Shifting to Outcomes-Based Education: The Mapúa Institute of Technology Experience

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Abstract— **This paper presents the different processes that the Mapúa Institute of Technology started to implement when it shifted to outcomes-based education. Preparations for ABET accreditation started in 2003 with the Electrical Engineering, Electronics Engineering, and Computer Engineering programs under the School of EECE. These programs were visited by a team of ABET evaluators in October 2009 and official accreditation was granted in July, 2010, giving Mapúa the distinction of being the only institution in the Philippines and in the whole of East Asia to be granted international accreditation in Engineering Education. While preparing for OBE implementation and ABET accreditation, the curricula and the PEOs were revised, the POs were implemented and the assessment and evaluation processes were put in place. Although the shift took time, OBE implementation was helped along by the organizational structure and the systems that were already being implemented at the time of the shift. For one, Mapúa already had an institutional Continuous Quality Improvement Office even before CQI became an ABET criterion for Accreditation. The CQIO started the formulation of procedures for PEO and PO assessment and evaluation and the School of EECE was tasked to implement these procedures. The School of EECE has a CQI committee having the Dean, the Program Chairs and the Course Cluster heads as members. Course clusters are groups of faculty members teaching courses related to each other. This organizational structure made the implementation of assessment and evaluation procedures easier because the Course Clusters were already performing some of the functions that were eventually formalized and focused towards the implementation of outcomes-based education.**

Index Terms — **ABET, accreditation, CQI, Mapúa, OBE**

I. Introduction

Mapúa Institute of Technology or simply Mapúa is the premier and largest engineering school in the Philippines. It was founded in 1925 by Don Tomas Mapúa, a graduate of Cornell University and the Philippines' first registered architect. The Institute was founded as a non-sectarian night school offering BS Civil Engineering and BS Architecture programs [1]. At present, Mapúa offers several bachelor and graduate degree programs. The current president of the Institute, Dr. Reynaldo B. Vea, a Ph.D. graduate of UC Berkeley, envisioned Mapúa to pioneer the implementation of outcomes-based education (OBE) in the country as well as to take the lead role in producing world class graduates. In 2003, Dr. Vea instructed the Dean and Chairs of the Electrical Engineering (BS EE), Electronics Engineering (BS ECE), and Computer Engineering (BS CpE) programs to prepare and submit the three programs to ABET accreditation, a major step towards the realization of the vision of Mapúa.

The shift to OBE was a long process that required continuous and sustained effort. There was a need for internal constituencies to learn the principles of OBE and to actively participate in its implementation. Since the EE, ECE, and CpE programs of the Mapúa Institute of Technology are now ABET accredited, it is the purpose of this paper to report how these programs implement OBE .

Spady and Marshall [2] explained outcomes as: clear, observable demonstrations of the student learning that occurs after a significant set of learning experiences. They also stated that these are not values, attitudes, feelings, beliefs, activities, assignments, goals, scores or averages, as many people believe. They further added that typically, these demonstrations reflect three things: (a) what the student knows; (b) what the student can actually do with what he or she knows; and (c) the student's confidence and motivation in carrying out the demonstration. They also state that outcomes are what learners can actually do with what they learned. In short they are the concrete application of what has been learned. OBE compels educators to use action verbs like describe, explain, design or produce. These action verbs are preferred more than the vague and non-demonstration processes like know, understand, believe or think.

Outcomes-based education is a model that rejects the traditional focus on what the school provides to students, in favour of making students demonstrate that they "know and are able to do" whatever the required outcomes are. The OBE transformation emphasizes setting clear standards for observable and measurable outcomes; this system can be judged by the following attributes: (a) creation of a curriculum framework that outlines specific, measurable outcomes. The standards included in the frameworks are usually chosen through the area's normal political process; (b) a commitment not only to provide an opportunity of education, but to require learning outcomes for advancement. Promotion to the next level, a degree, or other reward is granted upon achievement of the standards, while extra classes, repeating the year or other consequences entail upon those who do not meet the standards; (c) standards-based assessments that determines whether students have achieved the stated standard assessments may take any form, so long

Manuscript received June 2, 2011; revised June 14, 2011. This paper was supported by the Mapúa Institute of Technology, the School of EECE, and the Continuous Quality Improvement Office.

