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Application of the ABET Student Outcome Scores to the Advancement of a Power Engineering Program: An Accomplished Experience

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Abstract: This article describes the application of a systematic approach to an electric power technology engineering (EPTE) program that ensured high-quality (Accreditation Board for Engineering and Technology - ABET) preparation. It describes how the Electrical Engineering Department at Palestine Polytechnic University (PPU), in Palestine, prepared for the EPTE program by defining and reviewing objectives and outcomes through a well-designed quality improvement process, and then implementing these evaluation results to develop the program. By obtaining results from courses delivered in two consecutive semesters, which could be more widened to a cycle of two consecutive academic years, it was possible to identify all student outcomes (SOs) with performances that either improved or deteriorated against a set threshold level of 80%. The final scores showed a mixed performance. While some SOs fell shortly below the set 80% threshold to an average level of 70%, others either met or exceeded threshold expectations. A deterioration in student outcome SO1 score related to ability of students to formulate and solve complex engineering problems. The SO2 score would require the laboratory and theoretical instructors to provide more discussion lectures and homework, in regard to circuit, system or process design, implementation and verification. The SO5 score showed that students needed to function more effectively as a team, while SO6 score indicated that students needed to improve their skills in experimentation, interpretation and analysis of data. The good scores; SO3, SO4 and SO7 related to ability of students to communicate effectively, recognize professional ethics and acquire and apply new knowledge.

Keywords: Academic accreditation; Program educational objectives; Student outcomes; Quality assurance; Electrical engineering.

1. Introduction

Engineering education is concerned with the development and integration of engineering expertise, skills, understanding, and experience. In becoming more widely available across the world, engineering education is continually evolving to meet the new demands of the developing information society and global economic integration. Accreditation is a form of quality assurance mechanism in which an impartial agency evaluates the facilities and activities of educational institutions or programs to see whether applicable requirements are met. The organization grants accredited status if those criteria are met [1]. Palestine Polytechnic University at Hebron, Palestine, has, in principle, agreed to obtain accreditation from the renowned US-based Accreditation Board for Engineering and Technology

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[2] to ensure that selected engineering and information technology programs are equal to peer programs worldwide, as well as to secure professional credibility in awarding engineering degrees from reputable institutions. ABET is a nonprofit organization tasked with "organizing and carrying out a comprehensive process of accreditation of pertinent programs leading to degrees, and assisting academic institutions in planning their educational programs" [2]. Their objective is to "promote the intellectual development of those interested in engineering and related professions, and provide technical assistance to agencies having engineering-related regulatory authority applicable to accreditation." On a global scale, ABET is regarded as one of the most recognized organizations in the engineering and technology disciplines.

ABET has developed new Engineering Criteria [3] to address the needs of industry and the engineering sector. These criteria evaluate the effectiveness of engineering education programs by concentrating on an assessment and evaluation framework that ensures the achievement of a set of educational goals and outcomes. The development of a quality improvement process through objectives is a key component of these criteria. The old system of counting course credits was changed and replaced with a results-based system. The emphasis of outcomes-based evaluation is on what students have achieved or can do at the time of graduation. ABET's accreditation requirements reaffirmed a number of essential "hard" engineering skills while also adding a new set of "technical or soft" engineering skills. These soft skills include: "communication, teamwork, understanding ethics, professionalism within a global and societal context, lifelong learning, and knowledge of contemporary issues" [3].

Any educational program's design and execution should be focused on achieving the department's mandate as well as the program's educational goals and outcomes. Engineering schools must show that their graduates, in addition to technical discipline-specific expertise, achieve appropriate levels of the desired skills [4]. Student results must be measured for quality development and to satisfy accreditation agencies. It is also critical to meet the needs of students and encourage them to meet the program's outcomes and objectives [5].

To meet the ABET criteria; Palestine Polytechnic University, in cooperation with the College of Engineering and the College of Information Technology and Computer Engineering established a quality assurance committee and a system for their educational processes. The first step was for each department to develop a mission that was appropriate for them. The second step was for the program committees to determine educational goals and results for each degree program, which had been established to prepare for accreditation. There were a few different versions of this. As a result, the program committees and their stakeholders (the university council, faculties, and employers) discovered that regular revision and rephrasing were needed to ensure clarification.

The process of continuous improvement is at the heart of the quality assurance system. Professional expertise drawn from industry, program alumni and their employers is the main source of access if and at what level the educational objectives of the program have been achieved, while faculty and senior exit students also assess the results of the program. Improvements such as curriculum revisions, teaching techniques, and lab facilities [5] are implemented as required. The quality assurance system requires documentation of these changes and the assessment process that contributed to them.

