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Abstract

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1. INTRODUCTION

ABET (Accreditation Board for Engineering and Technology) accreditation, is a voluntary, periodically renewable review process performed by an external team of professional experts from the academic and industrial discipline to determine if the education program meets a defined global standard of quality and if these educational programs are maintained. The ABET accreditation is a processed that developed and refined over 80 years of continuous dedication of educators to provide the highest standards of quality assurance. The ABET review process guaranteed significant commitment to quality that helps interest both students and faculty. Diversity is a common term when used with fields where the limit of the applications cannot be gauged. In this case mechanical engineering is one the most renowned fields that have been so widely perceived as engineering itself. For a discipline so broad it requires a certain form of qualification that is accredited by regulated bodies that can pertain the level of skill and knowledge to ensure the outcome and future of the field. This also carries forward towards being able to prove an Engineer's skill when it comes to a global standard and also their ability to benefit any organization in all countries. This kind of certification can easily be considered a passport between nations and a key that helps set in motion a graduate's or student's chances at pursuing graduate studies at world class academic institutions. Program accreditation is a major step for any institution. It ensures high quality level of education and makes it easier for students and their guardians to select the right program and institution. It is beneficial so employers can recruit good quality graduates and it gives the colleges and universities a structured mechanism to assess, evaluate; and improve the quality of their programs. An academic

institution that sets acquiring accreditation as one of its standards ensures the education staff and the program that satisfy global standards for all professions that are encompassed by the qualification. This is proven by the ample collection of publications that set the precedent that accreditation on an academic basis is a requirement for any institution. [1-7].

Maintaining high education standards of engineering education depends solely on the followed accreditation and assessment process the institution is implementing. Arun et. al. [8], in this article, the authors focus on identifying the important issues of accreditation and quality assurance in engineering education worldwide. They outline a research project on the design and development of a scientific accreditation model that can be implemented to assess engineering and technology courses. The authors also include the strategy of a multiple study case design in order to investigate important issues of accreditation and assessment.

Warren Roane; [9], reported the history and the objectives of accreditation in USA in his paper. He examined its basic elements, and noted its tendency to encompass an ever-increasing geographical area. The study compares the accreditation process in USA with Uruguay within MERCOSUR in term of engineering standards.

In this paper a case study on the accreditation process of the Mechanical Engineering Program (MEP) offered at UAEU is of interest and in the subsequent discussions some of the relevant details related to this process and assessments tools and its attainments will be highlighted.

HISTORY OF ABET ACCREDITATION AT UAEU

One very prominent source of accreditation is ABET which is widely known as a nonprofit, non-governmental organization that is recognized in the United States by the Council for Higher Education Accreditation. It has since become worldwide, accrediting academic institutions that show interest in the initiative. United Arab Emirates University's (UAEU) Engineering programs became one of the aforementioned institutes in the year 1998 and have since then kept a successive record of maintaining ABET accreditation.

UAEU held the inauguration of the College of Engineering in 1980. The first batch to enter Mechanical Engineering Program (MEP) was a male batch in 1981. Five female students joined the program in 2001, which in number has greatly increased ever since. The spanning of MEP-UAEU continued from 1992-1998. In 1998 the MEP was granted a substantial equivalency by the ABET. Recognition was granted to the MEP in 2004. At the time, ABET was only granting a substantial equivalency recognition to institutes that were outside the US. In 2004 ABET altered the rules and finally expanded their full-accreditation to overseas. The MEP-UAEU received full ABET accreditation recognition in 2010 and in 2016. Maintaining the accreditation and keeping in line with the accreditation criteria helped MEP-UAEU upgrade to modern trends and adopt to international standards of the Mechanical Engineering Education (MEE). This motivated the graduates to join industries and graduate studies programs, both nationally and internationally. Since the first ABET accreditation in 1998, the MEP has witnessed various stages of evolvement. A consequence of these evolvement stages were to form a set of effective program learning outcomes (POs); (in 2013-2014 POs was replaced to "Student Outcomes

(SOs)” by ABET). These SOs statements were designed to lead to the well satisfaction of the broadly stated goals of the Program Educational Objectives (PEOs). During accreditation, MEP carried out revisions of SOs and PEOs to keep the statements consistent with the ABET criteria, both the mission and the vision statements. To ensure a well-established quality assurance (QA) system was set in place tools were required (direct and indirect) to measure the attainment level of the SOs and PEOs. This QA system led to the success of the MEP program since to the measures taken prevent sources of potential deficiency, as well as predicts future technology demands.

