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A SIMPLIFIED APPROACH TO MEASURE COURSE OUTCOMES AND PROGRAM OUTCOMES FOR ACCREDITATION OF ENGINEERING INSTITUTES

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ABSTRACT

The Outcome Based Education (OBE) has been one of the major concern of most academic institutions globally, especially among the engineering institution. Indian higher education system is the one of the largest system in the world. The system has its own specific approaches to find the solution. This paper aims to provide an evaluation method for the attainment of Course Outcomes and Program Outcomes for Engineering Programme as defined by National Board of Accreditation (NBA) for Tier II institutions. NBA needs assessment methods for measuring the attainment of Course Outcomes and Program Outcomes.

Keywords: Course Outcomes, Program Outcomes, Program Educational Outcomes, Program Specific Outcomes, Rubrics, Analysis, Assessment, Attainment, Engineering

I. INTRODUCTION

Education plays a vital role in the development of any nation. Like in any other domain, the method to improve quality remains the same that is finding and recognising new needs and satisfying them with products and services of international standards.

The National Board of Accreditation (NBA), India was initially established in September 1994 by All India Council of Technical Education (AICTE) for periodic evaluations of educational institutions and programmes according to specified norms and standards as recommended by AICTE council. Programmes were from diploma to the postgraduate level in the fields of engineering and technology, management, pharmacy, architecture, and related disciplines.

The NBA, came into existence as an autonomous body with effect from 7th January 2010, with the objective of assurance of quality and relevance of the technical education through the mechanisms of accreditation of programmes offered by the technical institutions. It introduced new process, parameters and criteria for accreditation. These are in line with the best international practices and oriented to assess the outcomes of the programme. NBA works very closely with stakeholders (faculty, educational institutions, government, industries, regulators, management, recruiters, alumni, students and their parents) to ensure that the programmes serve to prepare their graduates with sound knowledge of fundamentals and to develop in them an adequate

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level of professional competence, such as would meet the needs of the engineering profession locally as well as globally.

II.WASHINGTON ACCORD

The Washington Accord is an International Agreement among bodies responsible for accrediting professional engineering academic degrees covering diploma to post - graduate engineering degree programs. The membership of Washington Accord is an international recognition of the quality of undergraduate engineering education offered by the member country and is an avenue to bring it into the world class category. It encourages and facilitates the mobility of engineering graduates and professionals at international level. In India the body responsible for accrediting the engineering degrees is the National Board of of Accreditation (NBA).

The accord was established in 1989 and the current members include: Australia, Canada, Chinese Taipei, Hong Kong China, India, Ireland, Japan, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, the United Kingdom and the United States. The agreement recognizes that the undergraduate engineering programs accredited by these signatories are equal in nature and that the graduates of signatory countries are recognized by other signatory countries as having met the academic requirements for entry to practice of engineering. National Board of Accreditation, India has become the permanent signatory member of the Washington Accord on 13th June 2014.

The NBA accredited programmes offered by the Tier -1 and Tier – II Institutions are eligible for the recognition of the programmes by other signatories of the Washington Accord.

Eligible Under TIER I	Eligible Under TIER II
Central Universities offering programmes of Technical Education in their campus itself. State Universities offering programmes of Technical Education in their campus itself and not in affiliated institutions. Deemed Universities. Universities Eligible Under TIER I Private / Self Financing Universities established under State Legislations.	Colleges affiliated to universities not enjoying the privileges of full academic autonomy Deliver programs prescribed by universities to which they are affiliated Only universities empowered to examine the enrolled students for award of degrees

TIER II institutions are not eligible to apply in TIER I category until and unless these institutions either get Autonomous status or declared Deemed Universities/Universities.

III. NBA TERMINOLOGY

National Board of Accreditation (NBA) is outcome based learning education.

