AC 2008-1279: THE ELECTRICAL ENGINEERING TECHNOLOGY PROGRAM OUTCOME ASSESSMENT PROCESS – DEVELOPMENT AND IMPLEMENTATION

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The Electrical Engineering Technology Program Outcome Assessment Process – Development and Implementation

Abstract

The Electrical Engineering Technology program developed a Program Outcomes assessment process in response to ABET accreditation requirements. The EET Program Outcomes capture the desired attributes that the EET program aspires to impart to its students through both the curriculum and academic experience. This paper details the assessment process developed by the program, as well as its implementation process during the 2006-2007 academic year. The program outcomes are identified in line with ABET's Technology Accreditation Commission (TAC) and grouped into three categories, Design and Troubleshoot ability, Depth of Technical Knowledge, and Professional Practice. A set of assessment tools has been identified for each category.

The overall average results for the three categories were obtained by using several assessment tools. The results revealed no major shortcomings in the EET students' achievement, i.e. the overall averaged results were above the targeted achievement levels. However, the results of the assessment tools identified areas which might benefit from improvement. Based on this assessment, recommendations are made for the purpose of continuous improvement. This paper provides information on the Program Outcomes assessment process issues and challenges and will be of benefit to engineering technology programs seeking accreditation or re-accreditation.

1. Introduction

The curriculum of the Electrical Engineering Technology program covers a broad based educational experience that emphasizes practical, hands-on laboratory work, closely coordinated with theoretical classroom discussion. Students receive a solid foundation of coursework in electric circuits, digital electronics, solid-state electronics, communications, power and electrical machinery.

The Electrical Engineering Technology program has developed a Program Outcomes assessment process to fulfill ABET accreditation requirements. The Assessment Process adopted ABET's program outcomes and grouped them into three categories; Design and Troubleshoot ability, Depth of Technical Knowledge, and Professional Practice. A set of assessment tools has been identified which include both direct and indirect assessment tools For each category.

2. EET Program Outcomes

The EET Program Outcomes capture the desired attributes that the EET program at School of Technology (SoT) aspires to impart to its students through both the curriculum and academic experience. The desired outcomes of the EET program were adopted from ABET's (a) through (k) outcomes[1] shown in Table 1 as Outcomes 1 through 11 as well as ABET's Electrical/Electronics Engineering Technology Program Criteria Outcomes[1] shown in Table 1 as Outcomes 12 through 16.

Table 1 Electrical Engineering Technology Program Outcomes [1]

Outcome 1	An appropriate mastery of the knowledge, techniques, skills and modern tools of the discipline (ABET 2.a)
Outcome 2	An ability to apply current knowledge and adapt emerging applications of mathematics, science, engineering and technology (ABET 2.b)
Outcome 3	An ability to conduct, analyze and interpret experiments and apply experimental results to improve processes (ABET 2.c)
Outcome 4	An ability to apply creativity in the design of systems, components or processes appropriate to the program objectives (ABET 2.d)
Outcome 5	An ability to function effectively on teams (ABET 2.e)
Outcome 6	An ability to identify, analyze and solve technical problems (ABET 2.f)
Outcome 7	An ability to communicate effectively (ABET 2.g)
Outcome 8	A recognition of the need for and ability to engage in lifelong learning (ABET 2.h)
Outcome 9	An ability to understand professional, ethical and social responsibilities (ABET 2.I)
Outcome 10	A respect for diversity and a knowledge of contemporary professional, societal and global issues (ABET 2.j)
Outcome 11	A commitment to quality, timeliness and continuous improvement (ABET 2.k)
Outcome 12	The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a)
Outcome 13	The application of physics or chemistry to electrical/electronic(s) circuits in a rigorous mathematical environment at or above the level of algebra and trigonometry. (ABET 8.b)
Outcome 14	The ability to analyze, design and implement control systems, instrumentation systems, communication systems or power systems. (ABET 8.c)
Outcome 15	The ability to apply project management techniques to electrical/electronic(s) systems. (ABET 8.d)
Outcome 16	The ability to utilize statistics/ probability, transform methods, discrete mathematics, or applied differential equations in support of electrical/electronic(s) systems. (ABET 8.e)

3. Assessment Tools

The target outcomes impact the EET program curriculum in areas related to basic and advanced Electrical Engineering Technology skills. The achievement standard is set at 70%. The EET program developed a set of assessment tools to measure the program outcomes defined in Table 1, in response to ABET Criterion 3 (Program Outcomes and Assessment). The Assessment tools include a combination of direct and indirect measures[2,3,4] of the EET Program. Examples of direct measures are the Senior Project Evaluation, the End of Semester Course Assessment and the Senior Exit Exam, the Senior Exit Survey represents an indirect measure. Table 2 shows the four assessment tools that were used. The individual assessment tools are fully described in sections 3.1 through 3.4.

