A rubric-based mathematical model for evaluation of direct PO attainment through CO attainment and CO-PO articulation matrix for OBE system

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Training program in School of Engineering on direct CO-PO attainment (October 26, 2022)

Presentation plan

Presentation plan

- Introduction to OBE system
- Design and evaluation of attainment of COs
- Design and evaluation of attainment of POs
- Implementation of the CO-PO attainment model
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- Traditional education system is mostly input-oriented
  - It gives more emphasis on the availability of input resources
  - It puts little or no concern to the quality of output
  - Its teaching-learning process suggests to work hard mainly to complete the syllabus so as to score good marks in examinations
  - Thus, it compromises with the need of acquiring enough knowledge or skill to become employable or self-professional in some form
- Hence, the present emphasis all around the world is put on the measurable *Outcome-Based Education* (OBE)
  - It targets to allow students to customize a Program as per their own choices, so as to achieve certain desirable outcomes related to the acquiring of knowledge, skills, attitudes and behavior under the guidance from teachers, instructors and mentors

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Introduction to PEO

- OBE system involves a continuous methodology for ascertaining the achievement of the desired outcomes, which are usually benchmarked as the *Program Educational Objectives* (PEOs)
- PEOs describe the career and professional accomplishments desirable to be achieved by graduates
  - That is, what the graduates are expected to perform and achieve in their professional lives after the completion of the Program
- PEOs justify the existence of the Program by stating the areas or fields where the graduates can find employment, or their preparedness to take up higher studies

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Introduction to PO and CO

- PEOs are targeted to be achieved through the attainment of a set of *Program Outcomes* (POs) in the form of just like vision and mission, respectively
  - POs are narrow statements that describe what students upon graduating from the Program are expected to learn in terms of knowledge, skills, attitudes, and behavior [3]
- Attainment of POs of a Program are materialized through the attainment of the *Course Outcomes* (COs) of the Courses of the Program
  - COs are narrower statements that describe what students upon completing a Course are expected to learn in terms of knowledge, skills, attitudes, and behavior [3]
- Accordingly, OBE-PEO-PO-CO becomes the hierarchy tree of the modern education system
  - It allows Institutes themselves to assess and evaluate the objectives and outcomes of their Programs and make necessary modifications accordingly, in the form of finding and bridging gaps, for attaining the targeted objectives and outcomes

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Difference between traditional and OBE systems

- The traditional input-based education system works as follows:
  - Job of teachers is just to complete the teaching as a one-way process
  - It leaves the learning as well as the building of professional careers of students solely upon the students themselves
- Scenario in the OBE system is quite different
  - Job of teachers is not only to teach the curricula as a one-way process
  - But also to design and implement an effective teaching-learning process:
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Accreditation

- Formal recognition of the attainment of objectives and outcomes of a Program can be obtained through its accreditation by an independent external agency
- Accreditation is a process of quality assurance and improvement
  - It assesses a Program impartially and critically to verify that the Program continuously meets the assessment criteria prescribed by the accrediting agency
- All stakeholders are benefited from the accreditation of Programs as it helps an Institute to know its SWOC and to make necessary changes for improvement
- NBA [6] is a major accrediting board in India, which also represents India in the Washington Accord [1] for Engineering Programs of Tier-I Institutes since 2014
  - Washington Accord recommends the Graduates of the Engineering Programs accredited by any of its signatory body to be recognized by other signatory bodies as having met the academic requirements for entry to the practice of engineering
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Design and evaluation of attainment of COs

- Design and evaluation of CO attainment involve a series of jobs
  - Defining some expected COs for a Course
  - Preparing lesson plan for effective teaching and learning
  - Setting question paper with CO-wise questions
  - Moderating question paper for correctness and appropriateness
  - Evaluating answer scripts in a particular style to facilitate the evaluation of CO attainment
  - Then, evaluating the attainment of COs of the Course