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ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

as the assessments actually measure whether the student knows the required information or can perform the required task; (d) a commitment that all students of all groups will ultimately reach the same minimum standards. Institution may not give up on unsuccessful students. The emphasis in an OBE education system is on measured outcomes rather than inputs. Outcomes usually require a range of skills and knowledge, and outcomes of learning are expected to be quantifiable [3].

II. Shifting to Outcomes-based Education (OBE)

Outcomes-based Education is an approach to education in which decisions about the curriculum are driven by the outcomes the student should display by the end of the course [4]. William Spady [5], widely regarded as the OBEs leading advocate, explains outcomes-based education as focusing and organizing everything in the education system around what is essential for all students to be able to do successfully at the end of their learning experiences. Essentially, everything starts with a clear and unambiguous picture of what is paramount for students to be able to do. In OBE the educational outcomes are clearly specified. These outcomes determine the organization and curriculum content, the instructional methodologies and strategies, the courses to be offered, the assessment process and the curriculum timetable. The outcomes also provide a framework for curriculum evaluation and improvement. In the traditional education system, the curriculum and assessment are not structured around defined outcomes [6].

Whereas previously the school calendar determined what a student might do at any moment of any school day, now progress toward specific outcomes will control activity [7]. However, in OBE, time is used as an alterable source depending on the needs of educators and learners and it is manipulated to the advantage of all learners. OBE considers the fact that some learners learn some parts sooner, while others master those parts later [3]. Killen [8] defines outcome-based education as an approach that requires educators and learners to focus their attention and efforts on the desired end results of education. OBE contrasts with traditional education, which primarily focuses on the resources that are available to the student, which are called inputs [3]. This is what faculty members were using before OBE was introduced. OBE on the other hand focuses on what is essential for all students to be able to do successfully at the end of their learning experiences [5]. These essentials are known as outcomes. Although OBE requires that students demonstrate and show they have learned the necessary skills, no singular style of teaching is specified.

In general, OBE standards are clearly defined and are known by all learners. This system allows the learners to reach and receive full credit for achieving any performance standard. OBE focuses on increasing students' learning and ultimate performance abilities to the highest possible level before leaving school. That means that OBE takes a general idea of the student's learning and achievement. In this situation, mistakes are treated as inevitable steps towards development and demonstration of high level performance capabilities. The traditional system takes the opposite approach where testing and permanently grading of learners is very important and emphasizes on rewarding learners for assigned work covered in class. Those students who are fast and consistent performers get the best grades and those who are slower never get the opportunity to catch up because previous mistakes cannot be removed [3].

The three Programs started its preparations for ABET accreditation and the implementation of OBE in summer of 2003. In conformity with the requirements of ABET Criteria for Accrediting Engineering Programs 2009-2010 Accreditation Cycle, the following had to be done: revision of the Program Educational Objectives; implementation of the required Program Outcomes; establish the Student Advising System; revision of the Program Curriculum; redesign the Course Syllabi; develop the Assessment and Evaluation processes; establish the Program Academic Advisory Panel; and creation of the Continuous Quality Improvement Office.

A. Program Educational Objectives (PEOs)

As defined by ABET, Program Educational Objectives or PEOs, are be broad statements that describe what graduates are expected to attain within a few years after graduation [9]. ABET requires that programs seeking accreditation must have in place: published PEOs that are based on the needs of the program's constituencies; consistent with the mission of the institution; a process that periodically documents and demonstrates that the objectives are based on the needs of the program's various constituencies; and an assessment and evaluation process that periodically documents and demonstrates the degree to which these objectives are attained. To conform to the requirements of ABET, the PEOs of the EE, ECE and CpE programs had to be revised. The revised PEOs are published in all official documents and publications of Mapúa such as the Curricular Guidelines, the course syllabi, and its official website. The PEOs of the three programs are listed in Table I.

The Mapúa mission statements are: (1) The Mapúa Institute of Technology disseminates, generates, preserves and applies knowledge in various fields of study;(2) The Institute, using the most effective and efficient means, provides its students with highly relevant professional and advanced education in preparation for and furtherance of global practice; (3) The Institute engages in research with high socio-economic impact and reports on the results of such inquiries; and (4)The Institute brings to bear humanity's vast store of knowledge on the problems of industry and community in order to make the Philippines and the world a better place[12].