Outcome Based Education (OBE) can be stated as "an outcome is visible and observable demonstration of knowledge, competence and orientation at the end of a learning experience." (Spady, 1994) [4]. Thus for OBE implementation, initially it is necessary that the desired or defined outcomes are determined and then according

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to defined outcomes, programme curriculum, teaching and learning methodology and supporting facilities are designed. During the course of the programme, various measurement methods are used to measure the attainment of outcomes.

Vision Statement can be stated as "An inspirational description of what an organization would like to achieve or accomplish in the mid-term or long-term future. It is intended to serves as a clear guide for choosing current and future courses of action."

Mission Statement can be stated as "A mission is different from a vision in that the former is the cause and the latter is the effect; a mission is something to be accomplished whereas a vision is something to be pursued for that accomplishment."

Program Outcomes (POs) as identified by National Board of Accreditation (NBA), India are what the graduates of an undergraduate engineering program should be able to do at the time of graduation. The POs are discipline non-specific. A total of twelve Program Outcomes have been prescribed in the NBA as

PO1. Engineering Knowledge

PO2. Problem Analysis

PO3. Design/development of solutions

PO4. Conduct Investigations of Complex Problems:

PO5. Modern Tool Usage

PO6. The Engineer and Society

PO7. Environment and Sustainability

PO8. Ethics:

PO9. Individual and Team Work

PO10. Communication

PO11. Project Management and Finance

PO12. Life-long learning

Program Specific Outcomes (PSOs) are what the graduates of a specific undergraduate engineering program should be able to do at the time of graduation. The PSOs are program specific. PSOs are written by the Department offering the program. PSOs should be two to four in number. A Department can differentiate its program through PSOs. Some sample PSOs are

Sample 1 : Electrical and Electronics Engineering

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power

2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.

Sample 2 : Electronics and Communication Engineering

1. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.

2. Architect, partition, and select appropriate technologies for implementation of a specified communication system.

3. Design essential elements (circuits and antennas) of modern RF/Wireless communication systems.

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Program Educational Objectives (PEOs) describe the career and professional accomplishments that programs are preparing graduates to attain within a few years (3-5 years) of graduation.

Course Outcomes (COs) -- Course Outcomes are narrower statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behaviour that students acquire in their matriculation through the course.

Assessment – Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of programme educational objectives and programme outcomes.

Evaluation – Evaluation is one or more processes, done by the evaluation team, for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which programme educational objectives or programme outcomes are being achieved, and results in decisions and actions to improve the programme.

Mapping – Mapping is the process of representing, preferably in matrix form, the correlation among the parameters. It may be done for one to many, many to one, and many to many parameters.

Bloom's Taxonomy of Learning Domains was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom in order to promote higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, and principles, rather than just remembering facts (rote learning). It is most often used when designing educational, training, and learning processes. The three Domains of Learning are (1) Cognitive: Mental Skills (Knowledge), (2) Affective: growth in feelings or emotional areas (attitude or self) and (3) Psychomotor: manual or physical skills (skills).

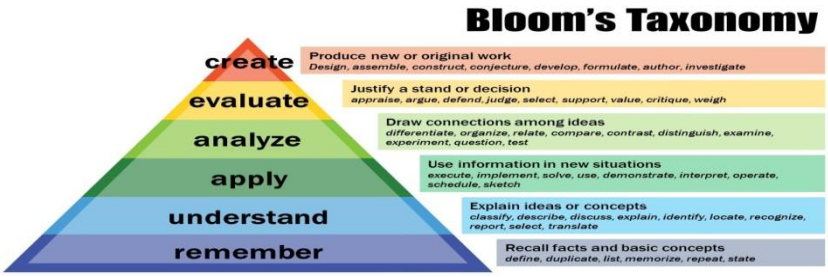

Fig. 1.Bloom's Taxonomy

Most of the state engineering institutes of MP are affiliated to Rajiv Gandhi Proudyogiki Vishwavidhyalaya - the state technical university of Madhya Pradesh. It has provided the syllabus for various engineering courses where all courses/subjects have its own objectives and methodology to achieve the course outcomes.

