ASSESSMENT EXPERIENCE ON PROGRAM LEARNING OUTCOMES

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ABSTRACT

The School of Information and Communications Technology (SICT) is one of the branch schools of Mongolian University of Science and Technology (MUST). As of 2017, the SICT consists of five departments, in which Department of Communication Engineering Technology (DCET) currently offers two distinctive programs for bachelor degrees, i.e. Wireless communications engineering technology (WCET) and Telecommunications engineering technology (TET).
In order to cope with the fast developments of information and communications technologies as well as to satisfy the requirements and needs of employers, the Program Educational Objectives (PEOs), and Program Learning Outcomes (PLOs) and curriculum of undergraduate programs have been changed and improved periodically and systematically.
Since 2012, Mongolian University of Science and Technology (MUST) has been working with the aim of improving the quality of education and reaching a global educational standard level by intensively deploying an Outcome-Based Education (OBE).
In this paper, we address our experience on how to set up an assessment process, and the methods, cycle and expected performance levels of PLOs for undergraduate programs offered by DCET.

KEYWORDS

Outcome-Based Education, Program Educational Objectives, Program Learning Outcomes, Assessment plan, Standards: 1, 2, 3, 11, 12

1. INTRODUCTION

We are implementing an Outcome-Based Education (OBE) framework through the following steps according to the PDCA principle as depicted in Figure 1.

- Correctly determining the learning outcomes at all levels and properly elaborating the curriculum;
- Organizing the teaching and learning activities through student-centered and active learning technology;
- Assessment and evaluation of all levels of learning outcomes (i.e., Program's Educational Objectives (PEOs), Program Learning Outcomes (PLOs), Course Learning Outcomes (CLOs));
- Continuous improvement of program activities.

As an OBE framework, the PEOs' achievement depends on how graduates are attained PLOs. The PLOs' performance is defined by how graduate students acquired the knowledge,

skills, and attitudes during whole program progress. Accordingly, current students attained the level of knowledge, skill, and attitude will be determined by achievement level of each courses' CLOs.

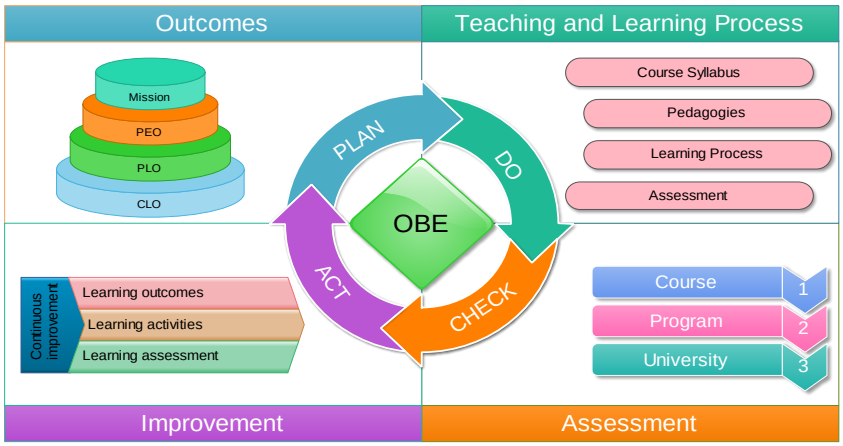

Figure 1. Outcome-based education (OBE) framework consistency with PDCA(Plan-Do-Check-Act) principle

The performance evaluation of PEOs is executed using an indirect assessment method, while the performance evaluation PLOs and CLOs are executed using both direct and indirect assessment methods. Using these assessment results, we can organize the many activities such as revising and optimizing the learning outcomes, improving the learning activities and environments (workspace) as well as enhancing the faculty teaching competence.

In order to evaluate relevance and performance of PEOs and PLOs of undergraduate programs implemented by DCET, we have implemented the assessment and evaluation process depicted in Figure 2.

As shown in Figure 2, there are two types of assessment of PEOs and PLOs, where;

- **Assessment for defining the relevance of PEOs and PLOs:** This assessment is used to define the significance of PEOs and PLOs and how consistent with stakeholder's needs and requirements.
- **Assessment for defining the performance level of PEOs ба PLOs:** This assessment is used to define the graduates' and student's attainment level of PEOs and PLOs. In other words, this assessment defines the level of knowledge, skill, and attitude of the graduates and students.