Many writers [4, 6-7] have written about their ABET accreditation experiences. How to teach and evaluate ABET professional skills was explored by Shuman et al. [4]. Quimpo [6] defined the steps taken to address a flaw in the "Water Resources program curriculum at the University of Pittsburgh's Department of Civil Engineering in Pittsburgh, PA."Sebern et al. [7] focused on the differences in the preparation of the initial ABET review in the field of software engineering compared to other engineering disciplines.

More recently, several authors reported on further experiences in applying the ABET accreditation. Damaj et al [8] proposed a framework which identified a set of courses to be assessed using direct tools. The tools enabled "measurements of attainment scores at the course learning outcomes, performance indicators, and student outcome levels to create a paradigm for unified assessment" [8]. Grebski et al discussed and analyzed the implementation of "a comprehensive continuous quality improvement process (CQI)" for individual courses as well as the entire engineering program [9]. Shafi et al addressed implementation details of processes and strategies for assessing and evaluating SOs that formed the basis of the continuous improvement activities for the computer science and computer information systems programs [10].

Ayadat and Asiz presented and analyzed detail accreditation experience for a new established Civil Engineering program [11]. Most notably, they summarized continuous improvement in terms of the curriculum upgrade which included "adding another semester for senior design course, offering new sustainability engineering course, and adding computer aided design course at the early semester." Rashid [12] presented a systematic approach for presenting the assessment data which began by "identifying the tasks for preparing the data, mapping them on appropriate resources then interfacing such resources in an explicit way. Various implementation examples were demonstrated through different aspects of an engineering program."

This paper describes the Electrical Engineering Department's experience in applying the ABET accreditation process to its EPTE program, as well as the quality assurance system, used during the process. When carefully implemented, these well-designed systems and quantified processes can result in a high-quality power engineering program and will facilitate accreditation.

2. Faculty Qualifications and Size

The Electrical Engineering Department in the Faculty of Engineering at PPU consists of 16 full-time members as follows: Two full professors, three associate professors, eight assistant professors, and three lecturers. Further, the department has full time administrative members such as technical laboratory supervisors and instructors. Occasionally the department hires part-time instructors or technicians to assist in teaching and laboratory work. It is worth noting here that the ages of the teaching staff predominantly ranges between 32 and 64 years. The faculty members are mainly responsible for instructing and teaching compulsory and elective courses in the program. It should be noted that teaching and research activities are highly encouraged by the presence of relatively younger faculty members in the department, as well as full and associate professors. The size of the faculty is proper for providing a high quality education to the students while leaving sufficient time to the faculty members for their research activities, administrative duties, and interactions with the students and industry. Further, the faculty members provide major support to the other program, for instance, courses such as mathematics for engineers, research methodology and other technical courses that would fit in the programs of mechanical and civil engineering programs. On the other hand, other faculty member, from different program specializations, may offer courses, within the power technology engineering program such as, signal processing, digital systems, electric circuits and electronic circuits.

As far as the students in the department, Table 1 shows the distribution of students at all levels of the four specializations, in the Electrical Engineering department, between years 2014 and 2019. On the other hand, the full-time academic faculty members are 16, the full-time laboratory supervisors are 13, while the part time lecturers are 4. Hence the total is 33 members. The ratio of students to full time academic faculty, at the Electrical Engineering department, is 16.75/1, whereas the ratio of students to total full time faculty members is 9.24/1.

Table 1: Distribution of Students throughout 2014 – 2019

Specialization	2014	2015	2016	2017	2018	2019	Sum
Electrical Engineering (General, first year)	-	-	-	-	-	32	32
Industrial Automation Engineering	3	14	12	23	15	8	75
Biomedical Engineering	7	9	8	12	22	2	60
Communications and Electronics Engineering	2	5	1	5	1	0	14
Electric Power Technology Engineering	11	29	13	8	24	2	87
Total							268

3. Program Development

The Palestinian Authority (PA) has been seeking, since the early nineties to establish an independent sector for electric power. Accordingly, the PA required Palestinian Engineering caliber in the field of transporting and distributing electric power to realize this goal. In addition, and in the context of increasing interest in alternative energy resources and the necessity for Palestine to ride the wave of development in this sector, the department of electrical engineering saw the necessity to supply the Palestinian society with power engineers, capable to uphold the country towards the developing countries in the alternative energy field. The EPTE program was launched in 2010 and the first cohort was received in the academic year 2010/2011. The EPTE specialization aims to supply the local Palestinian market with high quality power engineers. The department has staffed PhD specialists in power engineering and founded an advanced laboratory, in this respect. The program plan has been revised and updated in 2016. Table 2 shows eight courses, totaling 17 credit hours, were cancelled, that originally existed in program plan 2011. Nine developed courses, emphasizing a number of laboratory courses, totaling 19 credit hours were added to program plan 2016. The changes were the result of the "Triple Helix" project; funded by the World Bank.