Some of the courses/subjects are only theoretical in nature, some are theoretical with practical and others with only practical/sessional. To attain the course outcomes for the course/subject, the faculty members use various Direct or Indirect tools as assessment methods.

Faculty has to assess the CO and PO attainment using some direct and indirect methods, where a lot of clerical actions get involved. Due to the time constraints and many other activities such efficient assessment may get not good results.

IV. COURSE OUTCOME ASSESSMENT METHODOLOGY

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The process of attainment of COs, POs and PSOs starts from writing appropriate COs for each course in the four-year engineering degree program. The course outcomes are written by the respective faculty member using action verbs of learning levels as suggested by Bloom Taxonomy [3]. Then, a correlation is established between COs and POs and COs and PSOs on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation. A 6x12 mapping matrix of COs-POs and 6x4 mapping matrix of COs-PSOs is prepared in this regard for all courses in the program. Course Outcomes and the CO-PO & CO-PSO mapping matrix for a sample course is discussed below.

Course Outcomes of Course : EC- 504 Microprocessors and Microcontrollers

The student will be able to

- Apply the fundamentals of assembly language programming of microprocessor and microcontroller.
- Implement microcontroller and microprocessor interfaces including serial ports, ADCs and DACs etc.
- Utilize hardware and software interaction and integration.
- Develop real time embedded systems using microprocessor and microcontrollers
- Analyse microprocessor and microcontroller based digital circuits
- Detect faults in commercial applications using microprocessor and microcontroller.

Table II.1 shows 'CO-PO' mapping matrix and Table II.2 shows CO-PSO' mapping matrix.

Table II.1 CO – PO Matrix for EC- 504 Microprocessors and Microcontrollers

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C504.1	3	3	3	2	-	2	1	2	2	3	3	3
C504.2	3	3	2	-	3	2	1	2	-	1	3	3
C504.3	3	3	2	3	3	2	1	2	2	3	3	3
C504.4	3	3	2	2	-	2	1	2	3	-	3	3
C504.5	3	2	2	-	3	2	1	2	-	-	3	3
C504.6	2	3	2	2	3	2	1	2	3	3	3	3
Average	**2.8**	**2.8**	**2.2**	**2.2**	**3.0**	**2.0**	**1.0**	**2.0**	**2.3**	**3**	**3**	**3**

Table II.2 CO – PSO Matrix for EC- 504 Microprocessors and Microcontrollers

	PSO1	**PSO2**	**PSO3**	**PSO4**
C504.1	3	2	-	-
C504.2	3	3	-	1
C504.3	3	3	2	1
C504.4	3	2	-	-
C504.5	3	1	1	1
C504.6	3	1	1	1
Average	**3**	**2**	**1.5**	**1.33**

IV. ATTAINMENT OF COS AND POS

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Thus, mapping matrix of COs – POs and COs - PSOs are prepared for all the 56 courses and finally these matrices are merged to form a 'Program level CO-PO Matrix and CO – PSO Matrix as shown in Table II.3'.

Table II.3 : COs – POs – PSOs Matrix for all courses of Engineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
C101	3	3	2	3	3	3	3	3	3	3	0	3	3	0	1	2
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C106	3	3	3	3	3	2	3	1	3	3	2	3	3	3	3	3
C201	3	3	2	2	2	2	1	1	2	1	0	3	3	0	0	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C206	3	3	1	3	2	3	3	3	3	3	2	3	2	2	2	2
C301	3	3	3	3	0	1	0	0	2	1	0	3	3	1	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C308	3	2	2	2	2	0	0	2	2	3	0	1	3	2	2	0
C401	3	3	3	3	0	1	1	0	2	1	0	3	3	0	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C408	2	2	2	2	2	2	1	2	2	3	2	2	2	2	2	3
C501	**3**	**2**	**2**	**2**	**1**	**3**	**1**	**1**	**1**	**3**	**0**	**3**	**3**	**3**	**1**	**3**
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C508	**3**	**2**	**3**	**3**	**2**	**0**	**0**	**3**	**3**	**3**	**1**	**2**	**3**	**2**	**3**	**1**
C601	3	3	3	2	1	2	2	1	1	3	0	3	3	1	2	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C608	2	2	2	2	2	2	1	2	2	3	2	2	2	2	2	3
C7011	3	3	2	1	1	1	2	1	2	1	1	3	3	2	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C707	3	2	2	1	2	2	2	2	3	2	2	3	3	3	2	2
C8011	2	2	3	2	3	3	3	1	1	2	1	2	1	2	2	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
C806	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**
	2.77	**2.57**	**2.29**	**2.38**	**2.05**	**1.71**	**1.32**	**1.13**	**2.04**	**2.09**	**1.18**	**2.61**	**2.71**	**1.93**	**1.66**	**1.50**