Table 2 Assessment tools

Tool 1. Course Assessment	Tool 3. Senior Project Evaluation
Tool 2. Senior Exit Exam	Tool 4. Senior Exit Survey

3.1 Tool 1 - Course Assessment

For continuous improvement, faculty are required to conduct a Course Assessment at the end of each semester. The data will used to fine tune and improve the students learning experience[3]. Selected course assessments from senior year are used to measure program outcomes; courses are EET3225 (Special Electronics Devices), EET3281 (Electrical Project Development and Troubleshooting), EET4141 (Microcomputer Interfacing) and EET 4373 (Advanced Programmable Controllers). Table 3 shows Course Learning Objectives which capture the design and troubleshoot ability and mapping to the EET program outcomes.

Table 3 Senior Course Assessment Tool and EET Program Outcomes Mapping

EET Course	Course Learning Objectives	EET Program outcomes
EET3225	Demonstrate the ability to analyze and design linear integrated circuits used in signal conditioning and simple control system with an emphasis on practical application.	**Outcome 4.** An ability to apply creativity in the design of systems, components or processes appropriate to the program objectives (ABET 2.d) **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h)
EET3281	Demonstrate analytical and critical thinking in design and fabrication of a circuit board	**Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c). **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h)
EET4141 & EET4373	Demonstrate the ability to design, implement, and test a microcontroller application based on Motorola 68HC11 and understand practical design interface considerations. Demonstrate the ability to design, implement, and test a PLC based control system and understand the practical design interface considerations.	**Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c).

3.2 Tool 2 – Senior Exit Exam

The Senior Exit exam is necessary to measure students competence in areas identified as critical to the EET Program. The Exit Exam will consist of 50 MCQ questions with five questions for each representative course. Table 4 lists EET Program Outcomes targeted by the Standard Exit Exam and the course representative for each Outcome.

Table 4 List of EET Program Outcomes Targeted by Standard Exit Exam.

EET Program Outcomes	Electrical Engineering Technology Course	Representative Courses
a. **Outcome 12:** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a)	EET1120 EET2120 EET2141 EET2220 EET2233 EET2241 EET3225 EET3281 EET3353 EET3367 EET3373	EET1120 EET2120 EET2220 EET2141 EET3367
b. **Outcome 14:** The ability to analyze, design and implement control systems, instrumentation systems, communication systems or power systems. (ABET 8.c) c. **Outcome 16:** The ability to utilize statistics/ probability, transform methods, discrete mathematics, or applied differential equations in support of electrical/electronic(s) systems. (ABET 8.e)	EET 3225 EET 3281 EET 3353 EET 3373 EET 4311 EET 4141 EET 3390 EET 4311	EET2233 EET3373 EET3353 EET4141 EET4311

3.3 Tool 3 - Senior Project Evaluation

The Senior Project Evaluation comprises the student performance on the senior capstone project as measured by an examiner. The examiner attends the project presentations at the end of the semester and assesses each student based on relevant criteria using a level ranking assigned to quantify the senior project examiner's opinion. Each project was assessed by at least two examiners drawn from the Industrial Advisory Board and Faculty members.

3.4 Tool 4 - Senior Exit Survey

The EET program has developed a written questionnaire for graduating students called the Senior Exit Survey which all graduating seniors are asked to complete. It was completed by 13 of 14 graduating seniors. This is an excellent response rate. The Students feedback data is used to identify any emerging trends in either a positive or a negative direction.

4 EET Program Outcomes Categories and Assessment Tools

The EET Program Outcomes are identified in line with ABET's Technology Accreditation Commission (TAC) and grouped into three categories, Design and Troubleshoot ability, Depth of Technical Knowledge, and Professional Practice. For each category, a set of Assessment Tools has been identified. The assessment method includes mapping specific course/exam/survey learning objectives to the outcomes. Table 5 shows the Outcomes categories and the assessment tools that were employed, as well as the achievement standard for each of the program outcomes.