In addition to satisfying the requirements of the Programs, the Program Educational Objectives are likewise consistent with and are supportive of the Mission of the institution. Table I shows the relationship between the PEOs and the Mapúa Mission Statements.

B. Program Outcomes (POs)

Program Outcomes are statements that describe what students are expected to know and be able to do by the time of graduation. Also, these outcomes relate to the knowledge, skills, and behaviors that students acquire as they progress through the program [9]. To implement OBE, a set of program outcomes had to be identified. In compliance with

ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Criteria 3 of ABET, the three programs adopted the 11 (a to k) outcomes. Table II shows the relationship of POs to PEOs. It can be seen that the POs are consistent with and support the attainment of the PEOs.

TABLE I
RELATIONSHIP BETWEEN PEOs AND MISSION STATEMENTS

No.	Program Educational Objectives	Mission			
		1	2	3	4
1	The graduates are able to apply the broad fundamental concepts in social and natural sciences, mathematics, and engineering, and the depth of knowledge gained in electrical engineering, as professionals in their chosen careers	✓	✓	✓	✓
2	The graduates are practicing professionals who are qualified and proficient in the use and creation of appropriate and up-to-date research and design methodologies and tools required to successfully perform, their tasks in accordance with ethical norms and standards	✓	✓	✓	✓
3	The graduates demonstrate effective communication skills, the ability to work well either individually or as part of a team, who have embraced lifelong learning values for continuous self and professional or career development	✓	✓	✓	✓
4	As professionals, the graduates utilize appropriate knowledge and technology in dealing with local and global, industrial, community, and environmental concerns for the advancement of society.	✓	✓	✓	✓

C. Program Criteria

In addition to the above-mentioned a-k program outcomes, there are additional outcomes the students of each program are required to achieve as stated in Criterion 9 [9]. The EE, ECE, and CpE curricula provide both breadth and depth to cover the topics required so that these additional outcomes are achieved. The additional Program Outcomes for EE, ECE, and CpE are: (1) knowledge of probability and statistics, including applications in electrical engineering; (2) knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design electrical and electronic devices, software, and systems containing hardware and software components; (3) knowledge of discrete mathematics.

For the EE and ECE programs, a fourth additional outcome is: (4) knowledge of advanced mathematics, typically including differential equations, linear algebra, and complex variables.

D. Students

Policies regarding the monitoring, evaluation, and advising of students were put in place to contribute to the achievement of the program outcomes. The implementation of these policies requires close coordination between the Office of Student Affairs, the Registrar, and the School of EECE.

For the implementation of student advising, the School of EECE works closely with the principal office charged with this function, the Center for Student Advising.

E. Curriculum Revision

The curricula of the three programs were revised to conform to the standard and program requirements of ABET in terms of quality and quantity. New courses in mathematics and design were added. Also, the revised curricula were designed to facilitate attainment of POs and PEOs. The available courses as well as the number of units in the new curricula ensure the preparation of student for engineering practice and competency through general engineering, engineering sciences, and professional courses. To ensure continuous improvement, all curricula are regularly reviewed in the light of the PO and PEO assessment and evaluation processes.

TABLE II
RELATIONSHIP OF POs TO PEOs

	Program Outcomes (PO)	Program Educational Objectives (PEOs)			
		1	2	3	4
a	An ability to apply knowledge of mathematics, science, and engineering	✓	✓	✓	✓
b	An ability to design and conduct experiments, as well as to analyze and interpret data	✓	✓	✓	✓
c	An ability to design a system, component, or process to meet desired needs	✓	✓	✓	✓
d	An ability to function on multi-disciplinary teams	✓	✓	✓	✓
e	An ability to identify, formulate, and solve engineering problems	✓	✓	✓	✓
f	An understanding of professional and ethical responsibility	✓	✓	✓	✓
g	An ability to communicate effectively	✓	✓	✓	✓
h	The broad education necessary to understand the impact of engineering solutions in a global and societal context	✓	✓	✓	✓
I	A recognition of the need for, and an ability to engage in life-long learning	✓	✓	✓	✓
j	A knowledge of contemporary issues	✓	✓	✓	✓
K	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	✓	✓	✓	✓

F. Course Syllabi

All course syllabi were revised using a common specific format. This is to ensure that the course syllabi contain all the necessary information such as topics, resources, time allocations, teaching-learning activities, assessment tools, and methodologies. On top, the other usual information provided in the syllabus such as course code and title, course description and objectives, and course's prerequisites and co-requisites, additional information were added, namely: the relationship between the PEOs and the mission statements of the Institute; the relationship between the course objectives and the PEOs; the relationship between the PEOs and the POs; and the relationship between the course outcomes and the PEOs and POs. Course syllabi are regularly reviewed and updated to reflect the needed improvements, particularly to provide actions on recommendations that may come out of any evaluation process.