In LNCT which is a university affiliated college, the CO assessment tools used to measure the attainment levels are : Mid semester Exam – I, Mid semester Exam – II, Assignments, Quiz, end semester exams, performance during experiments etc. These are direct assessment tools. Course Exit survey is also conducted at the end of the semester. The different weights are assigned to each of above tools and are shown in Table II.4.

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In LNCT, Bhopal two Mid-semester Exams are conducted for each course in a semester (internal assessment tests). Mid-semester – I Exam is purely based on CO1 and CO2, whereas Mid-semester – II Exam is based on CO3, CO4, CO5 and CO6. Both the mid semester exam is of 20 marks each.

Similarly each student is given 6 assignments based on COs and marks awarded for each assignment to the student are out of 10. Course Exit Survey is conducted at the end of the semester which carries 12 Marks.

The end semester exam conducted by university is not based on COs, LNCT calculates the students marks based on the grades achieved by the student in end semester exam and distributes it over all COs equally. The final marks matrix is shown in Table II.4

Table : II.4 : CO - Assessment Matrix - V Sem

	Direct Assessment									**Indirect Assessment**	
	Midsem – Exam		**Assignment**						**End Sem**	**Course Exit Survey**	**Total**
	I	**II**	**1**	**2**	**3**	**4**	**5**	**6**			
CO1	10	-	10						70	2	92
CO2	10	-		10						2	92
CO3	-	4			10					2	86
CO4	-	4				10				2	86
CO5	-	6					10			2	88
CO6	-	6						10		2	88
Total	20	20	10	10	10	10	10	10	70	12	

Maximum data as mentioned in this table is filled at the end of the semester whereas the end semester exam data is fed as soon as university results are declared and then, the attainment is calculated for the regular students.

Sample calculations are as follows :

In the above matrix marks of end sem exam is fed as soon are the results are declared for the semester and attainment is calculated for the regular students.

NBA has given a guideline in its Self Assessment Report (SAR) has given guidelines for arriving at an attainment level:

Attainment Level 1: 60% of students score more than 55% marks out of the maximum relevant marks.

Attainment Level 2: 70% of students score more than 55% marks out of the maximum relevant marks.

Attainment Level 3: 80% of students score more than 55% marks out of the maximum relevant

Sample calculations are as follows :

1) **Midsem Record of Marks**

			Midsem Attainment (Marks)							
			10	**10**	**4**	**4**	**6**	**6**		
S. No.	**Enrrollment**	**Name of Student**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**	**Total**	**%**

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	No.									
1	0103EC131001	Aadrika Gupta	10	10	3	3	5	4	35	87.5
2	0103EC131002	Aakash Kumar Choudhary	9	9	3	3	6	6	36	90.0
3	0103EC131003	Aashi Sharma	8	9	3	3	6	5	34	85
…	…	…	…	…	…	…	…	…	…	
131	0103EC143D20	Vinay Kumar	10	7	4	3	6	3	33	82.5
	Total		1002	819	414	412	633	681		
	Average	10/10/4/4/6/6	7.6	6.3	3.2	3.2	4.8	5.2	30.3	75.75

Attainment Level : 100% students achieved marks greater than 55%, thus the attainment level is 3