3.1. Program Educational Objectives (PEOs)

The main goal of this program is to increase the employability of the university students by providing them with entrepreneurial and real life skills that would help them to best compete in the job market and equip them to venture with more confidence into self-employment.

The General Program Objectives are summarized hereby:

1. Practice the electric power technology engineering (EPTE) discipline successfully.

2. Contribute to society and the profession.

3. Engage in life-long learning to advance professionally through continuing education and training.

4. Succeed in graduate studies in EPTE or a related field if pursued.

In regard to the primary mission, Palestine Polytechnic University emphasizes quality vocational and technical engineering education. This is achieved by providing students with practical knowledge to help them acquire an up-to-date experience directly related to their disciplines. The second component is to engage its faculty and students in relevant and timely research programs that would be needed to fuel economic growth and development of the country, which would also contribute to human welfare and prosperity in its wider context. The third component is to render public service at the local, national, and international levels through fostering a dynamic environment of cultural enrichment, and the provision of educational and training opportunities to non-student groups.

Table 2 : Course Changes in EPTE Program in the Edited Plan 2016

Cancelled Courses from Program Plan 2016 that originally existed in Program Plan 2011		Added Courses in Program Plan 2016	
Course No.	**Course Name**	**Course No.**	**Course Name**
4204 (2)	Electrical Drafting Application	5963 (3)	Energy Auditing and Rationalization
5599 (3)	Distribution of Elec. Energy	5618 (3)	Electrical Installations and lightning
5503 (3)	High Voltage Technology	5965 (1)	Renewable Energy Laboratory
5513 (3)	Power Systems Protection I	5962 (3)	Power System Protection
5601 (3)	Power Systems Protection II	5617 (3)	Electrical Drive
5603 (3)	Electrical Power Plants	5675 (1)	Field Training I
4165 (0)	Field Training I	5676 (1)	Field Training II
4631 (0)	Field Training II	5966 (1)	Electric Drive Laboratory
		8213 (3)	Numerical Analysis and Applications
Total: 17 credit hours		Total: 19 credit hours	

The program educational objectives are consistent with the mission of the institution. The University has a caliber of highly qualified faculty members, able to transfer knowledge and skills to students. The program ensures a number of laboratories in which students can run experiments and undertake short and graduation projects, in fulfillment to the requirements of their degrees. Furthermore, the University conducts a student innovation conference, each year, in which students have the opportunity to show their implemented designs and built systems. Top students are further encouraged to submit their projects for incubators and regional award opportunities.

Most importantly, an advisory Committee for the EPTE program has been established, that meets regularly to discuss program development and its contained sustainability in the face of market needs, locally and regionally. The committee members are faculty, representatives of national electric power companies, as well as graduate Alumni and students. The committee looks collectively at the developing market needs, faculty and student opinions, as well as technology development and studies results of questionnaires put to a sample of Alumni and students. Faculty members in the Committee are then tasked to propose syllabus for agreed upon new courses, required to develop the program plan. The committee members would then meet to approve plan changes. The new plan would, in turn, be submitted to the department's chairman, faculty dean and registration department for endorsement.

3.2. Student Outcomes (SOs)

ABET spells out the following general seven student outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

3. An ability to communicate effectively with a range of audiences.

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The courses in the EPTE program were designed to address the following student outcomes. These outcomes are emphasized in the syllabus of the program courses and are accordingly mapped to the mentioned ABET general outcomes. In particular, the graduation projects are expected to address all student outcomes. These program-designed student outcomes are:

1. An electrical engineer specialized in the areas of power engineering, power technology, and power networks. (1,2 and 6)

2. An electric engineer that can engage with those working in related areas from public and private sectors and international institutions. (3,4 and 5)

3. An electric engineer equipped with knowledge, design, analysis, practice and measurements of power networks. (1 to 7)

4. An electric engineer capable to formulate and develop scientific research in the power engineering discipline. (1)

5. An electric engineer contributing to the dissemination of awareness, among students and community, of the role and importance of developing power networks and systems. (3 and 5)

6. A power engineer who can locally and regionally compete to implement projects related to domestic or global industries, through the development of a system or finding a solution to a particular problem in order to contribute to the development of local and global industries. (2, 4 and 7)

The following describes how the student outcomes prepare graduates to attain the program educational objectives:

1. Graduate engineers are prepared to work in the field of generation and utilization management of electric power.

2. Graduate engineers are prepared to work in the field of transportation and distribution of electric power.

3. Graduate engineers are prepared to work in the field of system monitoring of transportation and distribution of electric power.