4.1 Group 1 - Design and Troubleshoot ability

This outcome is concerned with the student ability to design. To measure the students' ability to design, we took specific course learning objectives to collectively provide an indication of student ability in the area of design. In addition to senior course assessment tools, we used both the Senior Exit Exam as well as the Senior Project Evaluation. Table 5 shows the program outcomes represented by Group 1 (Design and Troubleshoot ability) as well as the Assessment Tools utilized; the Assessment Tools included the Senior Project Evaluation, the Senior Course Assessment, and the Senior Exit Exam. The achievement standard is set at 70%.

4.2 Group 2 - Depth of Technical Knowledge

This outcome is concerned with a depth of knowledge in the area of electrical engineering technology. The level of achievement was measured using the Senior Exit Exam and the Senior Course Assessment. Table 5 shows the program outcomes represented by Group 2 (Depth of Technical Knowledge) as well as the Assessment Tools used to measure these outcomes. The achievement standard is set at 70%. We relied on both Senior Exit Exam and Senior Course Assessments to measure this group of outcomes. As shown in table 5, some of the Program Outcomes in group 1 (Design and Troubleshoot ability) appear also in group 2 (Depth of Technical Knowledge) since mastery of Technical Knowledge is a key for the Design and Troubleshoot ability stated in group 1.

4.3 Group 3 - Professional Practice

The Group 3 Outcomes are concerned with communication skills, ethics, professional responsibility and the ability to function as part of a team. Achievement was measured using the observations of Senior Project Evaluation as well as the Senior Exit Survey. Table 5 shows the Program Outcomes represented by Group 3 (Professional Practice) as well as the Assessment Tools used to measure these outcomes. The achievement standard is set at 70%.

Table 5 Assessed Program Outcomes

EET Program Outcomes	Assessment Tools	Success Criteria
Group 1 – Design and Troubleshoot ability **Outcome 4.** An ability to apply creativity in the design of systems, components or processes appropriate to the program objectives (ABET 2.d) **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c).	• Senior Project Evaluation • Course Assessment from Senior Courses • Senior Exit Exam	At least 70%
Group 2 – Depth of Technical Knowledge **Outcome 1.** An appropriate mastery of the knowledge, techniques, skills and modern tools of the discipline (ABET 2.a) **Outcome 2.** An ability to apply current knowledge and adapt emerging applications of mathematics, science, engineering and technology (ABET 2.b) **Outcome 3.** An ability to conduct, analyze and interpret experiments and apply experimental results to improve processes (ABET 2.c) **Outcome 6.** An ability to identify, analyze and solve technical problems (ABET 2.f) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c). **Outcome 13.** The application of physics or chemistry to electrical/electronic(s) circuits in a rigorous mathematical environment at or above the level of algebra and trigonometry. (ABET 8.b) **Outcome 16:** The ability to utilize statistics/ probability, transform methods, discrete mathematics, or applied differential equations in support of electrical/electronic(s) systems. (ABET 8.e)	• Senior Exit Exam • Course Assessment from Senior Courses	At least 70%
Group 3 – Professional Practice **Outcome 5.** An ability to function effectively on teams (ABET 2.e) **Outcome 7.** An ability to communicate effectively (ABET 2.g) **Outcome 9.** An ability to understand professional, ethical and social responsibilities (ABET 2.I) **Outcome 10.** A respect for diversity and a knowledge of contemporary professional, societal and global issues (ABET 2.j) **Outcome 11.** A commitment to quality, timeliness and continuous improvement (ABET 2.k)	• Senior Project Evaluation • Senior Exit Survey	At least 70%

5. Assessment Results - Data

The Assessment Process used different tools for different Outcomes as shown in Table 5. The assessment method includes mapping specific course/exam/survey learning objectives to the EET Program Outcomes. Table 6 shows the assessment results of senior course. In all of the courses the 70 % standard goal is achieved. For example, for EET4141 (Microcomputer Interfacing), 87.75 % of the students scored 70% or better on final exam questions as well as lab assignments.

