter 2019, Prof. Allan Douglas (N = 9)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	–	3	6	100%
b.2 - Design	1	2	6	88.9%
b.3 - Evaluation	–	6	3	100%

Outcome (b) : EE 552, Winter 2019, Dr. Prahl

The assignment to assess this outcome is to design a system to transmit a 2 Gbs signal over a given distance without the use of repeaters while maintaining a specific bit error rate. As part of their design, students must specify all components (source, detector, fiber, couplers, connectors), provide the operating characteristics of the components, and create a detailed power and bandwidth budget.

There were no students enrolled in EE 552 this year and therefore this assessment was not conducted, as Table 10 indicates.

Table 10: Outcome (b) : EE 552, Winter 2019, Dr. Scott Prahl (N = 0)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	–	–	–	N/A
b.2 - Design	–	–	–	N/A
b.3 - Evaluation	–	–	–	N/A

Outcome (b) : REE 549, Winter 2019, Dr. Venugopal

This outcome was assessed in REE 549 - Power Systems Protection and Control during the Winter 2019 term. Students were given a design project to assess this outcome. There were totally 4 assignments to carry on the project stage by stage.

In the first assignment students were asked to design a single line diagram of given power system transmission loop. The purpose of the assignment was to develop the basic understanding of the given specification and to develop power flow diagram accordingly. The second assignment of this project was to develop voltage control methods, including use of generator excitation control, tap changing and regulating transformers, static capacitors, static var systems and parallel transmission lines. The purpose of this assignment was to prepare an engineering design according to the constraints specified. The third assignment specifies the types of faults under which the performance of the designed project need to be tested. Using this assignment, the performance of the designed project under different fault conditions were tested. The fourth assignment was used to test the ability of students in selecting the breaker and fuse characteristics to handle the fault currents tested in assignment 3.

All the assignments were intended to test the understanding of the given problem, design an engineering project according to the specification, test the design performance for various real time fault situations and provide acceptable solution to handle the fault conditions. The results were submitted as an executive summary and detailed report for each case along with the data files. Table 11 summarizes the results of this assessment.

Table 11: Outcome (b) : REE 549, Winter 2019, Dr. Chitra Venugopal (N = 2)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	–	2	–	100%
b.2 - Design	–	1	1	100%
b.3 - Evaluation	–	1	1	100%

Outcome (b) : SEM 522, Winter 2019, Prof. Eastham

This outcome was assessed in SEM522 - Advanced Systems Engineering in Winter 2019 by means of a homework assignment. The homework assignment required students to create a linear program (LP) model aimed at finding the optimum solution for a product mix problem. The model was created with assigned goal(s) and constraints. A mathematical representation of the model was developed along with the software model. A sensitivity analysis was conducted. Students consider how sensitive their model's solution was to changes or estimation errors which may occur in the objective function and constraint coefficients.

One student was considered "developing" for outcome b.1. A detailed mathematical model was not included in the assignment. However, the LP model was properly designed with acceptable goals, constraints, and results. Evaluation of the solution and sensitivity results were considered "accomplished". Table 12 summarizes the results of this assessment.

Table 12: Outcome (b) : SEM 522, Winter 2019, Prof. Eastham (N = 2)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	1	1	–	50.0%
b.2 - Design	–	1	1	100%
b.3 - Evaluation	–	1	1	100%

Outcome (b) : ENGR 597, Spring 2019, Prof. Allan Douglas

This outcome was assessed in ENGR 597 - Graduate Project, in Spring 2019. The Graduate Project is a year-long (three-term) project that students typically complete in their final year of the MSE program, which involves a major design experience encompassing knowledge and skills gained through the program.

Students worked as a team to develop an underground remotely operated vehicle. Each student was responsible for design and implementation a different subsystem as well as integration of their subsystem into the complete project. Subsystems included user interface, power distribution, software architecture and framework, 2D LIDAR, and 3D LIDAR. This project required significant research, development, time management, and the use of advanced engineering concepts to implement.

A total of 5 students were assessed in Spring 2019. The results of this assessment are presented in Table 13.

Table 13: Outcome (b) : ENGR 597, Spring 2019, Prof. Allan Douglas (N = 5)

Performance Criteria	1-Developing	2-Accomplished	3-Exemplary	% Students ≥ 2
b.1 - Definition	–	–	5	100%
b.2 - Design	–	3	2	100%
b.3 - Evaluation	–	1	4	100%

6.3 Summary of Indirect Assessment for AY2018-19

In addition to direct assessment measures, the program outcomes are indirectly assessed through an exit survey of graduating students.