4. Graduate engineers are prepared in the generation and transportation systems of renewable energy.

5. Graduate engineers are prepared to work in the training, professional and academic sector.

6. Graduate engineers are prepared to work in all related research units.

7. Graduate engineers are prepared to work in maintenance units of power distribution companies and municipalities.

8. Graduate engineers are prepared to work in related engineering trade businesses.

9. Graduate engineers are prepared to work in domestic and industrial electric power extensions.

10. Graduate engineers are prepared to work in hospitals, hotels and institutes that own backup generating stations.

11. Graduate engineers are prepared to work in cables and transformers factories.

The linkage between the Program Educational Objectives (PEOs) and the Student Outcomes (SOs) is shown in Table 3. The achievement of the Student Outcomes (SOs) ensures that our graduates are well equipped to achieve the Program Educational Objectives in the actual practice following their graduation.

Table 3 : Linkage of PEOs to SOS

PEOs	Student Outcomes (SOs)						
	#1	#2	#3	#4	#5	#6	#7
PEO#1	X	X		X	X		X
PEO#2			X	X			
PEO#3							X
PEO#4	X	X	X	X	X	X	X

3.3. Major Components of the Program

The EPTE program produces graduates who are prepared to enter the practice of electric power and renewable energy engineering. There are three major components of the program: (1) foundation in the mathematical and physical sciences, (2) engineering topics in both electric and mechanical systems with design applications, and (3) general education in English and Arabic courses and in humanities.

The engineering science fundamentals and engineering design skills are built upon the basic mathematics and physical sciences. These courses are summarized in Table 4 and sum up to 33 credit hours. The minimum total required by ABET is 30 credit hours.

Table 4: Foundation Courses in Mathematical and Physical Sciences

Item	Course No.	Course name	Cr. r.
1	4004	Calculus I	3
2	4006	Physics I	3
3	4007	Physics laboratory I	1
4	4005	Calculus II	3
5	4068	Physics II	3
6	4069	Physics laboratory II	1
7	4043	Differential Equations I	3
8	4169	Linear Algebra I	3
9	4008	Chemistry I	3
10	4009	Chemistry laboratory I	1
11	4071	Probability and Statistics	3
12	5593	Mathematics for Engineers	3
13	8213	Numerical Analysis & Apps.	3
Total			33

The EPTE core courses, totaling 112 credit hours, address electrical and mechanical systems. Most of these courses, of theoretical and laboratory nature, are compulsory, except a few of them (totaling 9 credit hours) which are selective. More than ten courses have significant design (√) in them. These are summarized in Table 5.

The remaining courses, totaling 20 credit hours, are in languages and humanities; 8 credit hours for English, 3 credit hours for Arabic, 3 credit hours for a university selective course and 6 credit hours for courses in humanities.

In summary, the total number of program credit hours is 165 and the courses can be distributed over 10 academic semesters (5 academic years).

4. Program Evaluation Tools

The evaluation process of this engineering program started with the instructed academic staff by the program committee to enforce changes in designing the course outlines. The major required changes involved spelling out the intended learning outcomes (ILOs) of each course and the mapped ABET student outcome (SO) associated with each of the ILOs. Each ILO has a percentage contribution and all ILO contributions would add up to 100%. Those ILOs and mapped SOs are required to be reflected, on the first page of each exam that students take throughout the semester. To ease the process of program evaluation, the academic instructors and technical staff (laboratory supervisors) were asked to map only one SO for each ILO and at least to lay out a minimum of three ILOs for each theoretical or laboratory course. All course assessments were based on exams, projects, team work, presentations, homework and quizzes. The graduation project course normally emphasizes all seven SOs.

Each instructor or lab supervisor is required to fill up a course report while each student is required to fill up a survey form by the end of the semester, respectively. These are central to the evaluation of all course results. Similarly, the program committee coordinator would have to combine all results and fill up a program report and a program survey form for the required data analysis.

The instructor's report constitutes of three parts. The first part simply covers the details of the course, the instructor's name and number of students taking the course. The second part consists of fields for reporting the average score of all students per student outcome. Here is an example, demonstrated inTable 6.

The third part consists of various objective and subjective questions for the instructor to answer. These are related to course issues, program issues, evaluation of outcomes, recommendations for improvements and comments by the quality insurance committee. The last two (recommendations and comments) are most important as they present a commitment on behalf of the instructor for sustainable improvement, throughout the following academic years.