Table 6 Senior Course Assessment results

EET Course	Course Learning Objectives	EET Program outcomes	Assessment
EET3225	Demonstrate the ability to analyze and design linear integrated circuits used in signal conditioning and simple control system with emphasis on practical application.	**Outcome 4.** An ability to apply creativity in the design of systems, components or processes appropriate to the program objectives (ABET 2.d) **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h)	Based on cumulative final exam questions as well as lab experiments, 73.8% of the students scored 70% or better on final exam questions and lab assignments
EET3281	Demonstrate analytical and critical thinking in design and fabrication of a circuit board	**Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c) **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h)	Based on cumulative final exam questions as well as lab experiments, 83% of the students scored 70% or better on final exam questions and lab assignments
EET4141 & EET4373	Demonstrate the ability to design, implement, and test a microcontroller application based on Motorola 68HC11 and understand practical design interface considerations Demonstrate the ability to design, implement, and test a PLC based control system and understand the practical design interface considerations	**Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c)	Based on cumulative final exam problems as well as lab experiments, 87.75% of the students scored 70% or better on final exam questions and lab assignments Based on mini-projects lab, students were asked to work is teams on small projects, 96.1 % of the students scored 70 % or better on lab projects

Figure 1 shows Senior Exit Exam results, Courses with a score of 70% or more are EET1120 (Circuits I), EET2141 (Digital Electronics and Microprocessor Fundamentals), EET2233 (Electrical Machinery), and EET4141 (Microcomputer Interfacing). On the other hand, the remaining courses have a score range of 38% (EET4311: Advanced Circuits and Control) to 63% (EET3367: Communications Systems). The overall performance assessment of Exit Exam is 59.14%.

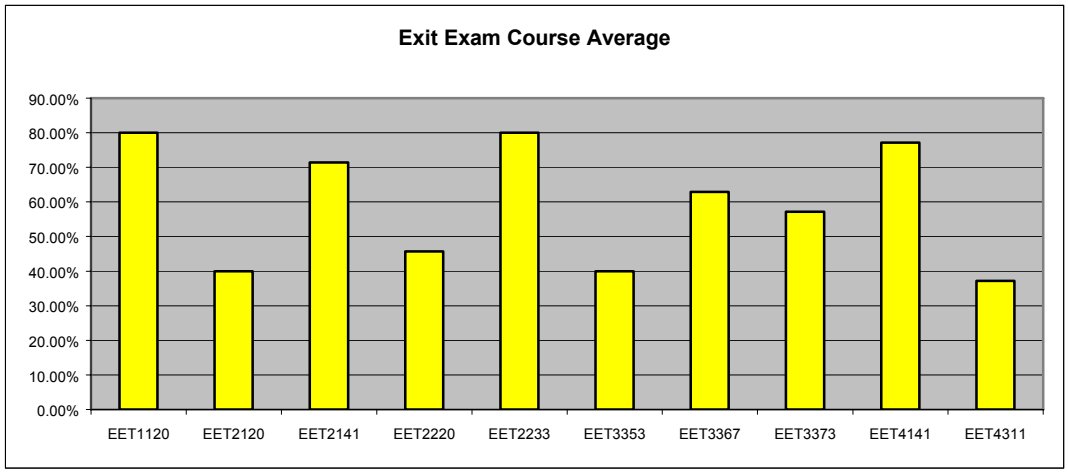

Figure 1: Exit Exam Results

6. Assessment Results - Program Outcomes Groups

The overall achievement results for the three groups of outcomes are evaluated. The raw data collected has been processed and the final results are presented here. The average scores from questions in each tool used were averaged to get the final result for that particular outcome. This was then compared to the 70% passing threshold. The overall results are shown in Figure 2 for all three groups of Program Outcomes. However, to take a close look, we have also shown the results of each assessment tool separately. In Figures 3, 4 and 5 we provide a graphical view of the data.