The survey includes the following questions for all students graduating with a MSE degree:

- **Q MSE 1 - Program Student Learning Outcomes for M.S. Engineering. Please rate your proficiency in the following areas:**
  (Limited Proficiency / Proficiency / High Proficiency)
  - (1.a) An ability to conduct research and development involving one or more engineering disciplines.
  - (1.b) An ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.
- **Q MSE 2 - Program Student Learning Outcomes for M.S. Engineering. How much has your experience at Oregon Tech contributed to your knowledge, skills, and personal development in these areas?**
  (Barely Contributed/ Contributed / Highly Contributed)
  - (2.a) An ability to conduct research and development involving one or more engineering disciplines.
  - (2.b) An ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.

This was the first year that the MSE program had graduating students, and the graduating class size was deemed too small to collect meaningful data. Therefore, no indirect assessment data was collected for AY2018-19. We expect the first set of indirect assessment data will be collected in AY2019-20.

7 Changes Resulting From Assessment

This section describes the changes resulting from the assessment activities carried out during AY2018-19.

The MSE faculty met on October 3, 2019 to review the assessment results and determine whether any changes are needed to the MSE curriculum or assessment methodology based on the results presented in this document. The objective set for all programs in the EERE department is to have at least 80% of the students perform at the level of accomplished or exemplary in all performance criteria of the assessed outcomes. Results below this attainment level would prompt a closer look and further discussion to determine appropriate course of action.

Tables 14 and 15 provide a summary of the 2018-19 direct assessment results for outcomes (a) and (b), respectively.

Table 14: Summary of MSE direct assessment for outcome (a) during AY2018-19.

Outcome (a): An ability to conduct research and development involving one or more engineering disciplines.		
	Students ≥ 2	% Students ≥ 2
ENGR 512, Winter 2019, Dr. Mateo Aboy (N = 13)		
1 - Research	12	92.3%
2 - Planning	12	92.3%
3 - Implementation	–	–
ENGR 597, Spring 2019, Prof. Allan Douglas (N = 5)		
1 - Research	5	100%
2 - Planning	4	100%
3 - Implementation	5	100%

Table 15: Summary of MSE direct assessment for outcome (b) during AY2018-19.

Outcome (b): An ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.		
	Students ≥ 2	% Students ≥ 2
EE 501, Spring 2019, Dr. Scher (N = 2)		
1 - Definition	2	100%
2 - Design	2	100%
3 - Evaluation	2	100%
ENGR 524, Winter 2019, Dr. Melendy (N = 5)		
1 - Definition	4	80%
2 - Design	4	80%
3 - Evaluation	4	80%
EE 555, Winter 2019, Prof. Douglas (N = 9)		
1 - Definition	9	100%
2 - Design	8	88.9%
3 - Evaluation	9	100%
EE 552, Winter 2019, Dr. Prahl (N = 0)		
1 - Definition	–	–
2 - Design	–	–
3 - Evaluation	–	–
REE 549, Winter 2019, Dr. Venugopal (N = 2)		
1 - Definition	2	100%
2 - Design	2	100%
3 - Evaluation	2	100%
SEM 522, Winter 2019, Prof. Eastham (N = 2)		
1 - Definition	1	50.0%
2 - Design	2	100%
3 - Evaluation	2	100%
ENGR 597, Spring 2019, Prof. Douglas (N = 5)		
1 - Definition	5	100%
2 - Design	5	100%
3 - Evaluation	5	100%

7.1 Curricular Changes Resulting from the 2018-19 Assessment

Summary tables 14 and 15 show that the outcomes were attained at the established level of 80% in all performance criteria, with the exception of outcome (b) in SEM 522, where one of the performance criteria was below this threshold. Prof. Eastham explained that one of the two students evaluated failed to submit that part of the assignment, so there was no basis for evaluation of the performance criterion in question.

Given the small student sample sizes (N=2 in this particular case), it is difficult to draw meaningful conclusions from the data, and faculty generally agreed that more data needs to be collected before curriculum weaknesses or need for curriculum changes can be identified. It was suggested that faculty should try to find means of encouraging completion of all portions of the assessment assignment (by providing clearer instructions, assigning significant weight for grading purposes, etc.).

7.2 Changes to Assessment Methodology

Faculty reviewed and approved the exit survey questions for the indirect assessment of outcomes, which will be sent out to all MSE students graduating from Fall 2019 onwards.

Since this was the first year assessment data was collected for the MSE program, faculty were also given an opportunity to provide feedback regarding the assessment methodology and assessment instruments (assessment cycle, courses, methods, rubrics, etc.), and suggest any changes or improvements.

It was recommended that in the future the MS Project/Thesis Evaluation Rubric should be used by all faculty in the MS Project/Thesis Evaluation Committee to assess the attainment of the program outcomes. The MS Project/Thesis Evaluation Rubric (included in the Appendix) was generated with the collaboration of all the MSE faculty as a consistent means to evaluate and grade the graduate project or thesis that MSE students are required to complete as the culmination of their MS studies. One faculty member typically acts as an advisor for a project, but at the completion of the project, the work is evaluated by a committee of (typically) 2-4 faculty members to ensure the work meets the expected standards for the MSE degree. Given that this project/thesis encompasses the application of the knowledge and skills acquired during the program, it is an ideal place to evaluate achievement of program outcomes by the time of graduation. Having the different faculty in the project/thesis committee directly evaluate the level of attainment of the outcomes provides a measure which is more consistent and robust to inter-rater variability.