The relevance of PEOs and PLOs is established and approved by stakeholders and students acquire those outcomes through learning activities, and we define the students' attainment level of outcomes by assessing for each outcome. In order to reach a higher level of performance, we will regularly review the learning outcomes and make changes to the learning outcomes based on the stakeholder's needs. These processes are described in Figure 2. In this paper, we explain about assessment plan of PLOs and its key evaluation methodology.

2. ASSESSMENT PLAN OF PLOs

In order to prepare the graduates with knowledge, skills, and attitudes that can satisfy the PEOs and requirements of employers, we must have to describe the PLOs optimally. Since

2014, we have been introduced CDIO standards and methodologies in undergraduate programs offered by DCET and implemented many activities according to 12 CDIO standards (Crawley et al., 2011) during the past years.

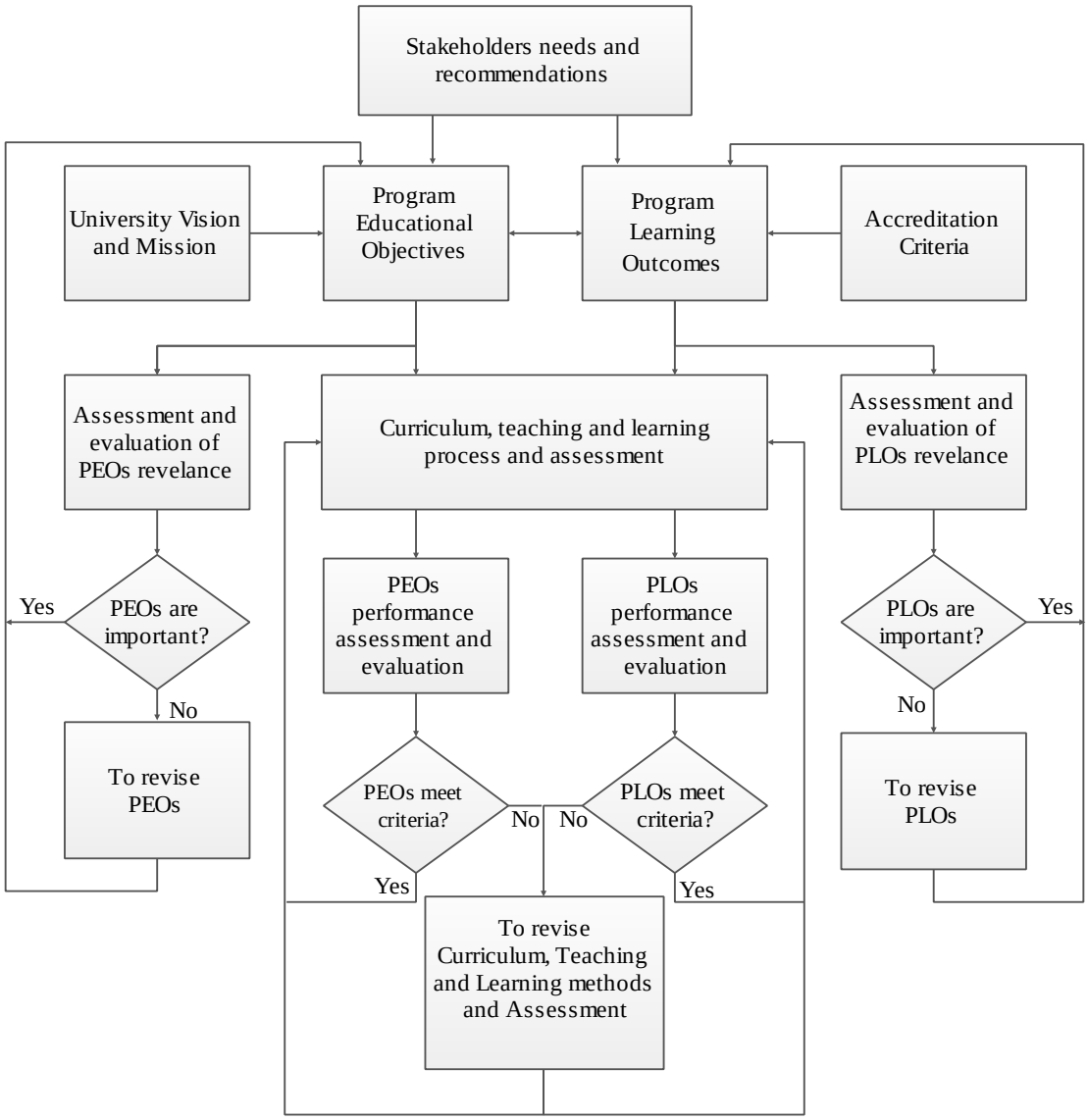

Figure 2. PEOs and PLOs assessment and evaluation process for Undergraduate program