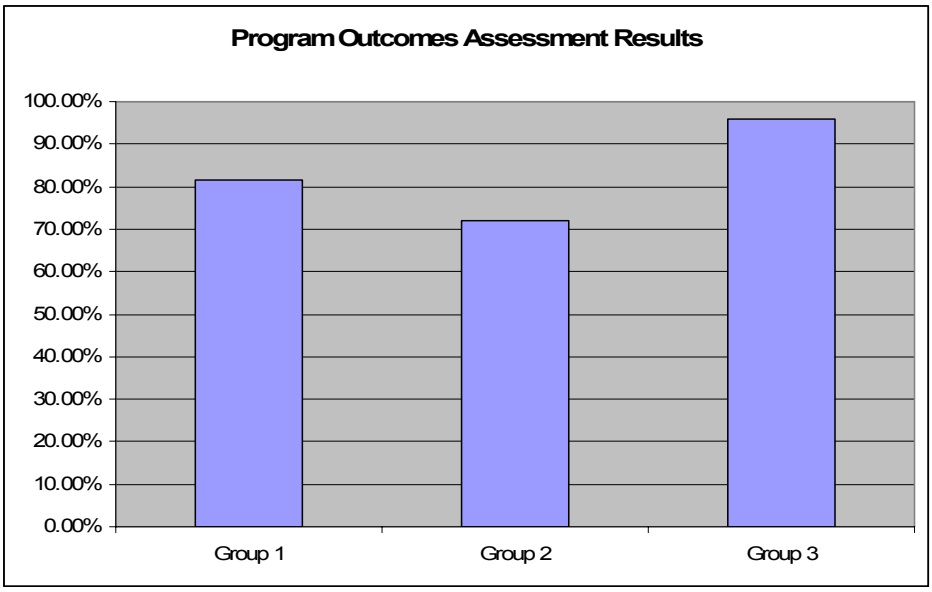

Figure 2: Program Outcomes Assessment Results

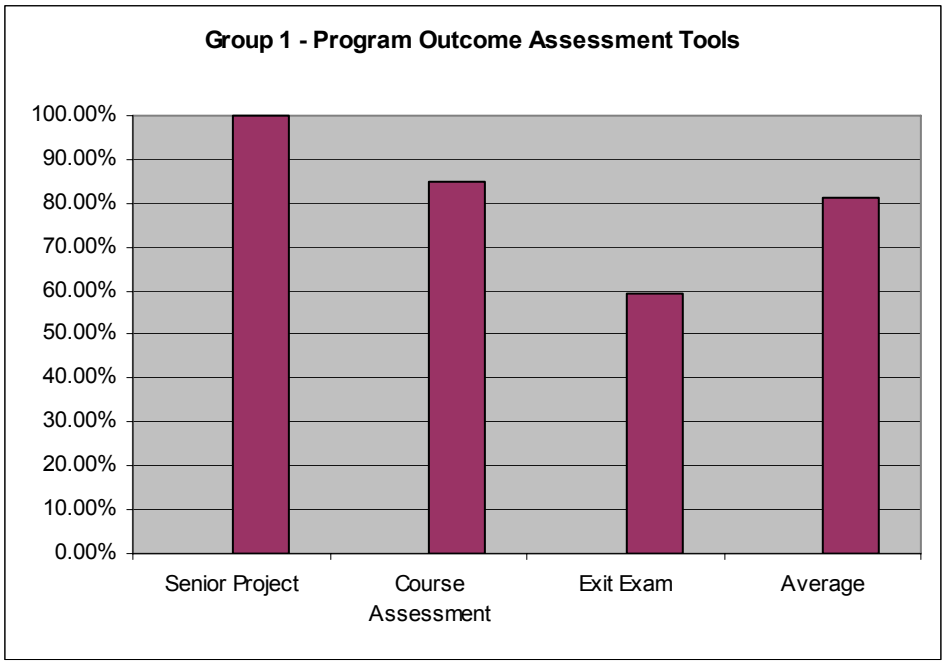

Figure 3: Group 1 - Program Outcomes Assessment Results

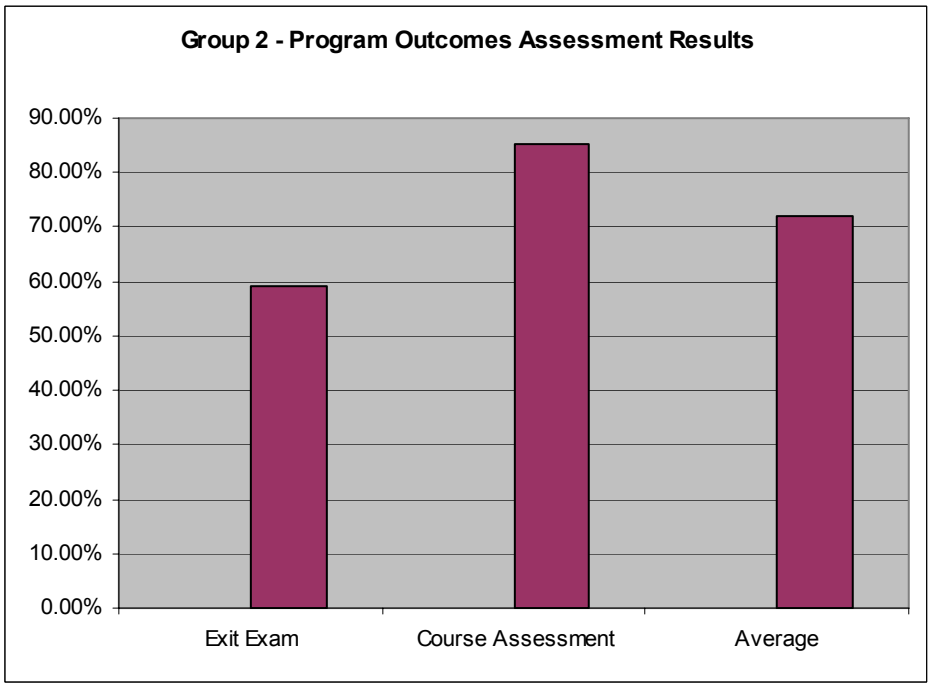

Figure 4: Group 2 - Program Outcomes Assessment Results

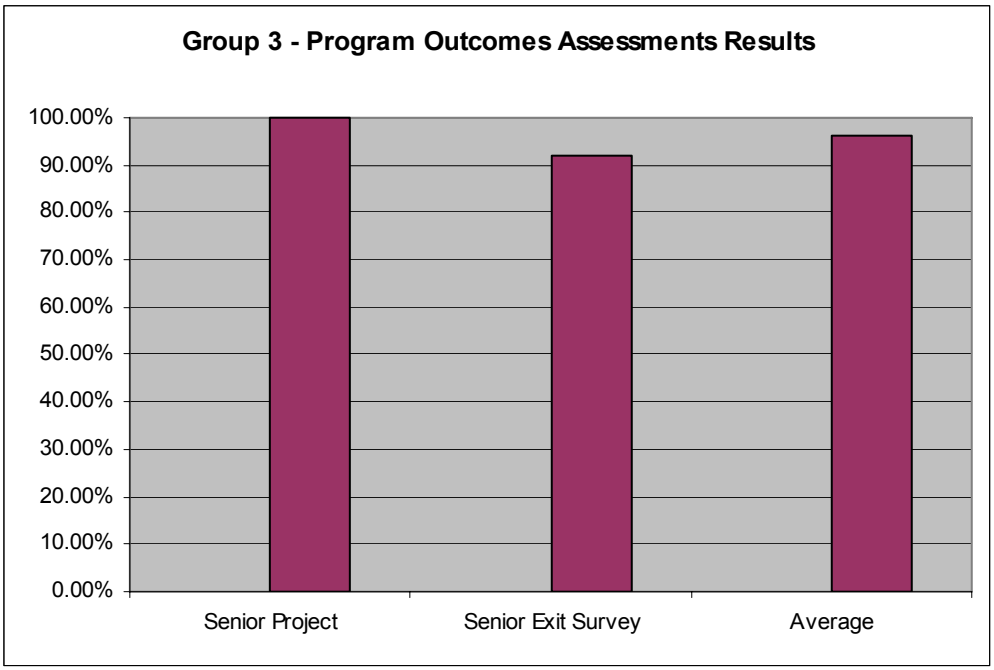

Figure 5: Group 3 - Program Outcomes Assessment Results

The overall average results for the three groups are shown in Table 7. The results revealed no major shortcomings in the EET students' achievement, i.e. the overall averaged results were above the desired 70% target of achievement. All of the three program outcomes groups (Design and Troubleshoot ability, Depth of Technical Knowledge, and Professional Practice) show higher than the passing threshold, for example, the Design and Troubleshoot ability showed an average score of 81.53 %. On the other hand, Depth and Technical knowledge showed an average score of 72.15 % and Professional Practice group showed an average score of 96 %. Based on this assessment, recommendations are made for the purpose of continuous improvement.