1) **Assignment Record of Marks**

			Assignment Attainment (Marks)						
			10	**10**	**10**	**10**	**10**	**10**	
S. No.	**Enrrollment No.**	**Name of Student**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**	**%**
1	0103EC131001	Aadrika Gupta	6	8	10	10	6	8	80
2	0103EC131002	Aakash Kumar Choudhary	8	10	5	8	10	8	82
3	0103EC131003	Aashi Sharma	6	8	4	6	6	4	57
…	…	…	…	…	…	…	…	…	…
131	0103EC143D20	Vinay Kumar	7	5	8	9	4	5	63
		Total	854	892	818	675	734	775	8151
		Average	6.52	6.81	6.25	5.16	5.6	5.92	

Attainment Level : 82% students achieved marks greater than 55%, thus the attainment level is 3.

1) **Course Exit Survey – Marks**

			Course Exit Survey Attainment (Marks)						
			2	**2**	**2**	**2**	**2**	**2**	**12**
S. No.	**Enrrollment No.**	**Name of Student**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**	**%**
1	0103EC131001	Aadrika Gupta	2.0	2.0	2.0	2.0	2.0	2.0	100
2	0103EC131002	Aakash Kumar Choudhary	2.0	2.0	2.0	2.0	2.0	2.0	100
3	0103EC131003	Aashi Sharma	1.0	2.0	2.0	1.0	2.0	2.0	83
…	…	…	…	…	…	…	…	…	…
131	0103EC143D20	Vinay Kumar	2.0	1.0	2.0	1.5	1.5	1.0	75
		Total	233.0	239.5	228.0	236.0	246.5	238.0	1421
		Average	1.78	1.83	1.74	1.80	1.88	1.82	11

Attainment Level : 92% students achieved marks greater than 55%, thus the attainment level is 3.

1) **End Sem Marks**

		Attainment	**End Sem Exam Grades**	**Marks**	**Marks**
S. No.	**Enrrollment No.**	**Name of Student**	**Total**	**Out of 100**	**Out of 70**
1	0103EC131001	Aadrika Gupta	A	85	59.5

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2	0103EC131002	Aakash Kumar Choudhary	A	85	59.5
3	0103EC131003	Aashi Sharma	B+	75	52.5
…	…	…	…	…	…
131	0103EC143D20	Vinay Kumar	C	45	31.5
	Total			10203	7208
	Average	70		78.58	55

Attainment Level : 82% students achieved marks greater than 55%, thus the attainment level is 3

As the attainment level in all the exams is above 55%, the assessment table of II.4 is converted CO Attainment Table as given in II.5

Table II.5 CO Attainment Table

	Direct Assessment									**Indirect Assessment**		
	Midsem - Exam		**Assignment**						**End Sem**	**Course Exit Survey**	**Total**	**%**
	I	**II**	**1**	**2**	**3**	**4**	**5**	**6**				
CO1	7.6	-	6.52						55	1.78	70.9	0.77
CO2	6.3	-		6.81					55	1.83	69.94	0.76
CO3	-	3.2		-	6.25				55	1.74	66.19	0.77
CO4	-	3.2				5.16			55	1.80	65.16	0.76
CO5	-	4.8					5.60		55	1.88	67.28	0.76
CO6	-	5.2						5.92	55	1.82	67.94	0.77

Thus, the average of percentage of students attaining all the COs decides the CO attainment level. For the case example considered, the target attainment level for each CO and for each student is set at 55% which is university average as per Ordinance 10.4. The percentage of students attaining this target level of each CO is computed and the average of these percentages is considered for deciding the attainment level of course outcome as shown above in the example guidelines. The process of computing CO attainment in internal assessment is shown in Table II.4