In this respect, we have revised the PLOs of undergraduate programs through properly grouping and sequencing it in correlating with the reference learning outcomes of CDIO approach. As a result, current PLOs of Wireless communications engineering technology (WCET) program listed in Table 1 are not only described according to four package reference learning outcomes of CDIO approach (Figure 3), but also perfectly match with the criteria of international accreditation organizations such as ABET (Accreditation Board of Engineering and Technology). If we classify these PLOs by knowledge, skill and attitude categories, PLOs of A1-B3, D2 and D3 refer to cognitive domain, PLOs of B4-D3 refers to affective domain, while PLOs of A3, B2, C2, C3, D2, D3 refers to the psychomotor domain.

Table 1. List of PLOs of WCET program

No	Program Learning Outcomes
A.1	Ability to *apply* knowledge of mathematics, physics and basic science for engineering technology problem-solving.
A.2	Ability to *apply* core engineering fundamental knowledge of electric circuits, electronics, programming, communication technology and networking for engineering technology problem-solving.
A.3	Ability to *apply* advanced wireless communications engineering technology fundamental knowledge of radio frequency circuit, radio transmission system and modern software and tools for broadly-defined engineering technology activities.
B.1	Ability to *identify, analyze, and solve* broadly-defined engineering technology problems.
B.2	Ability to *conduct* measurements; to *conduct, analyze, and interpret* experiments on wireless communications equipment and system; and to *apply* experimental results.
B.3	An ability to *apply* system thinking
B.4	An ability to *apply and demonstrate* personal skills and attitudes such as creative and critical thinking, life-long learning and time management.
B.5	An *understanding* of and *demonstration* of professional ethics, integrity, and responsibilities.
C.1	An ability to *function* as a member and leader of a team
C.2	An ability to *apply* written and oral communication in technical and non-technical environments; *use* appropriate technical literature
C.3	An ability to *demonstrate* communication skill of technical English.
D.1	An ability to *explain* and *analyze* the impact and importance of any engineering technology solutions in a societal, environmental, enterprise and business context.
D.2	An ability to *execute* conceiving and designing stages of any products, processes, and systems to meet customers' needs and requirements.
D.3	An ability to *execute* implementation and operation stages of products, processes, and systems by the phased planning process.

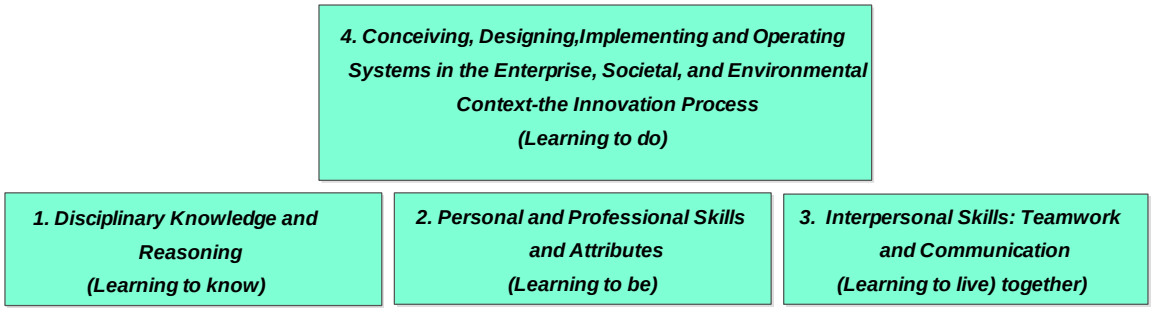

Figure 3. 1st level learning outcomes of CDIO approach

2.1. Relevance assessment process of PLOs

The relevance assessment of PLOs is performed based on survey questioner taken from the members of program advisory board, employers, and alumnus. A Department Curriculum Committee (DCC) organizes the relevance assessment of PLOs in every 4 years and revises PLOs if necessary. In some cases, when the government policy or university's vision and mission are changed, we accordingly renovate the PLOs regardless of

assessment frequency. Tables 2 and 3 reflects the PLOs' relevance assessment plan and assessment cycle and minimum achievement level including the respondents of surveys, respectively.
If a result of a survey for relevance assessment of PLOs satisfies the minimum achievement level, then no need to change the PLOs.