Given the small student sample sizes, which make it difficult to draw meaningful conclusions from the data, another recommendation was to evaluate data over a 3-year moving window. Since the outcomes are evaluated annually in the same courses using the same type of assignment, this should lead to increased sample sizes without affecting the integrity of the data by introducing confounding factors.

8 Closing the Loop: Evidence of Improvement in Student Learning

At the moment it is too early to see any trends in data or evaluate the effects of changes made in response to assessment results. Faculty in the MSE program will continue to monitor the proper implementation of the suggested changes to the assessment methodology, as well as the corresponding effects on the student learning and the assessment process.

9 APPENDIX: MSE Program Rubrics

9.1 Rubric for Assessment of Outcome (a): An ability to conduct research and development involving one or more engineering disciplines.

9.2 Rubric for Assessment of Outcome (b): An ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.

9.3 Rubric for MS Thesis/Project Evaluation

MS ENGINEERING - RUBRIC FOR STUDENT OUTCOME (A)

OUTCOME (A): AN ABILITY TO CONDUCT RESEARCH AND DEVELOPMENT INVOLVING ONE OR MORE ENGINEERING DISCIPLINES

PERFORMANCE CRITERIA	1-DEVELOPING	2 – ACCOMPLISHED	3 - EXEMPLARY
A.1 Research and Information Gathering Student is able to identify adequate sources, effectively gather relevant information, and critically evaluate it.	• Limited or inadequate sources of information. • Information gathered is insufficient or lacks relevance, does not provide a solid understanding of the topic under study. • Critical evaluation of information gathered not provided or very limited.	• Adequate and sufficient sources of information. • Information gathered is relevant and sufficient to provide a solid understanding of the topic under study. • Some critical evaluation of information gathered and its applicability.	• Sources of information are adequate and thoroughly cover all relevant aspects of the topic under study. • Information gathered is extensive and relevant, providing an in-depth understanding of the topic under study. • Thorough critical evaluation of information gathered and its applicability to the particular context.
A.2 Planning Student is able to define a technical project in terms of objective outcomes, and to generate a plan outlining the time, resources, and methodologies needed to achieve those outcomes.	• No clear definition of objective outcomes. • Plan lacks detail or is inadequate for accomplishing the project outcomes.	• Objective outcomes clearly defined. • Plan has sufficient level of detail, including time, resources, and methodological steps, and is adequate for accomplishing the project outcomes.	• Objective outcomes clearly defined. • Plan is extremely well developed, including time, resources, and methodological steps, is adequate for accomplishing the project outcomes, and accounts for potential setbacks.
A.3 Implementation Student is able to develop or implement a creative solution to a technical problem involving one or more engineering disciplines.	• Does not follow a robust methodological approach to project implementation. • Does not adhere to project plan (outcomes, deadlines, resources, methods). • Shows limited creativity in the implementation of a solution to a technical problem.	• Follows a robust, methodological approach to project implementation. • Adheres reasonably well to project plan (outcomes, deadlines, resources, methods). • Shows a reasonable level of creativity in the implementation of a solution to a technical problem.	• Follows a robust, methodological approach to project implementation, and is able to adapt the methodology as needed to enhance the quality of the project implementation. • Adheres exceptionally well to project plan (outcomes, deadlines, resources, methods). • Shows an exceptional level of creativity in the implementation of a solution to a technical problem.

MS ENGINEERING - RUBRIC FOR STUDENT OUTCOME (B)

OUTCOME (B): AN ABILITY TO APPLY ADVANCED ENGINEERING CONCEPTS, METHODS AND PRINCIPLES TO SOLVE COMPLEX TECHNICAL PROBLEMS.