Table 5 : Engineering Core Courses offered in the EPTE Program

Item	Course No.	Course name	Cr.Hr.
1	5055	Computers and Programming Principles	3
2	5060	Engineering drawing	2
3	5059	Computer programming	3
4	5061	Engineering workshop	2
5	4106	Electric Circuits I	3
6	4101	Electric circuits II	3
7	4102	Electric circuits laboratory	1
8	4103	Electronics I	3
9	5587	Digital Systems	3(√)
10	4104	Electronics II	3(√)
11	4105	Electronics laboratory	1
12	4221	Electromagnetism	3
13	4706	Signals & Data Communications	3
14	5589	Electrical Machine I	3
15	5588	Digital Systems laboratory	1
16	5504	Renewable Energy sources	3(√)
17	5595	Fluids & continuous systems mechanics	3
18	4206	Power Electronics	3(√)
19	5220	Control Systems	3(√)
20	5594	Electrical Machines II	3(√)
21	5590	Electrical Machines laboratory	1
22	5596	Power System Analysis I	3
23	4015	Methods of Scientific Research	2
24	5600	Renewable Energy Systems	3(√)
25	5597	Power System Analysis II	3
26	4207	Power Electronics laboratory	1
27	5633	Control Systems laboratory	1
28	5634	Electrical workshop	2
29	5618	Electrical installations and lighting	3(√)
30	4691	Measurements and transducers	3(√)
31	4011	Engineering economics and management	3
32	5591	Microprocessors and microcontrollers	3(√)
33	5965	Renewable energy laboratory	1
34	5502	Transmission and distribution electrical lab	1
35	5962	Power system protection	3
36	5617	Electrical drive	3
37	4692	Measurements and transducers laboratory	1
38	Selective	Program Elective Course I	3
39	5966	Electric drive laboratory	1
40	5592	Microprocessors and microcontrollers lab	1
41	4359	Introduction to graduation project	1
42	5598	Software applications and simulation in electrical energy systems	1
43	Selective	Program Elective Course II	3
44	5602	Power systems protection laboratory	1
45	5505	Economy of electrical energy	3
46	5963	Energy auditing and rationalization	3
47	4360	Graduation project	3(√)
48	Selective	Program Elective Course III	3
		Total	**112**

After collecting all reports and forms from instructors/supervisors and students, respectively, the ABET program coordinator embarks on extracting all data into an excel sheet, in preparation of the program data analysis. An average weighted assigned student outcome, PSO(i) can be calculated, according to Equation (1), where SO(i,k) is the assigned weighted outcome for each course and N(i,k) is the number of credit hours of the course in which SO(i,k) is being calculated. Hence,

$$PSO(i) = \sum_{k=0}^{n}(SO(i,k) \text{ x } N(i,k)) \;/ \sum_{k=0}^{n} N(i,k) \ldots (1)$$

Likewise, an average weighted achieved student outcome, PVO(i) can be calculated, according to Equation (2), where SV(i,k) is the achieved weighted outcome for each course and N(i,k) is the number of credit hours of the course in which SV(i,k) is being calculated. Hence,

$$PSV(i) = \sum_{k=0}^{n}(SV(i,k) \text{ x } N(i,k)) \;/ \sum_{k=0}^{n} N(i,k) \ldots (2)$$

On the other hand, the average surveyed student outcome, PSS(i) can be calculated, according to Equation (3), where SS(i,k) is the number of students with a particular rating of a student outcome in all courses, the rate M(i, k) = [0.45, 0.65, 0.75, 0.85, 0.95] and P(i, k) is the number of students that rated a student outcome in a course in the program

$$PSS(i) = \sum_{k=0}^{4}(SS(i,k) \text{ x } M(i,k)) \;/ \sum_{k=0}^{n} P(i,k) \ldots (3)$$

4.1. Courses Evaluated

Table 8 : EPTE Courses offered in Fall 2018/2019

Item No.	Course no.	Course Name	No. of credit hours
1	4015	Methods of Scientific Research	2
2	4103	Electronics 1	3
3	4206	Power Electronics	3
4	4691	Measurements and Sensors	3
5	5331	Renewable Energy Resources	3
6	5503	High Voltage Technology	3
7	5505	Power System Economics	3
8	5587	Digital Systems	3
9	5589	Electrical Machines I	3
10	5597	Power Systems Analysis II	3
11	5600	Renewable Energy Systems	3
12	5601	Power System Protection II	3
13	4360	Graduation Project	3

The courses, selected for evaluation, were engineering core courses in the EPTE program that were offered by the electrical engineering department, throughout Fall 2018/2019 and Spring 2018/2019 semesters. These courses are shown in Tables 8 and 9, respectively. Table 9, shows also those courses that were surveyed by all students, taking the courses and their numbers in Spring 2018/2019.