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Setting of COs

- Some COs for each Course can be set based on the expected learning by students on completion of the study of a Course, e.g.,
  - Ability to recognize the physical phenomena of the contents of the Course
  - To demonstrate the understanding of the theories and their limitations covered in the Course
  - To identify and solve industrial and real life problems by applying the studied theories, etc.
- Different assessment tools can be used for evaluating the attainment of the COs of a Course by measuring the learning of students from the Course, such as:
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Preparation of Course lesson plan

- For a transparent and recorded process of teaching as well as for enabling students to know how the teaching will progress, a detail lesson plan of each Course should be prepared and distributed among students prior to starting the teaching

Unit	Title	Contents	CSU	CO	L-T-P
1	Introduction	Definition of ...	1	1	4-1-0
		Significance of ...	2	3	
		Application of ...	3	2	
2	...	...	4	1,2	6-2-2
		...	5	4	
...	...	...	...	...	...
6	...	...	17	3	3-1-1
		...	18	2	
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Question paper setting

- In order to ease the evaluation of CO attainment of a Course, its question papers may be set as per its COs, making sub-questions under a CO, if required

CO	Sub	Content of question	CSU	BTL	Marks	Total
1	(a)	Define ...	3	2	2	5
	(b)	Express ...	4	3	3	
2		Explain what does ...	6	2	7	7
...		...	...	...	...	...
5		Apply the formula of ...	17	5	10	10
					Grand total	**100**

  - Sub-questions, e.g., 1(a) and 1(b) above, may be from different Units also, but must be from the same CO
  - In order to avoid the dropping of coverage of any CO from the question paper, optional questions, if any, should be made only in sub-questions of equal marks, e.g., answer Q.1(a) or Q.1(b) in the above example (instead of, answer Q.1 or Q.2)

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- Question-wise CSUs may also be shown in order to depict the setting of the question paper by covering the contents of the Course to the maximum extent
- Further, questions may also be set as per *Bloom's Taxonomy Level* (BTL) as AICTE has suggested under its *Examination Reform Policy* 2018 [2], to depict that questions of different levels of difficulties have been set
  - As per BTL, questions can be numbered according to their levels of difficulties

BTL	Meaning	Attainment
6	Creating	Generating new ideas or products for viewing things differently
5	Evaluating	Justifying a decision or situation
4	Analyzing	Exploring understanding by breaking information into pieces
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Question paper moderation

- Moderation of a question paper by a subject-expert is an integral part of the question paper setting in order to crosscheck its correctness and appropriateness

1.	Whether the question paper is set CO, CSU and BTL wise?	: Yes/No
	Comments of Moderator:	
2.	Does the question paper meet the standard of the level of students?	: Yes/No
	Comments of Moderator:	
3.	Does the question paper properly cover the syllabus specified for this examination?	: Yes/No
	Comments of Moderator:	
4.	Whether the question paper is technically accurate?	: Yes/No
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5.	Whether the question paper is edited/ formatted accurately?	: Yes/No
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Answer-script evaluation

- As the setting of question papers CO-wise in order to ease the evaluation of CO attainment, answer-scripts of students may also be evaluated CO-wise

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2											
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Evaluation of CO attainment

- Once the teaching of a Course as well as the evaluation of students' performance on the Course are complete, its CO attainment can be evaluated
- For this, a mechanism for evaluating individual COs needs to be devised first
- Evaluation of attainment of individual COs can be made rubric-based
  - Rubrics help in defining thresholds through a set of criteria for complex or not easily quantifiable parameters that are not measurable by any standard method
- A rubric system on a 3-point scale based upon the CO-wise performance of students can be used
- Performance of students on a Course is usually measured by absolute marks or some letter grades bearing different letter points
- Today in most cases, the scored overall absolute marks are finally converted into some letter grades (proposed model is for this system)

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Evaluation of CO attainment (*Contd... 1*)

- Here, the grading system suggested by UGC in its one model [7] can be used

Letter grade	Description	Grade point
O	Outstanding	10
A+	Excellent	9
A	Very good	8
B+	Good	7
B	Above average	6
C	Average	5
P	Pass	4
F	Fail	0
Ab	Absent	0

- It involves 7 successful completion grades (O, A+, A, B+, B, C and P) and 2 unsuccessful grades (F and Ab) on a 10-point scale
- Accordingly, the successful grades of the highest (outstanding), middle (good) and lowest (pass) levels are O, B+ and P, respectively