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Attain-ment	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
C101	2.63	2.63	1.75	2.63	2.63	2.63	2.63	2.63	2.63	2.63	0.00	2.63	2.63	0.00	0.88	1.75
C106	3.00	3.00	3.00	3.00	3.00	2.00	3.00	1.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00	3.00
C201	2.85	2.85	1.90	1.90	1.90	1.90	0.95	0.95	1.90	0.95	0.00	2.85	2.85	0.00	0.00	0.95
C206	2.85	2.85	0.95	2.85	1.90	2.85	2.85	2.85	2.85	2.85	1.90	2.85	1.90	1.90	1.90	1.90
C301	2.50	2.50	2.50	2.50	0.00	0.83	0.00	0.00	1.67	0.83	0.00	2.50	2.50	0.83	0.00	0.00
C308	2.95	1.97	1.97	1.97	1.97	0.00	0.00	1.97	1.97	2.95	0.00	0.98	2.95	1.97	1.97	0.00
C401	2.87	2.87	2.87	2.87	0.00	0.96	0.96	0.00	1.91	0.96	0.00	2.87	2.87	0.00	0.00	0.00
C408	1.91	1.91	1.91	1.91	1.91	1.91	0.96	1.91	1.91	2.87	1.91	1.91	1.91	1.91	1.91	2.87
C501	2.69	1.79	1.79	1.79	0.90	2.69	0.90	0.90	0.90	2.69	0.00	2.69	2.69	2.69	0.90	2.69
C508	2.95	1.97	2.95	2.95	1.97	0.00	0.00	2.95	2.95	2.95	0.98	1.97	2.95	1.97	2.95	0.98
C601	2.77	2.77	2.77	1.84	0.92	1.84	1.84	0.92	0.92	2.77	0.00	2.77	2.77	0.92	1.84	0.00
C608	1.90	1.90	1.90	1.90	1.90	1.90	0.95	1.90	1.90	2.84	1.90	1.90	1.90	1.90	1.90	2.84
C7011	2.50	2.50	1.67	0.83	0.83	0.83	1.67	0.83	1.67	0.83	0.83	2.50	2.50	1.67	0.83	0.83
C707	2.90	1.93	1.93	0.97	1.93	1.93	1.93	1.93	2.90	1.93	1.93	2.90	2.90	2.90	1.93	1.93
C8011	1.91	1.91	2.87	1.91	2.87	2.87	2.87	0.96	0.96	1.91	0.96	1.91	0.96	1.91	1.91	0.96
	2.46	2.28	2.03	2.13	1.86	1.51	1.17	0.99	1.82	1.88	1.06	2.32	2.40	1.71	1.47	1.34

Similarly, after the declaration of the university results, the percentage of students who attained the COs is computed. Here, it is assumed that the questions answered by a student cover all the course outcomes defined for that course.

Target levels may be set (percent of marks scored by a student in a course) for deciding the course attainment level. The author argued that this target should be set based not only on the university previous results for 3-4 years but also on the type of course (subject) and the quality of students admitted. In engineering programs, there are few courses which students feel rather difficult compared to other courses. Few example courses to cite in Electronics & Communication Engineering program are 'Maths - III', 'Networks Analysis' etc. where university results vary drastically every year.

In the example considered in this paper, the target percent of marks scored by the students is set by the course faculty member based on the university results of the course in the institute in the past three years.

The above procedure of computing overall CO attainment is to be repeated for each course from first year to final year in an academic year including electives, project work and GD/ seminars in order to enable computation of PO and PSO attainment levels.

Attainment of POs Program Outcomes (POs) are one step broader statements than COs that describe what students are expected to know and be able to do upon the graduation. These relate to the skills, knowledge, and behavior that students acquire during the program.

After computing all the CO attainment, one has to calculate the PO attainment. Table II.6 shows the CO-PO-PSO attainment matrix.

V.CONCLUSION

Demand for quality of education and employable work-force is ever increasing globally. This paper will help the faculty members in calculating their course outcomes and program outcome attainments and which in turn will help to monitor the students' performance in coming sessions as well as improving teaching efficiency. National Board of Accreditation (NBA) is one of the platforms that provides a framework to bridge the 'academic-industry gap' and enables better employment prospects for engineering graduates.

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