2. THE NEED FOR ACCREDITATION PROCESSES

In order to ensure the quality of the engineering program and a high standard of the program’s graduates UAEU’s management works hard to seek accreditation from international organizations, such as ABET. The benefits of the educational assessment and accreditation process for engineering and technology affect two main constituents directly; namely academic (student) and administrative (institutional), [8]. The student’s benefits can be summarized by:

- Design and implement advanced curricula, courses and laboratory works to meet international standards;
- Measure and assess the learning outcomes of students and identify strengths and weaknesses;
- Foster all national constituencies of the program such as industrial, governmental interactions and the appointment of students;
- Identify and develop the professional development of students;
- Design quality educational programs in engineering and technology, etc.

The administration benefit can be summarized by:

- Improve the institution infrastructure such as: classroom and laboratory facilities;
- Develop and implement faculty resources;
- Strengthen the communication tools and facilities between institutions and related partners;
- Attract funding resources and agencies to secure funding;
- Enhance national and international networking.

3. ME UAEU STUDENT LEARNING OUTCOMES (SOS)

Before 2014, the naming adopted by ABET for the currently named “Student Outcomes; SOs” was the “Program Outcomes; POs”. The student outcomes (SOs) describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. Up to 2004, the mechanical engineering department at UAEU had in place eighteen SOs. These were mapped to ABET outcomes 3a-k and to previous program specific criteria which was effective at the time. Since the time of their inception in 2005, these SOs (in conjunction with the PEOs), were periodically reviewed and discussed with the constituencies in different capacities and different opportunities. Just prior to the previous ABET accreditation visit in 2009, the SOs

were revisited one more time in the open house day held in 2009 and they were found by the program constituencies to still be a good match with the university and departmental mission. Recently, and based on feedback and extensive discussions with one of our major constituencies namely the Academic Advisory Board (AAB); who visited the ME department in a mock ABET accreditation visit in Fall 2014, a trigger for revisiting our SOs was made. These new SOs are explicitly the exact ABET 3a-k which were effective at the time. The department also decided to retain in the new list of SOs an SO from the previous twelve SOs namely SO12, that addresses one of our program educational objectives that is related to entrepreneurship skills. The twelve SOs are reported by the following statements:

- SO1. An ability to apply knowledge of mathematics, calculus based sciences and engineering to Mechanical Engineering.
- SO2. An ability to design and conduct experiments as well as to analyze and interpret data.
- SO3. An ability to design thermal and mechanical systems, component or processes to meet desired needs.
- SO4. An ability to function on multi-disciplinary teams.
- SO5. An ability to identify, formulate and solve engineering problems.
- SO6. An understanding of professional and ethical responsibility.
- SO7. An ability to communicate effectively with written, oral and visual means.
- SO8. The broad education necessary to understand the impact of engineering solutions in a global and societal context and knowledge of contemporary issues.
- SO9. A recognition of the need for and ability to engage in life-long learning.
- SO10. An Ability to use modern engineering techniques, skills and computing tools necessary for engineering practice.
- SO11. Familiarity with statistics and linear algebra.
- SO12. A recognition of the need for and an ability to engage in entrepreneurial activities.

4. THE UAEU PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

In the pursuits towards maintaining reputable international recognition for its MEP by consistently securing ABET accreditation, the ME Department at UAEU was keen to develop and maintain a well-defined set of Program Educational Objectives PEOs. These PEOs undergo a continuous review and modification to assure the quality of our program and graduates and at the same time compliance with the university mission and vision statements. Our review process employs feedback instruments such as surveys and other assessment tools. Up to September 2014, the PEOs of the mechanical engineering program were stated as:

- PEO1. Serve UAE industries with a broad-based knowledge of mechanical engineering, related principles, theories, and applications.
- PEO2. Provide UAE industries capacity in designing, analyzing, testing, and implementing mechanical systems and processes.

- PEO3. Meet industry expectations with a set of professional skills including communication skills, the use of modern engineering tools, an ability to perform well in teams, and a commitment to life-long learning.
- PEO4. Be committed to the highest standards of ethical practice and to social and environmental issues relevant to the engineering profession.
- PEO5. Be aware of the tools and skills necessary for participating effectively in graduate education, building a healthy, diverse and sustainable UAE economy.

5. SELF-STUDY REPORT (SSR)

The ABET made it clear that meeting the ABET international criteria is a direct responsibility of the accredited institution. The ABET summarized the program criteria which demonstrates clearly that the program educational objectives and outcomes are met and achieved. The ABET caritas are summarized by the following areas:

- Criterion 1: Students.
- Criterion 2: Program Educational objectives.
- Criterion 3: Program Outcomes.
- Criterion 4: Continuous Assessment/Improvement.
- Criterion 5: Curriculum.
- Criterion 6: Faculty.
- Criterion 7: Facilities.
- Criterion 8: Support.
- Criterion 9: Program Criteria.