Table 9 : EPTE Courses offered and student-surveyed in Spring 2018/2019

Item No.	Course no.	Course Name	No. of credit hours	No. of students
1	4102	Electric Circuits Lab	1	41
2	4206	Power Electronics	3	19
3	4692	Sensors Lab	1	32
4	5220	Control Systems	3	17
5	5502	Electric Power Systems Lab	1	27
6	5590	Electric Machines Lab	1	17
7	5592	Microcontroller Lab	1	50
8	5594	Electrical Machines II	3	23
9	5596	Power Systems Analysis I	3	14
10	5602	Electric Power System protection Lab	1	8
11	4360	Graduation Project	3	not surveyed

5. Results and Discussion

Table 10 shows the score percentages achieved in Fall and Spring 2018/19 as compared to an agreed-

Table 10: Score percentages of Fall AND SPRING 2018/2019 compared to a set threshold of 80%

SOs	Thres hold	Fall Score	Spring Score	Score Difference
SO1	80	71.30	68.08	-3.22
SO2	80	74.62	67.92	-6.69
SO3	80	71.72	86.96	15.25
SO4	80	77.15	78.02	0.87
SO5	80	71.94	66.73	-5.21
SO6	80	69.20	68.23	-0.97
SO7	80	61.47	90.67	29.19
AVE		71.06	75.23	4.17

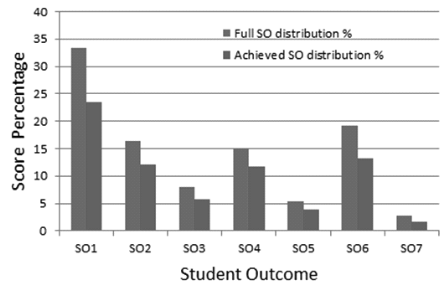


Fig.1: Histogram of Score Percentage of Student Outcomes in Fall 2018/19

upon set threshold of 80%. While there is a slight decrease in score, not exceeding (7%) in most of the student outcomes, a notable increase in score is observed in SO3 (15%) and SO7 (29%).

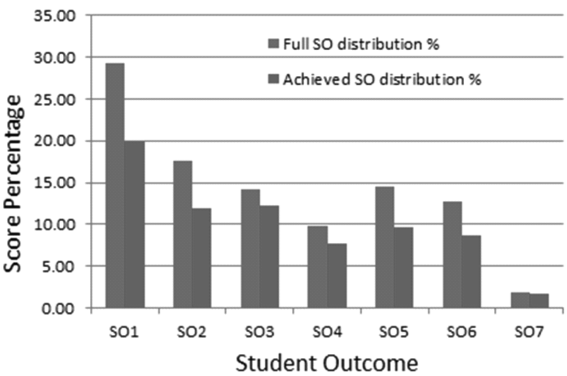
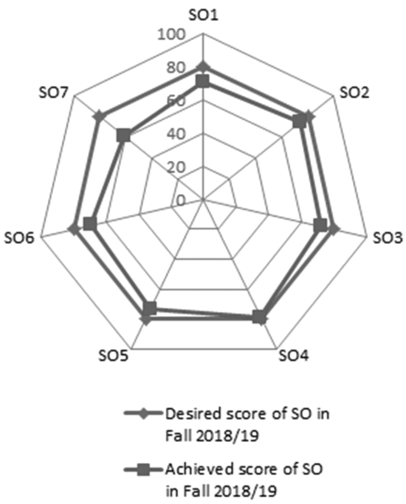
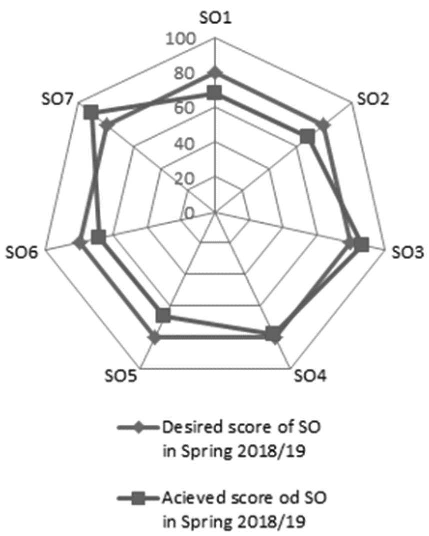


Fig. 2: Histogram of Score Percentage of Student Outcomes in Spring 2018/19

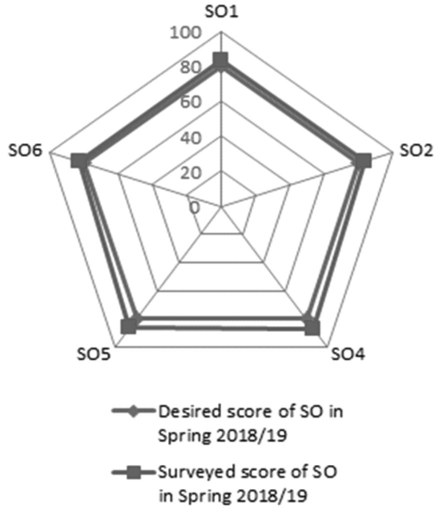


(a)



(b)

Figures 1-4 summarize the general results of the achieved and surveyed student outcomes in the EPTE program courses, taken in Fall and Spring semesters of 2018/19.