G. Continuous Quality Improvement (CQI) Office

The Continuous Quality Improvement Office was created primarily for the purpose of conducting internal quality audits to check compliance of the programs with mandatory, statutory, and regulatory requirements of the Institute. It also ensures that a methodical approach to continuous quality improvement is strictly being implemented by the Schools and academic programs for purposes of program improvement. Furthermore, CQIO manages and coordinates all activities relevant to the accreditation or certification of academic programs by local and foreign accrediting bodies.

H. Program Academic Advisory Panel (PAAP)

In 2004, Mapúa established Academic Advisory Panel at the program level known as Program Academic Advisory Panel or PAAP. The members consist of business, technology, and community leaders and shall meet twice a year so that their recommendations shall serve as inputs to the program's annual planning session usually done during March or April each year. The objectives are the following: (a) to assure that the academic program of Mapúa stay attuned to advances in engineering theory and practice; (b)

ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

to sharpen Mapúa's understanding of and responsiveness to local and global industry manpower needs; (c) to improve competitiveness of Mapúa graduates with regard to placement; (d) to achieve the proper curricular balance between the classroom and exposure to the workplace, between theoretical and practical knowledge; (e) to develop meaningful OJT, placement, faculty internship, and other cooperative programs; (f) to sharpen Mapúa's understanding of local and global industry needs in terms of new knowledge; (g) to identify sustainable and viable consultancy and R&D projects; (h) to develop mutually beneficial scholarship and professorial chair programs; and (i) to develop links with communities and apply technology to help solve local problems [10].

I. Assessment and Evaluation Processes

Systems for assessment and evaluation processes were developed to determine the extent of attainment of the PEOs and POs. Assessment is one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes and program educational objectives while evaluation is one or more processes for interpreting the data and evidence accumulated through assessment practices. Each PEO and PO must be assessed using appropriate assessment tools. Internal and external stakeholders must be included in the assessment process. Evaluation results in decisions and actions to improve the program [11].

To facilitate the assessment of POs, standard class records were developed. These class records are used to generate the outcome scores based on the students' grades. The standardized grading excel file for each of the courses automatically generates the outcomes score. Another excel file links all the courses in the program together and gives a summary of the outcomes score for all the courses in the program for which the faculty has utilized the standard grading sheet. Figure 1 illustrates the assessment and evaluation process to determine the achievement of the PEOs and the POs. A faculty course review is in-place to assess, reflect, and rate the course based on the collected portfolios [13].

Evaluation of the results of all the assessments done come in two levels: through the Faculty Course Review FGD and through the Performance Committee Meeting (PCM). The Faculty Course Review FGD is an activity conducted by members of the course cluster to gather in-depth overall assessments, reflections, ratings, and other improvements to be done in the course under review through a question-answer interview [14]. The PCM is a once-a-year activity involving the Dean, Program chairs, CQI committee heads, and course cluster heads to evaluate the performance scores of all program outcomes and to determine the degree to which program outcomes are attained [15].

III. PEO & PO Assessment and Evaluation Processes

To determine the degree of achievement of the PEOs and the POs, assessment tools had to be identified and evaluation methods had to be put in place. Direct and indirect data collection methods were employed involving both internal and external constituencies of the three Programs.

A. PEO and PO Assessment

The tools for assessing the degree of attainment of PEOs include surveys and consultations with external constituents of the programs which are mainly composed of the alumni, industry representatives, and employers of the graduates. Surveys and consultations are conducted at least once a year. A chart of the PEO evaluation process is shown in the left-hand side of Figure 1. The blocks related to PEO evaluation are connected by black arrows in the figure.