Table 7 Assessed Program Outcomes Groups, Tools Used and Results

EET Program Outcomes	Assessment Tools	Success Criteria	Averaged Achieved Results
Group 1 – Design and troubleshoot ability **Outcome 4.** An ability to apply creativity in the design of systems, components or processes appropriate to the program objectives (ABET 2.d) **Outcome 8.** A recognition of the need for and ability to engage in lifelong learning (ABET 2.h) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c)	• Senior Project Evaluation • Course Assessment from Senior Courses • Senior Exit Exam	At least 70%	**81.53 %**
Group 2 – Depth of Technical knowledge **Outcome 1.** An appropriate mastery of the knowledge, techniques, skills and modern tools of the discipline (ABET 2.a) **Outcome 2.** An ability to apply current knowledge and adapt emerging applications of mathematics, science, engineering and technology (ABET 2.b) **Outcome 3.** An ability to conduct, analyze and interpret experiments and apply experimental results to improve processes (ABET 2.c) **Outcome 6.** An ability to identify, analyze and solve technical problems (ABET 2.f) **Outcome 12.** The application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to the building, testing, operation and maintenance of electrical/electronic(s) systems. (ABET 8.a) **Outcome 14.** An ability to design a system, component, or process to meet desired needs (ABET 8.c) **Outcome 13.** The application of physics or chemistry to electrical/electronic(s) circuits in a rigorous mathematical environment at or above the level of algebra and trigonometry. (ABET 8.b) **Outcome 16:** The ability to utilize statistics/ probability, transform methods, discrete mathematics, or applied differential equations in support of electrical/electronic(s) systems. (ABET 8.e)	• Senior Exit Exam • Course Assessment from Senior Courses	At least 70%	72.15 %
Group 3 – Professional Practice **Outcome 5.** An ability to function effectively on teams (ABET 2.e) **Outcome 7.** An ability to communicate effectively (ABET 2.g) **Outcome 9.** An ability to understand professional, ethical and social responsibilities (ABET 2.i) **Outcome 10.** A respect for diversity and a knowledge of contemporary professional, societal and global issues (ABET 2.j) **Outcome 11.** A commitment to quality, timeliness and continuous improvement (ABET 2.k)	• Senior Project Evaluation • Senior Exit Survey	At least 70%	96.00 %

6.1 Assessment Results Analysis

Analysis of assessment results shows that both Senior Project Evaluation (Tool 3) and Course Assessment (Tool 1) reflect more accurate results than Senior Exit Exam (Tool 2). This could be as a result of:

- This is the first time the Exit Exam was utilized and students may not have been prepared for it.
- Students were better prepared for their Senior Project than for the Exit Exam.
- Students usually tend to do better when working on a design problem related to a senior project or course project, and are more able to present technical concepts than when these same concepts were presented to them in the form of exam problems.
- Examiners who answered the senior project survey overestimated the students' knowledge of the related outcome.

6.2 List of Continuous Improvement Actions

- Students did not do well in EET2120 (Circuit II) Exit exam questions related to network analysis methods of AC networks. The recommendations are to spend more time on topics related to methods of Analysis and Network Theorem of AC circuits.
- Increase emphasis of transistor biasing circuits in EET2120 (Electronics Devices and Circuits) both in class and lab and increase the time spent on covering basics of operational amplifiers.
- Expand types of sensors and control systems (transducers) covered in EET3353 (Sensors, Data Acquisition and Control) and increase emphasis on the physics of how different transducers operate.
- Utilize more of interactive and active learning by involving the students in the teaching process.
- Use student's peers to help and mentor other students. A single, confidential peer feedback form has been developed and will be used in all future senior project evaluations.

7. Conclusion

This paper provides guidance on the Program Outcomes Assessment Process developed and implemented by the Electrical Engineering Technology Program to ensure compliance with ABET Criterion 3 Criterion 3 (Program Outcomes and Assessment). The Program Outcomes are identified in line with ABET's Technology Accreditation Commission (TAC) and grouped into three categories, Design and Troubleshoot ability, Depth of Technical Knowledge, and Professional Practice. The Assessment tools for each individual group include a mixture of direct and indirect measures of the EET Programs Outcomes. The overall average results for the three groups revealed no major shortcomings in the EET students achievement; however, the results of the assessment tools identified some areas which might need improvement. Based on this assessment, recommendations are made for the purpose of continuous improvement.

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