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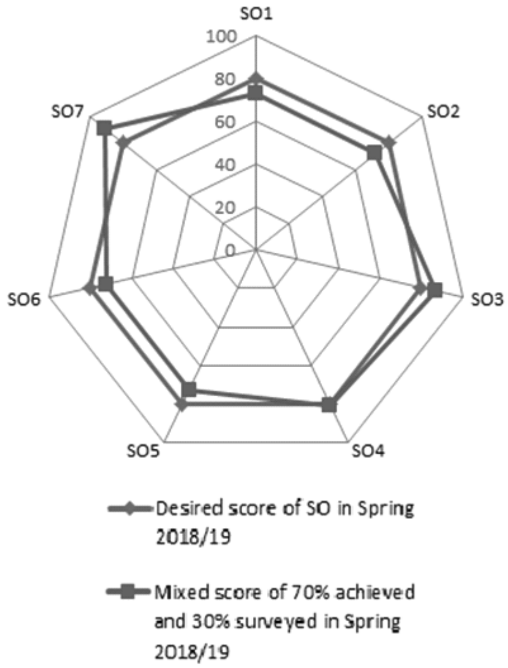

(d)

Fig.3: Radar Charts of Student Outcome Scores relative to the 80% set threshold (a) Achieved SO scores in Fall 18/19 (b) Achieved SO scores in Spring 18/19 (c) Surveyed SO scores in Spring 18/19 (d) Mixed SO scores 70% achieved, 30% surveyed

e results in Figures 1 and 2, show the different distribution of the assigned student outcomes in Fall and Spring of 2018/19, respectively. This is expected as the courses offered in each term are different. Most notably are the six laboratory courses that were included for evaluation in Spring 2018/19 where the SOs seemed more evenly distributed, in general, than those in Fall 2018/19. The full or assigned SO distribution in Figures 1 and 2, each adds up to 100%. The achieved SO distribution in both figures adds up to 72.03% and 71.95%, respectively.

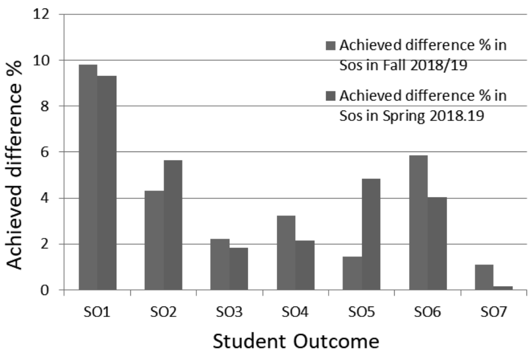

Fig.4: Histogram of Difference % between Full and Achieved SOs in Spring 2018/19 compared to Fall 2018/19

Figure 3 shows the tendency of the SOs towards approaching the set threshold of 80%, seen as the minimum, in the "very good" rate range of (80%-89%). Figures 3 (a,b) compare the student outcome scores for Fall and Spring 2018/19, respectively. Most notably, SO3 and SO7 scores in spring semester outperformed the set threshold level of 80%. The two outcomes which relate to effective communication and ability to acquire and apply new knowledge are assigned to the scientific research methods and graduation project courses in Fall and to the latter course, only, in Spring. While the SO3 and SO7 scores in the graduation project for both semesters are above 86%, the relative decrease in the two score percentages, during Fall 2018/19 was due to the methods of scientific research course. The course is one of the most important courses given at all engineering specializations and covers all seven SOs. The students learn fundamental and various research skills in this course. Figure 3 (c) shows the surveyed score of students who took all EPTE courses in Spring 2018/19. The ABET accreditation process allows for the student survey scores to have a weight in the overall evaluation of achieved student outcomes. The survey score weight was considered 30% as this would demonstrate a fair judgment of attained outcomes by the students. The survey shows slightly higher scores than the set threshold. Figure 3 (d) shows the final score of student outcomes in Spring 2018/19. The surveys excluded SO3 and SO7, as those were only considered in the SOs of the graduation project course that was not surveyed.

Figure 4 shows the difference percentages or the gaps in the achieved student outcomes relative to the assigned outcomes. It compares the gap in each outcome for both fall and spring semesters. Notably, SO1, common to all courses shows the largest gap. This is natural, as the students in this particular outcome are evaluated for how much they are able to apply engineering principles and solve complex engineering problems. The individual gap for each outcome seemed to have invariably decreased in Spring in comparison to Fall, except for SO2 and SO5 which show a notable increase. The gap increase in SO2 is attributed to the electric circuits, sensors, electric machines, and microcontroller laboratory courses, as well as the control systems, and power systems (I) analysis theoretical courses. The gap increase in SO5, on the other hand, is due to the electric power systems, and power system protection laboratory courses, as well as the power electronics and power systems analysis (I) theoretical courses. The total gap increase in both SO2 and SO5 balanced out the total gap decrease in the rest of the seven SOs.