Table 2. Relevance assessment cycle of PLOs

Assessment/Year	2014	2015	2016	2017	2018	2019	2020
Relevance assessment of PLOs			*				*

Table 3. Relevance assessment methods of PLOs

No	Assessment methods	Assessment frequency	Minimum achievement level	Data collected and evaluated by
1	Employer survey	4 years	80% of employers rated 4 and 5	DCC (Department Curriculum Committee)
2	Alumni survey	4 years	80% of alumni rated 4 and 5	DCC
3	Recommendation of professional advisory board	4 year	80% of advisory board members rated 4 and 5	DCC

2.2. Performance assessment process of PLOs

This is a key assessment to continuously improve the program quality. If we regularly conduct this assessment with the correct methodology and use its results for the program improvement, it enables us to constantly improve the learning quality. Table 4 demonstrates PLOs' performance assessment frequency and minimum achievement level including methods of assessment.

Table 4. Performance assessment methods of PLOs

No	Assessment method	Frequency	Minimum achievement level of PLOs' performance	Data collected and evaluated by
1	Employer survey	Every year	Above 70% of survey participants rated more than average	DCC
2	Alumni survey	Every year	Above 70% of survey participants rated more than average	DCC
3	Exit survey	Every year	Above 70% of survey participants rated more than average	DCC
4	Course survey	Every semester	Above 70% of survey participants rated more than average	DCC

5	Assessing the PLOs through assessment report of course learning outcomes	Every semester	Number of students with C or above grade is not less than 70%	DCC
6	Assessing the PLOs by the course which directly connected to one of the PLO	Every semester	Number of students with C or above grade is not less than 70%	DCC
7	Assessing the PLOs using performance indicator (PI)	Every 2 years	Number of students with C or above grade (2-4 score by rubrics) is not less than 70%	DCC

We have been evaluated the performance level of PLOs by using all assessment methods shown in Table 4, however, the method of assessing the PLOs' performance using Performance Indicator (PI) is a most important one.
To analyze the performance of PLOs using all these methods, we evaluate and criticize the student attainment by comparing with the criteria shown in Table 5.

Table 5. Performance criteria of PLOs

Fully satisfied (E)	Satisfied, maybe need to have some improvement (G)	Satisfied, but need an improvement (A)	Not satisfied, must behave improvement (P)
Direct assessment			
Percentage of a student who gets A, B, C+ and C score (2-4 points by rubrics) for each PLO and CLO			
91-100	81-90	70-80	<70
Indirect assessment			
Percentage of response with 3 and 4 points of survey for each PLO and CLO			
91-100	81-90	70-80	<70

Note: E: Excellent; G: Good; A: Average; P: Poor

3. ASSESSMENT METHOD OF PLOs USING PERFORMANCE INDICATOR (PI)

Since the direct use of the reports of all CLOs performance to evaluate the PLOs' performance are inadequate and time consuming, we use the method of evaluating the selected CLOs of chosen courses by using selected PIs for each PLO in the undergraduate programs implemented by DCET. We have described the PIs for every PLO and elaborated the rubrics for each PI. The DCC primarily describes these PIs and then it discussed and finalized by faculty meeting of DCET. We utilize the 3rd and 4th level breakdown of CDIO reference model results as a basis for identifying the PIs and elaborate the rubrics to evaluate by each PI as well as define the key courses pertaining to each PLO by correlating with the teaching activities. As explained in Table 6, the teaching activities such as TA – teach and assess; TUA – teach, use and assess; UA – use and assess; (Temasek foundation, Singapore polytechnic., 2015-2016) are correlated with the CLOs of key courses. "TA" category contains the course that initially gives knowledge, skills, and attitudes of particular science and professional field.

Similarly, "TUA" category contains the courses that acquire new knowledge, skills and attitudes and the learning activity that apply the previously acquired knowledge, skills and attitudes are performed in advance.
"UA" category contains courses that use the previously acquired knowledge, skills, and attitudes by particular courses or previous topics and assess its application.
We further split each PLO in terms of its contents such as A.3.1, A.3.2 etc., and define corresponding PIs as well as appoint the key courses to PLO in classifying them by teaching activities. PIs and key courses pertaining to PLO (A.3) are shown in Table 7 as an example.