6. ME PROGRAM OUTCOMES ASSESSMENT TOOLS

The program's direct and indirect tools used for assessing the SOs and the level of attainments of PEOs are briefly described in the coming paragraphs based on ME-UAEU SSR, [26]:

Course Assessment Form (CAF): The main assessment tool that is currently used in the course level assessment to collect quantitative and qualitative data is the course assessment form (CAF). The CAF consists of a mapping between the student outcomes (SOs) and course outcomes (COs). Mapping the course outcomes to the department's student outcomes also proved at the time.

Mid-Study Exam: It is a form of a test that students should undertake in the middle of their study. The exam comprises three separate sheets each includes about 40 questions that are mapped to a number of student outcomes. Each exam sheet covers questions related to one focus group and is performed within a course where the exam contributes to the grade of that course.

Exit Exams: It is a form of a test that students should undertake in senior year. The exam comprises questions that are mapped to a number of student outcomes.

Open House: The open house is an important event that brings together, in a very effective and fruitful framework, the program constituencies and gives them the chance to share, discuss, and exchange ideas

with ME Faculty on matters of importance for the program that contribute to continuous improvement pursuits.

Surveys: Collected questionnaires from graduating students, industrial employers, open house, industrial training supervisors, and alumni are compiled in a single folder. The received feedback is used for assessment of the level of attainment of the SOs and to achieve continuous improvement.

Tool for GPs and Industrial Training: To gain a more direct way of evaluating the attainment of the SOs, the ME department developed a direct tool for assessing Graduation Projects (GP) and Industrial Training (IT) students. This was in the form of an evaluation compiled by ME faculty members serving on the oral exam jury of ME students while defending their graduation projects theses or their final industrial training report.

Student Exit Survey: The student exit survey is conducted at the end of their tenure in the department and it provides input to the level of attainment of each of the twelve SOs.

IT supervisor Survey: The IT unit assesses the industrial training at the three levels of evaluation of the students. The first level is a survey filled by the industrial supervisor, the second level of evaluation adopted at the industrial training and graduation projects unit is for a report and the third level is the presentation by the student at the end of the training period.

Alumni Day and Alumni Surveys: ME faculty and ME alumni exchange and share ideas about different aspects that may result in improving the ME program and the way it is delivered. Recent Alumni surveys on the level of attainment of the PEOs and the SOs have been conducted.

Employer Survey: The ME department conducted surveys seeking the opinion of the employers of our graduates regarding our SOs and PEOs via open house meetings, and mail correspondences.

Faculty Opinion: Faculty members are all requested to complete a survey which requires an opinion on how they believe is the performance and level of attainment of the SOs by our students.

Academic Advisory Board (AAB): It is composed of academicians from different engineering schools in the United States with extensive experience with ABET Engineering Programs accreditation that enables them to provide us with valuable input and feedback on UAEU engineering programs.

Industrial Advisory Board (IAB): The College synthesized a board composed of leading members from the different industrial sectors in the country. Many of them might even be alumni of the college who already graduated some time ago and assumed leading positions in the local industry and institutions in UAE. The board's feedback to the college on issues and matters related to the college and its different engineering programs is expected to be of great value and help for us to attain continuous improvement.

6. EMPLOYED PROGRAM ASSESSMENT MODELS

Figure 1, [26] summarizes the QA process and demonstrates how and when different assessment tools (direct and indirect) and the interaction with the different constituencies, are being used at all three levels: Course, Curriculum, and Program levels. A brief description of each level of assessments are described below:

6.1 Course Level Assessment

The department developed two stages in assessing each course. The first stage is by the faculty teaching the course and the second stage is by a focus group consisting of faculty members in the field of that course. Each of the course's outcomes is mapped to relevant student outcomes. Each faculty member assesses his/her course and submits a course assessment form (CAF) at the end of the semester. Table 1 summarizes the components of the course level assessment system. It outlines the objectives of the course level assessment, defines the entities in charge, the assessment tools used and their nature (direct and indirect), and the frequency at which the assessment is done.

6.2. Curriculum Level Assessment

The curriculum level assessment is an intermediate level between the course level and the program level assessments. The curriculum level assessment leads the efforts of improvement of the ME curriculum. The focus groups then report the recommendations to the assessment committee and the curriculum committee who evaluate the proposed improvements and their relations to the overall curriculum. In this process the assessment committee interacts with the curriculum committee. The curriculum committee is the link between the department and the college where all suggested curriculum changes are carried to the college curriculum committee for discussion and recommendation. Table 2 gives more details of the curriculum level assessment. The objectives of the system are listed and the reporting chain is outlined along with the body in charge.