PERFORMANCE CRITERIA	1-DEVELOPING	2 – ACCOMPLISHED	3 - EXEMPLARY
B.1 Problem definition Student is able to identify the technical problem to be solved in its proper context and define it in engineering terms through the use of appropriate language, criteria, specifications, and constraints.	• Problem vaguely identified. Relevance or context not addressed or unclear. • Weak problem definition. Criteria are vague, subjective, or not relevant. Specifications and constraints are insufficient or unclear.	• Problem is identified, its relevance and context are minimally explained • Problem is adequately defined in engineering terms. Appropriate objective criteria are used. Specifications and constraints are clear and sufficient.	• Problem is clearly identified; its relevance and context are explained thoroughly and effectively. • Problem is clearly defined in engineering terms. Criteria are objective, relevant and adequately prioritized based on context. Specifications and constraints are clear and allow to thoroughly evaluate the effectiveness of the proposed solution in solving the problem.
B.2 Engineering Design Student is able to use engineering concepts, methods and principles in a creative and methodical way to devise an optimal solution that addresses the technical problem.	• Selects preliminary design based on criteria that are not well aligned with design specifications and constraints. • Describes design solution without articulated scientific or engineering principles. • Does not use iterative modifications in a systematic way to improve design. • Rudimentary use of engineering tools and methods in the design process. • Design meets some but not all specs/constraints.	• Provides subjective justification for preliminary design which aligns with design specifications and constraints. • Describes design solution using scientific or engineering concepts and principles. • Uses iterative modifications in a systematic way to improve design. • Uses engineering tools and methods effectively in the design process. • Design meets most or all specs/constraints.	• Provides objective justification for preliminary design which aligns with design specifications and constraints. • Describes design solution using scientific or engineering concepts and principles with great precision. • Uses iterative modifications in a systematic and effective way to improve design. • Shows mastery of engineering tools and methods in the design process. • Design meets or exceeds all specs/constraints.

B.3 Evaluation of Solution Student is able to characterize the performance of the design solution and discuss advantages, disadvantages, tradeoffs, and/or ideas for further improvement.	• Provides limited characterization of performance of the design solution. • Does not effectively communicate the advantages and limitations of the design solution. • Provides no or insufficient discussion of the design tradeoffs (i.e., how different design choices affect performance). • Provides no or vague suggestions for further improvement.	• Provides adequate characterization of performance of the design solution. • Briefly mentions the advantages and limitations of the design solution. • Provides brief discussion of the design tradeoffs (i.e., how different design choices affect performance). • Provides some reasonable suggestions for further improvement at a high level of generality.	• Provides thorough characterization of performance of the design solution. • Discusses the advantages and limitations of the design solution in detail. • Clearly articulates and discusses design tradeoffs (i.e., how different design choices affect performance). • Provides specific and detailed suggestions for further improvement.

MS ENGINEERING
GRADUATE THESIS/PROJECT EVALUATION RUBRIC

Student Name: ____

Type of Work: ❒ **MS Thesis** ❒ **MS Project**

Degree: ❒ **BS/MSE** ❒ **MSE** **Specialization:** ____________________

Evaluator's Name: ____

Date of Evaluation: ____

EVALUATION OF KEY AREAS:
(Please evaluate each one of the key areas according to how well the work produced by the candidate satisfies the descriptions provided. You may add any comments or observations to support or complement your assessment in each key area.)

1. Well Chosen Topic
Focuses narrowly on a specific research question or engineering design contribution; right scale and level of difficulty, relevant to the discipline, significant, makes an adequate contribution.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

2. Builds on Previous Research
The literature review shows awareness of wide range of relevant work and leading experts. The work motivates the chosen approach by citing appropriate published works and explains why alternate methods were not chosen.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

3. Strong Methodology
Presents a systematic approach (including testing and evaluation) to the overall research or design problem. The methodology followed is sound and adequate for the particular project/topic. Design decisions are adequately justified based on the application or sound design principles.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

4. Solid Understanding of the Discipline
Shows accuracy and rigor in the theoretical, design, and experimental aspects of the work; evidences sophisticated understanding of all relevant materials (sources, methods, theory, past results, etc.)

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

5. Adequate Use of Evidence
Accurate and critical use of data to interpret results; results are sufficient to assess the performance of the proposed solution and support conclusions.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

6. Comprehensive
Adequate coverage and discussion of the key issues, sources, results (answers the research question or R&D specification). Demonstrated ability to critically evaluate the validity and reliability of the work done.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

7. Conclusion and Future Work
Conclusion or summary succintly addresses the R&D problem, provides the key contributions made, and facilitates or guides future work on the topic.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

8. Communication
Clear and appropriate language throughout, excellent synthesis, awareness of limitations/ambiguity/nuance/complexity; clarity of expression, proper use of specialist vocabulary and figures.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

9. Satisfies Formal Criteria
Meets all the formal requirements in terms of format, style, length, formalities, etc.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

10. Overall Quality
Overall, the work is of appropriate quality in terms of content and format for a MS thesis or project.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

ASSESSMENT OF MSE PROGRAM OUTCOMES:
(Please evaluate each one of the following outcomes according to the degree to which the work produced by the candidate evidences achievement of the particular outcome. You may add any comments or observations to support or complement your assessment in each outcome.)

(a) An ability to conduct advanced research and development involving one or more engineering disciplines.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments

(b) An ability to apply advanced engineering concepts, methods and principles to solve complex technical problems.

❒ Developing ❒ Accomplished ❒ Exemplary

Evaluator's Comments