Table 6. Categories of teaching and learning activities

No	Teaching category	Correlation with CLOs	Learning activity	Assessment
1	TA-Teach and Assess	Clearly indicated in CLOs	The particular topic must be included in a learning activity.	**Assess** the student attainment of acquired knowledge and skills.
2	TUA-Teach, Use and Assess	Clearly indicated in CLOs	The particular topic must be included in a learning activity.	**Assess** the student attainment of acquired knowledge and skills, and the use of previously acquired knowledge and skills.
3	UA-Use and Assess	Can be connected with CLOs	The learning activity to apply the previously acquired knowledge and skills for the purpose to reach other CLO.	In order to acquire other CLO, **assess** the student attainment to apply the previously acquired knowledge and skills.

Table 7. Performance indicators and key courses pertaining to PLO (A.3)

(A.3). Ability to *apply* telecommunication engineering and technology fundamental knowledge of advanced level and modern software and tools for broadly-defined engineering technology activities.				
Detailed PLOs	Performance Indicators (PIs)	Key course packages		
		TA	TUA	UA
A.3.1 Apply the fundamental knowledge of the advanced level of switching technology, multiplexing, an optical and electrical communication network for broadly-defined engineering technology activities	• Explain the engineering fundamental understandings of an advanced level of engineering • Apply the engineering knowledge of advanced level for problem-solving	CN304 CN305 CN307 CN308	TC301 TC302 TC303 TC304	TC305 TC350 TC390
A.3.2. Acquire the modern software and tools and apply them to broadly-defined engineering technology activities	• Select the modern software and tools consistent with the engineering technology activities • Demonstrate the use of modern software and tools	CS101 CN203 CN204	CN302 CN304 CN305 CN306 TC303 TC304	TC201 TC305 TC390

Note: CN304 – code of course

In the rubrics to evaluate PLOs' performance by using PI, we get the evaluation levels of the rubric as 1-4 scores and the percentage of student who get A, B, C+ and C score (2-4 points by rubrics) must be not below than 70% for each PLO as shown in Table 5 above.
To define the performance level of particular PLO by using a rubric, we made the evaluation based on choosing evidence material of each selected courses according to corresponding PIs. We show the rubric for PI of PLO "A3 - Ability to apply telecommunication engineering and technology fundamental knowledge of advanced level and modern software and tools for broadly-defined engineering technology activities" in Table 8 as an example.

Table 8. Rubric for Performance Indicators of PLO (A3)

Performance Indicators	1	2	3	4
	Poor	Average	Good	Excellent
Explain the engineering fundamental understandings of an advanced level of engineering	• Little explain the fundamental engineering understandings learned in course. • Cannot identify any facts for a given situation.	• Explain some fundamental engineering understandings that learned in course. • Identifies some specific facts for a given situation, but many facts are missing.	• Generally, explains fundamental engineering understandings of advanced level. • Identifies the key facts for the given situation.	• Explains all fundamental engineering understandings of advanced level. • Identifies all the relevant facts for the given situation.
Apply the engineering knowledge of advanced level for problem-solving	• Missing basic principles govern the process or system. • Cannot formulate the engineering problem. • Little use is known theory/principles to solve engineering technology problem.	• Can understand basic principles govern the process or system. • Little formulate the engineering problem and identifies some key questions or variables in given engineering problem. • Able to carry through from knowing principles or theory to generating a solution of an engineering problem.	• Good understanding of basic principles and theory govern the process or system. • Formulates some engineering problem and identifies key questions or variables in given engineering problem. • Able to use right principles to solve the engineering problem but do the uncomfortable	• Good understanding of basic principles and theory govern the process or system. • Identifies all key questions or variables in given engineering problem. • Able to use the principles/theory together with the scientific method to rightly solve the engineering problem. • Can analyze and evaluate the importance of solution design.

			assumptions or simplification.	
Select the modern software and tools consistent with the engineering technology activities	• Does not know the right software/tools to reach the goal. • Choose wrong software/tools.	• Choose the software/tools used in engineering technology activities with the guidance of a teacher.	• Able to choose the software/tools consistent to goal. • But, cannot choose the best one.	• Able to choose best software/tools used in engineering technology activities.
Demonstrate the use of modern software and tools	• Little use the software/tools in engineering technology activities.	• Able to use some software/tools in engineering technology activities only with guidance of a teacher. • Inefficiently or poorly use selected software/tools.	• Generally, use the software/tools in engineering technology activities with the guidance of a teacher. • Efficiently or good use selected software/tools.	• Good use the software/tools in engineering technology activities and can generate the right solution. • Able to study new software/tools if required in solving the engineering technology activities.

3.1. Assessment plan of PLOs using PI

We started to use the assessment of PLOs using PI in undergraduate programs implemented by DCET since 2014, and an official evaluation has been performed since the 2015-2016 academic year within the 2-year frequency.