6.3 Program Level Assessment

The program level assessment provides the highest level of assessment to evaluate the overall attainment of the program educational objectives (PEOs) and the students' outcomes (SOs). The objectives of the assessment, person in charge, constituencies, assessment tools and frequency of evaluation are all outlined in Table 3.

7. CASE STUDY: SOS AND PEOS ASSESMENT ATTENMENT

In the following section an examined case study is to be reported where data was collected from all listed assessments tools, the assessment tool's data are required to provide a score on a scale from 1- 5, where 5 is the highest attainments and 1 is the lowest. A three-level scale is used to assess the extent of attainment of each student outcome. The first level of SOs attainment is "excellent". In which "Excellent" means that the outcome has shown an excellent level of attainment of 4 or above, with this high level of attainment, the driver for improvement actions would not be the need to rectify deficiencies. Instead, it would be the longing for an ever continuing improvement at a high level. The second level of SO attainment level is "ability", which indicates that the average score is 3-4 and this means that an action to improve is required as soon as possible. The third level on the extreme case when a SOs outcome is attained at a "Fair" level, this means that the average score is less than 3 and in that case a serious action to rectify this deficiency is urgently required, [26].

7.1 Level of Attainment of the SOs:

The results of the assessment of the years, 2012, 2013, and 2014 are summarized in figures 2 to 7. In these cycles many assessment tools are used such as: Course Assessment Files CAFs, Mid-study exam, Exit exam, Faculty Opinion, Industrial Training Supervisory survey and GP Quantitative Measure. Figure 2 shows the summary of the attainment of CAFs over the years 2012- 2014, overall the CAF achieved all SOs in an excellent level, equal or above 4 for all examined years. Figure 3 displays the summary of the attainment of mid study exams over the years 2012- 2014, results demonstrate a level of attainment which vary between excellent and fair. Somehow, this result is anticipated since students have the mid study exam in all studied topics without any prior preparation. But at the same time these results expose the areas of weakness for the students to the faculty.. Figure 4 shows the summary of the attainment of exit exams over the years 2012- 2014, within the available data the students attained a level between ability and fair, which again is expected keeping in mind that students are taking the exam in the graduation year and the exam cover all studied subjects. Figure 5 illustrates the summary of the attainment of Faculty Opinion over the years 2012- 2014, the reported level of attainment is ability and this level was consistent over all previous cycles. Figure 6 and 7 illustrate the summary of the attainment of Industrial Training Supervisory survey and GP Quantitative Measure over the years 2012- 2014, as described earlier this data was collected from surveys and the attainments levels vary between excellent and ability.

7.1 Level of Attainment of the PEOs:

The mapping between the twelve SOs and the above PEOs is given in Table 4. A three-level correlation between the SOs and the PEOs is used. The solid square presents the strongest correlation (high correlation). The hollow square indicates a moderate relationship (reasonably correlated) while the lowest level of correlation (slightly correlated) is represented by an empty square. The table shows a well exposed and distributed correlation between any given PEO and the SOs, where each PEO maps to at least four SOs. The table can also assist in correlating the results of the assessments obtained for SOs to those of the PEO. Figure 8 illustrates the average results of the mapping for the available data of the SOs to PEOs over the reported period 2012-2014. A level of attainments between excellent to ability was demonstrated over all PEOs results. Reported results suggested a consistency between the mappings of the same SO to different PEOs.

8. CLOSING REMARKES

In this article a description of ME-UAEU practice through the ABET accreditation process was reported for one period cycle 2012-2014. Direct and indirect assessment tools were defined and briefly described. An examined case study was reported.

From the assessment results, the attainment of the SOs has been achieved. The results also show steadiness, which reflects robustness in the assessment tools, and improvement, which results from the continuous support and reflection. Generally, all tools have scores that are somewhat steady over the past terms. However, there are some discrepancies among the scores. With good degree of confidence on the tool results, we can conclude that our students have achieved SO1 with a high average score. This is evident from the agreement of the CAF, GPs course assessment, IT supervisor assessment, student exit survey,

alumni survey and employer survey. Given the nature of the exit exam, 2.5 is considered to be satisfactory. The results show that attainments of SOs have been achieved at a satisfactory level. The assessment tools are found to be robust. The improvement noticed in the attainment of the SOs was driven by actions at focus group levels and the feedback from program constituencies. The mapping of PEOs to reported SOs show a level of attainment that varies between excellent and ability.