6. Conclusion

The ABET accreditation process was applied to the EPTE program courses; offered and surveyed throughout the academic 2018/19. The first surveyed semester acted as a reference, where the scores were compared against a set threshold, and the second semester scores facilitated early comparison with those of the first semester. The process would usually be applied over a two-year round and the data would be updated, every year. The program courses were evaluated for quality of student outcomes they reflected. That was enabled by sound quantitative analysis of the achieved and surveyed student outcomes, in reference to the overall assigned student outcomes of the program courses. By comparison of obtained results from courses delivered in two consecutive semesters which could be more widened to a cycle of two consecutive academic years, it was possible to identify the individual outcomes whose performances, either improved or deteriorated against a set threshold level of 80%. The final scores showed a mixed performance. While some SOs fell shortly below the set 80% threshold to an average level of 75%, others either met or exceeded threshold expectations.

A deterioration in student outcome SO1 score related to ability of students to formulate and solve complex engineering problems. The SO2 score would require the laboratory and theoretical instructors to provide more discussion lectures and homework, in regard to circuit, system or process design, implementation and verification. The SO5 score showed that students needed to function more effectively as a team, while SO6 score indicated that students needed to improve their skills in experimentation, interpretation and analysis of data. The good scores; SO3, SO4 and SO7 related to ability of students to communicate effectively, recognize professional ethics and acquire and apply new knowledge.

To generalize, the ABET process provides an effective tool that quantifies the strengths and weaknesses of an engineering program against the set student outcomes. If a certain weakness shows up, for example, in the "engineering design" category of the program, the tool would point it out and display its severity in reference to the desired level. It would not offer, by itself, remedies. It would be up to the stakeholders, starting with the teachers to work on remedies and commit themselves to apply them and improve performance, in all pertaining program courses, to "engineering design". That could be achieved by incorporating more discussion lectures, related to design, or providing more student assignments that may include design projects. The tool provides an opportunity for the teacher to keep on improving his or her teaching methods and skills. At the end of the day, all stakeholders; the university administration, the ABET program committee, the engineering faculty, the department, the teachers and the students have a collective responsibility to uphold the standards of the program and contribute towards its advancement, if they wish to obtain the accreditation license and eventually receive an international recognition of the program. It is worth mentioning that many jurisdictions require graduation from an ABET-accredited program as a minimum qualification for registration to practice because it signifies preparation for entry into the profession.

7. Recommendations

The studied process could be applied to any engineering program, if the top administration of the university chooses to internationalize its programs, subject to ABET accreditation, which demands all stakeholders commit towards working to comprehensively complete an ABET Self-Study Report (SSR) per engineering program.

Although analysis is enabled after a two-semester round of data collection, it is appropriate to consider a two-year round for more pronounced comparison.

It is necessary for the university administration to form an ABET program committee to liaise with all stakeholders. Each member of the committee may act as a coordinator of an engineering program; with a task to manage all requirements towards accomplishing the ABET Self-Study report.

The dean of engineering faculty and the chairmen of the departments should facilitate support, provide required data and lend assistance to the ABET committee in whatever tasks they would ask from teachers. In order to increase the opportunity of success to the process, faculty program coordinators should strictly avoid breaking regulations of registering new courses for students unless they pass the prerequisites, at all circumstances. The process starts by meeting with the teachers of the various programs, in an attempt to convince them of the merits of the process in developing their skills and advancing the programs. It is natural that many teachers may resist or negatively criticize a new process they are not used to. However, the level of resistance would gradually decrease as they get involved and receive support from the ABET coordinators towards accomplishing the process.

There are sections in the Self-Study report that are the sole responsibility of the university administration. The administration should update its clear vision and mission and document them in English. It should also facilitate the minimum required logistics pertaining to the laboratories that should display safety instructions and avail appropriate classrooms, floor space, library, parking, and cafeterias.

Other sections, on the other hand are of academic nature that teachers need to work on and submit to the ABET coordinators. These are summarized as follows:

- Updating the resumes of the teachers prior to the SSR submission.

- Rewriting the course and laboratory outlines that primarily reflect the intended learning outcomes (ILOs) and their correlated student outcomes (SOs) with the covered percentages.

- Ensuring that each written exam shows at the front page the SO and ILO that pertains to each question with the score points.
- Completing and Instructor's report (Table VI)
- Disseminating the student survey forms (Table VII) for students to fill at the completion of the course, prior to the final exams of the semester.
- Archiving, hard copies, per teacher, for the visiting ABET program examiners to the university. These would include: course outline, exam questions and answers model, sample copies of exam answers for students obtaining highest, average and lowest scores.

Finally, sustained improvement in semester scores can only be attained through the will, commitment and dedication of teachers to implement and deal with the score justifications and self-critical comments they fill in their instructors' reports and discuss on both individual and departmental levels.

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