Table 9. Plan to evaluate PLOs using PI

No	PLOs	2015-2016		2016-2017		2017-2018		2018-2019	
		Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
1	(A.1)	*		*		*			
2	(A.2)	*		*		*			
3	(A.3)		*		*	*			
4	(B.1)		*		*		*		
5	(B.2)	*	*	*	*		*		
6	(B.3)		*		*		*		
7	(B.4)		*		*		*		
8	(B.5)		*		*		*		
9	(C.1)		*		*			*	
10	(C.2)		*		*			*	
11	(C.3)		*		*			*	
12	(D.1)		*		*				*
13	(D.2)		*		*				*
14	(D.3)		*		*				*

We planned to evaluate all PLOs using rubrics of PI in every 4 semesters (i.e., in 2 years). The necessary data collection to be used to evaluate PLOs is performed during 4 semesters of 2015-2016 and 2016-2017 academic years and the incorporated assessment, analyses, and data elaboration has been done in the spring semester of the 2016-2017 academic year according to the schedule shown in above Table 9. Furthermore, the next data elaboration and evaluation processes will be continued regularly from 2017-2018 academic year according to the schedule shown in above Table 9.

3.2. PI based performance assessment results of PLOs

To evaluate PLOs using PI, we have chosen the project-based courses as the main interest, because the undergraduate students execute projects in project-based courses in every year. During project execution, the students conceive, design, implement and operate any product, system or activity using previously acquired knowledge and skills in the preceding courses, and they work with a team as well. Therefore, the project courses are most adequate to evaluate the performance level of PLOs using PI. In addition, we have chosen certain courses for the performance level evaluation of some PLOs which not planned to evaluate using the project-based course. Table 10 demonstrates the assessment schedule of this method. In this assessment, one PLO is evaluated by at least 2 courses evidence materials. In the data collection stage, we randomly chose no less than 20 students' work for the particular course as an evidence material. In the evaluation stage, we evaluated these materials by 1-4 scores according to corresponding rubrics of PI. Then, we have defined the percentage of students who have excellent (score 4), good (score 3) and average (score 2) grades from the results of the evaluation. At last, we have provided the suggestion and recommendation to improve the PLOs' performance depending on how this percentage satisfies criteria shown in above Table 5.

Table10. Assessment schedule of the PLOs done by rubrics using PI

	Courses to be assessed / PLOs	A.1	A.2	A.3	B.1	B.2	B.3	B.4	B.5	C.1	C.2	C.3	D.1	D.2	D.3
Project courses	Introduction to engineering		*	*	*		*	*	*	*	*			*	*
	Engineering project I		*	*	*		*	*	*	*	*		*	*	*
	Engineering project II		*	*	*		*	*	*	*	*			*	*
	Thesis project			*	*		*	*	*		*	*	*	*	*
Other courses	Signal and systems	*	*												
	Technical writing skills											*			
	Electronic Instruments and Measurements					*									
	Analog and Digital Communication Systems	*				*									
	Digital Signal Processing			*											

The evaluation result of the performance level of all 14 PLOs is demonstrated in Table 11.

Table 11. Performance assessment results of PLOs using PI

Evaluation methods	A.1	A.2	A.3	B.1	B.2	B.3	B.4	B.5	C.1	C.2	C.3	D.1	D.2	D.3
The average percentage of evaluation by rubrics using PI /for projects/		79	90	89		87	89	88	92	87	82	87	87	88
Achievement status of performance level	A	G	G	G	G	G	E	G	G	G	G	G	A	G
The average percentage of evaluation by rubrics using PI /for selected courses/	75	68	80		79						81			
Achievement status of performance level	**A**	P	A		A						G			

Note: E: Excellent; G: Good; A: Average; P: Poor

We make a detailed action plan to improve the performance level of PLOs of undergraduate programs based on the above evaluation result and have started to implement it in stages from the 2017-2018 academic year.

4. CONCLUSIONS

- Since we have revised the PLOs of undergraduate programs implemented by DCET in correlation with reference learning outcomes of CDIO standards and methodology and international accreditation organizations' requirements, it satisfies the requirement of learning outcomes of the modern engineering technology program.
- The assessment plan and methodology of PLOs discussed in this paper is implemented in undergraduate programs of DCET across 2 academic years and from this assessment experience, it is reflected that we have to organize training for enhancing faculty skills on new assessment methodology for further improvement.

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BIOGRAPHICAL INFORMATION

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