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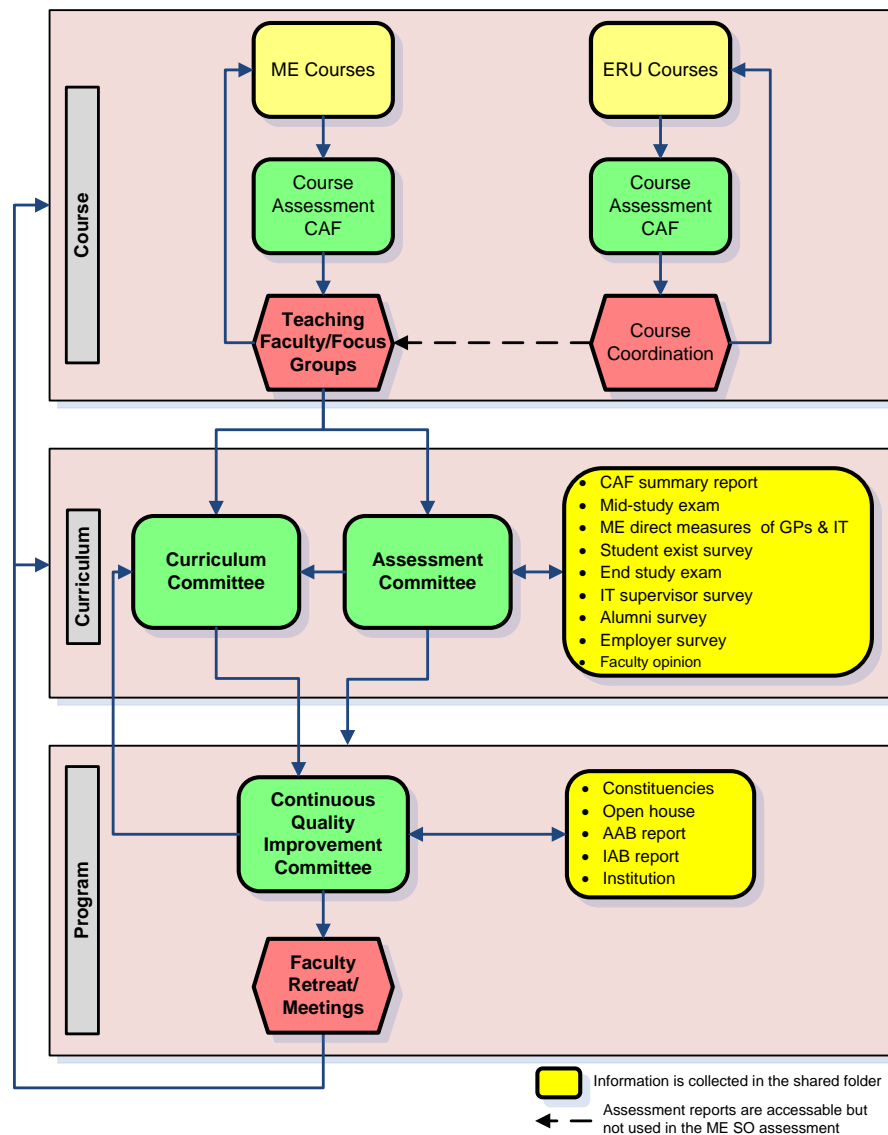


Figure 1. Program assessment and improvement process [26]

TABLE 1. COURSE LEVEL ASSESSMENT SYSTEM [26]

Objectives	Prepare objectives/outcomes	
	Conduct course assessment	
	Coordinate with focus group	
Person in charge	Teaching faculty	
Constituencies	Students	
	Faculty	
	Focus groups	
Assessment tools	CAF – Quantitative	Direct
	CAF - Student Course Surveys	Indirect
	GP I & II (course assessment)	Direct
	Focus Group Meetings	Indirect
Frequency	Every time the course is taught	

TABLE 2 CURRICULUM LEVEL ASSESSMENT SYSTEM [26]

Objectives	Ensure match between PEOs and SOs Design coherent learning tasks that meet the SOs Ensure that the courses serve their objectives in the curriculum Establish effective communication between faculty Implement improvement	
body in charge	Focus groups	
Assessment tools	CAF	Direct
	Mid-study exam	Direct
	ME direct measures of GPs & IT	Direct
	Student exit survey	Indirect
	Exit exam	Direct
	IT supervisor survey	Indirect
	Alumni survey	Indirect
	Employer survey	Indirect
	Faculty opinion	Indirect
Frequency	Every term	

TABLE 3 PROGRAM LEVEL ASSESSMENT SYSTEM [26]