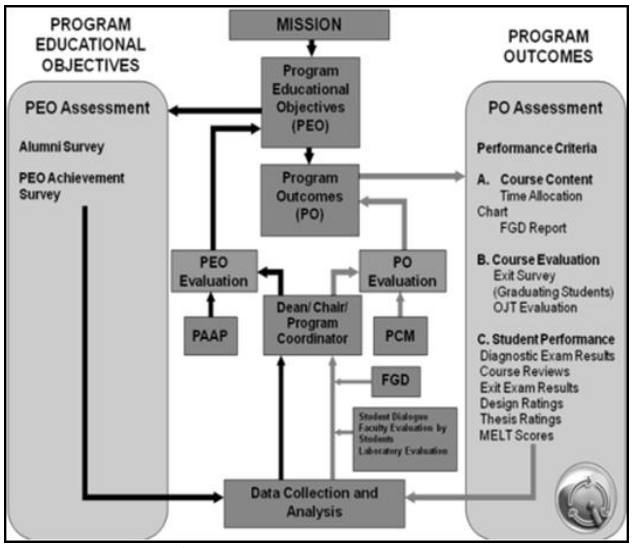

Fig. 1. Processes for assessing and evaluating Program Educational Objectives and Program Outcomes.

On the other hand, achieving program outcomes involves data gathering from the internal constituents, namely the faculty and students. Faculty course review is done at the end of each term for all regular course offerings. This review includes the processing of student grades and the collection of data for all assessment tools necessary for PO evaluation. A summary of the assessment tools and processes is shown in the right side of Figure 1. The collected information from all the program constituencies, are summarized in preparation for the evaluation process. The PO evaluation process is represented by the gray arrows on the right side of Figure 1.

B. Evaluating the Program Educational Objectives

The Program Educational Objectives assessment as stated previously is based mostly on surveys. The respondents are some of the institute's constituents namely: the faculty members, the PAAP, alumni, and industry\employer or public. Result and interpretation of the survey are considered in the evaluation process. The first faculty evaluation of the PEOs was conducted on April 14, 2009, while the PAAP, alumni, and industry\employer survey was first administered during the PAAP meeting held on April 16, 2009 attended by the PAAP members of the program, the Program Chairs, and the Dean of the School of EECE. The results of the differentPEO assessment are summarized, graphed and evaluated. Findings of the evaluation are used to provide recommendations and action plans to have a sustainable continuous improvement system.

ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Overall, the results of the surveys conducted regarding the Program Educational Objective were all satisfactorily since none of the average ratings presented fell below the score of 3 on a scale of 1 to 5, where 5 represents excellent attainment of the PEO. Recommendations, suggestions, and other measures to help in the improvement and/or attainment of the PEOs are the primary outputs of the evaluation meeting.

	Course Outcome	Average Score	91.86 A	0.00 B	0.00 C	91.86 D	94.49 E	94.06 F	94.06 G	94.06 H	94.71 I	94.06 J	91.86 K
1	Discuss basic principles, concepts, and methods of basic	85.73	x			x		x	x	x		x	x
2	Explain the role of engineering economy in the design and analysis of various engineering	85.73	x			x		x	x	x		x	x
3	Recognize elements of the economy that affect the practice of engineering and project the effects of these elements and	85.73	x			x		x	x	x	x	x	x
			Hidden Rows for brevity										
10	Explain basic concepts of accounting elements, the fundamental accounting	72.10	x			x	x						x
			10	0	0	10	7	9	9	9	5	9	10

Fig.2. Relationship between Course Outcomes and Program Outcomes with the corresponding PO ratings for a Laboratory Course

	Assesment Tools	Program Outcome a	b	c	d	e	f	g	h	i	j	k
2	Diagnostic Exam Results	71.60				71.60						71.60
3	Design Ratings											
4	Thesis Ratings											
5	OJT Evaluation											
6	Mock Board Exam Results	75.38				75.38						
7	MELT Scores							60.00				
8	Engineering Ethics											
9	Exit Exam Results	67.33				67.33						67.33
	Average:	**57.08**	**11.48**	**12.41**	**16.88**	**62.72**	**0.00**	**50.98**	**14.22**	**12.61**	**22.81**	**37.44**
	Rating:	**3.00**	**1.00**	**1.00**	**1.00**	**4.00**	**1.00**	**3.00**	**1.00**	**1.00**	**2.00**	**2.00**
		2.85	0.57	0.62	0.84	3.14	0.00	2.55	0.71	0.63	1.14	1.87