Objectives	Develop PEO that meets the college and university missions Monitor overall program outcomes and graduation attributes Devise clear advising, monitoring and evaluation plans Implement well-structured curriculum Identify assessment tools Continuous monitoring and improvement of the program Collect and analyze assessment data Devise action plans for continuous improvement	
body in charge	CQI- committee	
Assessment methods	Open House	Direct
	Academic advisory board	Indirect
	Industrial advisory board	Indirect
	Institution	Indirect
Frequency	Major review every 2 years during the open house	

Table 4. CORRELATION BETWEEN THE TWELVE SOS AND THE PEOs IN PLACE UP TO FALL 2014 [26]

	SO1	SO2	SO3	SO4	SO5	SO6	SO7	SO8	SO9	SO10	SO11	SO12
PEO1	■	■	■		■		□	□	□	■	■	■
PEO2	■	■	■		■	□	□	■	□	■	□	□

PEO3				■		□	■	□	■	■		□
PEO4						■	□	■				□
PEO5				□		■	■	■	■	■		■

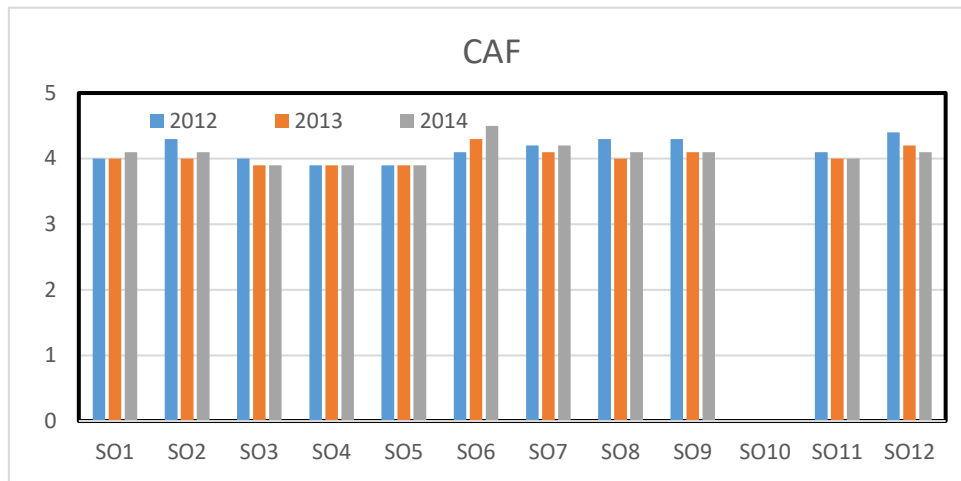


Figure 2. Summary of the attainment of CAFs over the years 2012- 2104. [26]

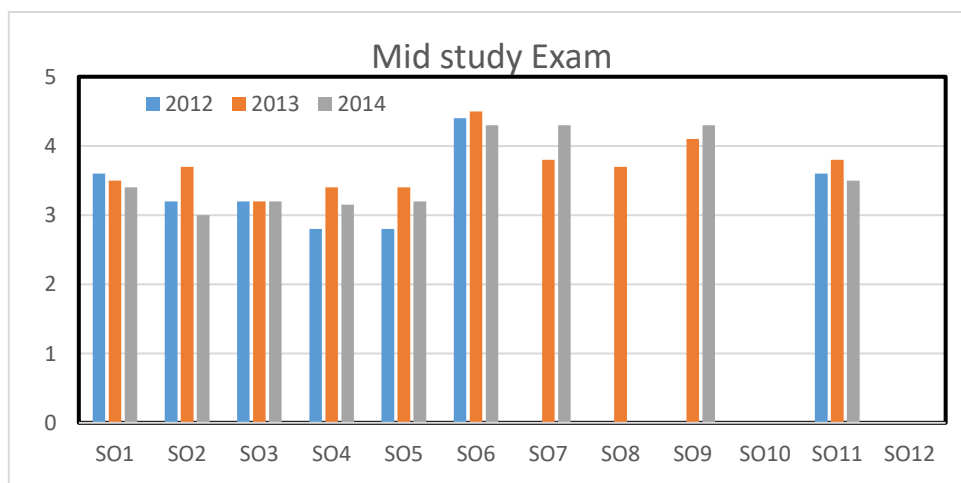


Figure 3. Summary of the attainment of Mid Study Exam over the years 2012- 2104. [26]

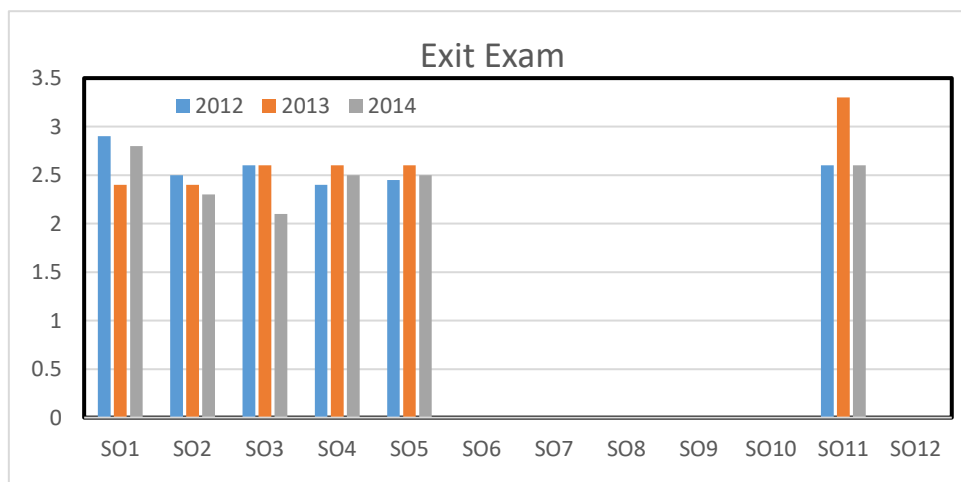


Figure 4. Summary of the attainment of Exit Exam over the years 2012- 2104. [26]

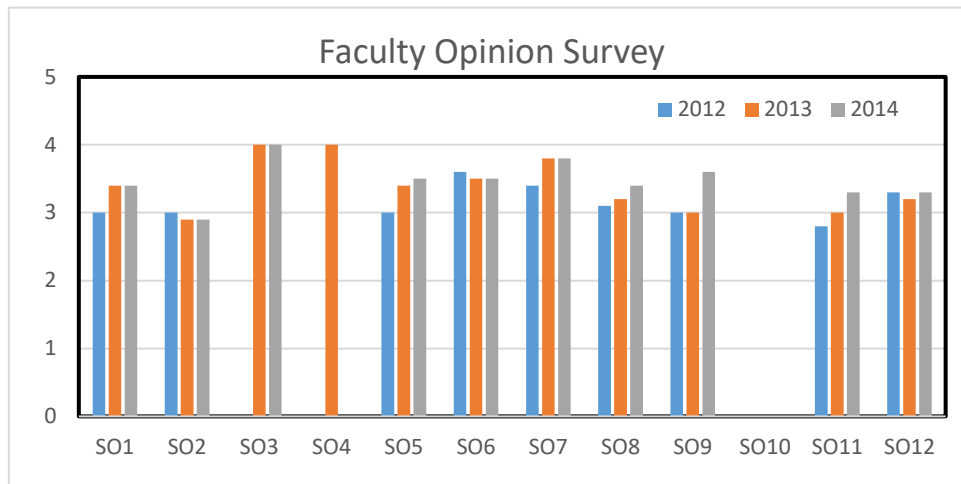


Figure 5. Summary of the attainment of Faculty Opinion years 2012- 2104. [26]

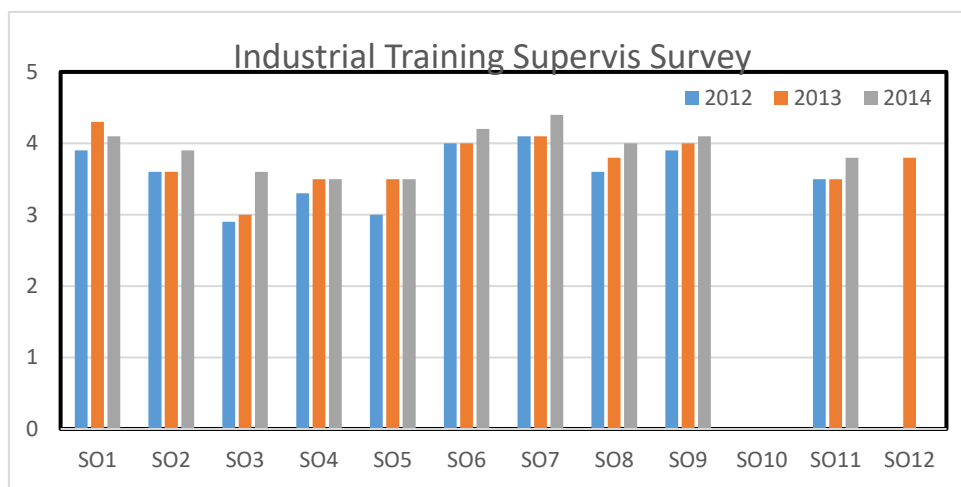


Figure 6. Summary of the attainment of Industrial Training Supervisory survey over the years 2012- 2104. [26]