ANALYSIS AND EVALUATION

Based on the average rating summary,

1. an ability to identify, formulate, and solve engineering problems were also noted as high (62.72%) considering that students do really apply what they had learned in their courses;
2. an average rating were seen on the following POs, namely, POs **a, and g** which tells us that students needs to be aware of for improvememnt; and
3. a low score was noted in PO **f** since the Standard Class Record is yet to be accomplished this 3rd Q SY 2009 - 2010. Nevertheless, improvements on the "Contracts, Specifications, Ethics and Laws" course are on-going through FGD.
4. For Thesis, Thesis 1 will be offered by 1st Q of SY 2010 - 2011.

Fig.3. Evaluation of the extent of attainment of Program Outcomes based on all assessment tools.

C. Evaluating the Program Outcomes

The Program Outcomes are evaluated through focused group discussions conducted by the course clusters after the necessary course assessments are conducted and processed. An example of an Excel screen shot showing the PO scores for one laboratory course is shown in Figure 3. Likewise, the findings and recommendations derived from the focus group discussion will validate the need for some syllabus revision and some course enhancements that may be necessary for the improvement of the program outcomes attainment. Furthermore, a Performance Committee is tasked with the responsibility to evaluate the degree of achievement of the Program Outcomes. Using the results of all assessment tools and the outputs of the FGD, the Committee evaluates the performance scores of all Program Outcomes and determines the extent to which the Program Outcomes are satisfied. The committee will also make recommendations to improve the performance scores in the different program outcomes. Table III shows the detailed Program Outcome evaluation process. Figure 3 shows an Excel screen shot of the result of the evaluation of program outcomes based on all assessment tools.

IV. Conclusion

Mapúa's shift towards outcomes-based education (OBE) has made it possible to have a more focused approach to delivering quality education to its students. Complying with the ABET accreditation requirements, Mapúa implemented assessment processes necessary to identify the extent or degree of accomplishment of the program educational objectives (PEO) and program outcomes (PO). Evaluation processes were also implemented to come up with recommendations and action plans for program improvement. This ensures continuous quality improvement of the programs. The processes the Institute adopted to implement OBE as well as to satisfy the ABET criteria for accrediting engineering programs, provided outcomes that further strengthened the position of the Mapúa Institute of Technology as a premier engineering school in the Philippines.

TABLE III
PROGRAM OUTCOMES EVALUATION PROCESS FLOW

Process Flow	Description	Responsible	Schedule
Course Syllabus • Prepare/Modify, Review and Approve, Develop/Modify Course Performance Table (CPT)	• The course syllabus contents relevant to the program outcomes • A Course Cluster Focused group discussion (FGD) deliberates on and approves the Course Syllabus. • The Course Performance Table is prepared and approved by the course cluster.	Faculty assigned by Course Cluster Head	As the need arises 3rd week of the term Base on regular offering.
Develop Standardized Class Record	• A Standard Class Record Computer Program in Excel based on the CPT is developed.	• Development Office for IT (DOIT) • Course Cluster / Faculty Member	Every Quarter until the Cycle is complete
• Accomplish Standard Class Record • Generate Report of PO Rating • Conduct Course Review FGD and evaluate the PO	• The Faculty member enters complete data on the Standardized class records which are submitted to the Office of the School of EECE. • The Computer Program in Excel generates a summary of the PO scores/ratings	Course Cluster / Faculty Member	Every Quarter Between 3rd and 6th week of the term
Conduct Performance Committee Meeting (PCM)	• An Excel Spreadsheet generates a summary of the PO scores/ratings • Performance Committee Meeting evaluates the degree of achievement of the POs	Dean, Subject Chairs, Program CQI coordinators	Between 7th and 10th week of the 4th Quarter

V. Future Activities

The Institute will continue to improve on its OBE processes. With institutional support, the coordinating function of the Continuous Quality Improvement Office, and the industrious implementation procedures involving all stakeholders, the assessment and evaluation processes will be continuously reviewed to ensure continuous quality improvement of the three Programs in the School of EECE.

ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

ACKNOWLEDGEMENT

The authors would like to thank Mapúa Institute of Technology, headed by its president Dr. Reynaldo B. Vea for the encouragement and support to write this paper.

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ISBN: 978-988-18210-9-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)