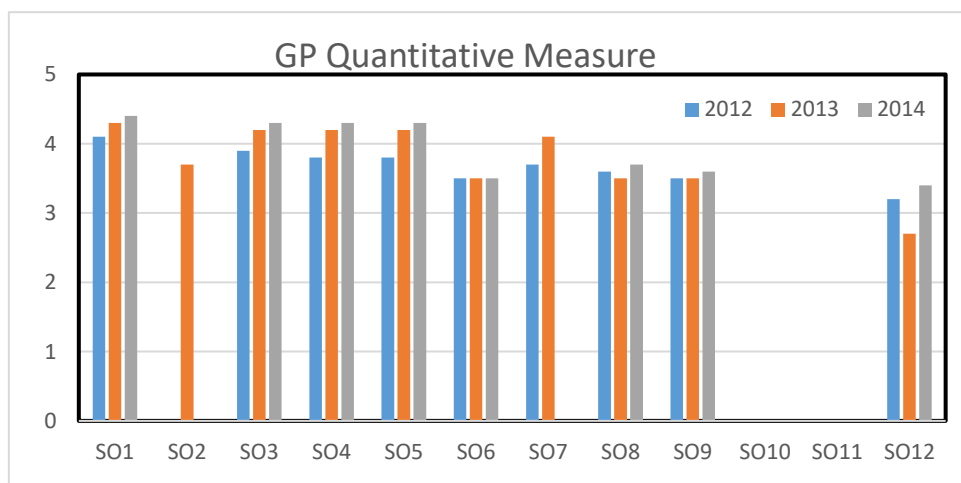


Figure 7. Summary of the attainment of GP Quantitative Measure over the years 2012- 2104. [26]

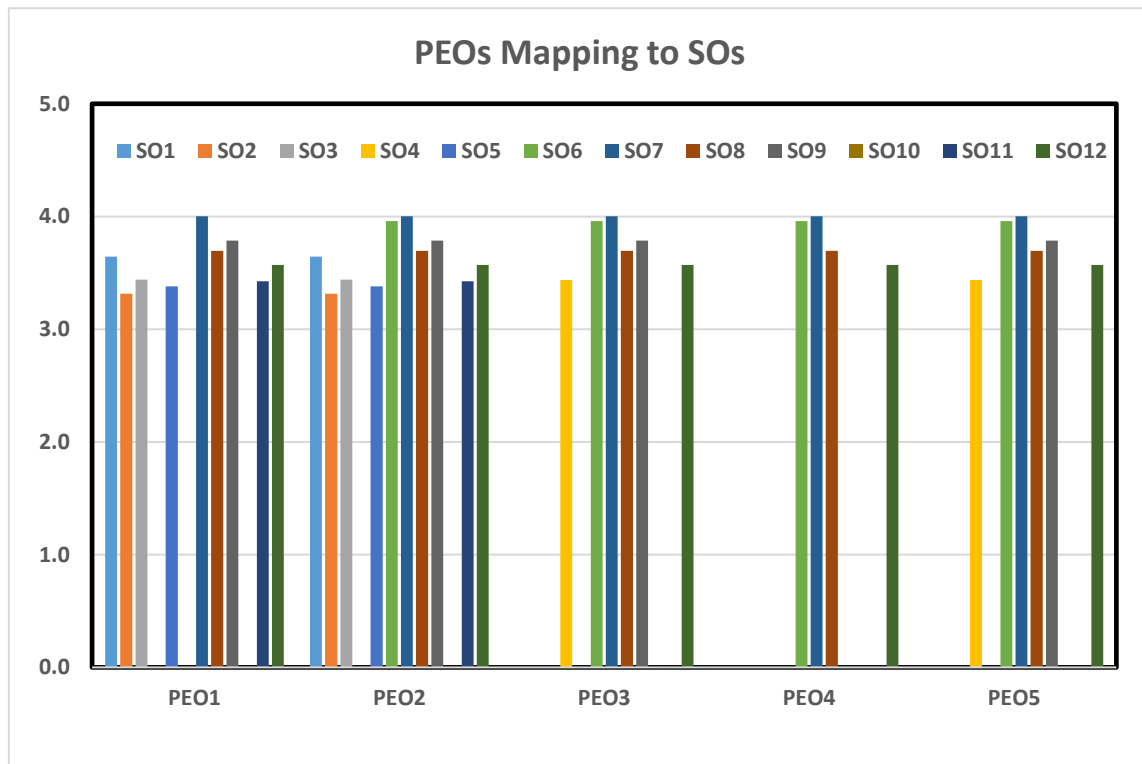


Figure 8. POEs mapping to the SOs displaying the average for the reported cycle 2012-2014