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Evaluation of CO attainment (*Contd. . . 2*)

- According to above, a rubric system on a 3-point scale can be devised as follows:
  - Performance of 50% or above students on an individual CO will lead to the attainment of a rubric level
  - Scoring of the minimum percentage of absolute marks, for which B+ and P letter grades will be awarded on a Course, will be the attainment of the highest and lowest levels of rubrics for the individual COs of the Course

Performance of overall students on individual COs	Rubric level	Rubric value
50% or above students scored the same minimum percentage of absolute marks on the CO for which B+ grade will be awarded on the Course	High	3
50% or above students scored the same minimum percentage of absolute marks on the CO for which C grade will be awarded on the Course	Medium	2
50% or above students scored the same minimum percentage of absolute marks on the CO for which P grade will be awarded on the Course	Low	1
50% or above students scored the same minimum percentage of absolute marks on the CO for which an unsuccessful grade will be awarded on the Course	Poor	0

Evaluation of CO attainment (*Contd... 2*)

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  - Scoring of the minimum percentage of absolute marks, for which B+ and P letter grades will be awarded on a Course, will be the attainment of the highest and lowest levels of rubrics for the individual COs of the Course

Performance of overall students on individual COs	Rubric level	Rubric value
50% or above students scored the same minimum percentage of absolute marks on the CO for which B+ grade will be awarded on the Course	High	3
50% or above students scored the same minimum percentage of absolute marks on the CO for which C grade will be awarded on the Course	Medium	2
50% or above students scored the same minimum percentage of absolute marks on the CO for which P grade will be awarded on the Course	Low	1
50% or above students scored the same minimum percentage of absolute marks on the CO for which an unsuccessful grade will be awarded on the Course	Poor	0

Evaluation of CO attainment (*Contd... 2*)

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Evaluation of CO attainment (*Contd... 3*)

- Note that the rubric system suggested by NBA for evaluating the CO attainment is slightly different from the one proposed here
  - In case of Tier-I Institutes, NBA suggests to set rubric levels in terms of percentage of students achieving the minimum targets set for Institute-level assessment tools and the minimum of class average targets for internal assessment tools [4]
  - The same for Tier-II Institutes are suggested numerically as the securing of the minimum of Institute average targets by 60%, 70% and 80% students in Institute-level assessment tools, and the securing of the minimum of 60% targets by 60%, 70% and 80% students in internal assessments tools [5]
- Notice that there is no attainment in the NBA model if minimum 60% students cannot secure average targets, which might be difficult to achieve in some cases
- Hence, a simplified rubric system is suggested in the present proposal
  - There will be some attainment in any assessment tool if a minimum of 50% students can secure the same minimum percentage of absolute marks for which the minimum qualifying letter grade will be awarded to students on the Course

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Evaluation of CO attainment (*Contd. . . 4*)

- An example of evaluating the attainment of individual COs is shown below:

Students' Roll No. and other detail	Sessional Test I				Sessional Test II				Mid-Sem. Exam				End Sem. Exam			
	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4
MEB3001	4	4	8	4	8	9	5	–	8	7	9	6	14	14	14	8
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
MEB3060	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Maximum marks	5	5	10	5	5	10	10	–	10	10	10	10	15	15	15	15
Total No.of students	60	60	60	60	60	60	60	–	60	60	60	60	57	57	57	57
Lowest % marks by $\geqslant 50\%$ students	72%	80%	45%	25%	77%	55%	71%	–	75%	70%	65%	55%	75%	59%	52%	79%
Scored rubric value (S_{ijk}*)	3	3	1	0	3	2	3	–	3	3	2	1	3	2	2	3
	S_{i11}	S_{i21}	S_{i31}	S_{i41}	S_{i12}	S_{i22}	S_{i32}	S_{i42}	S_{i13}	S_{i23}	S_{i33}	S_{i43}	S_{i14}	S_{i24}	S_{i34}	S_{i44}

*S_{ijk} is the attainment of the jth CO of the ith Course in the kth assessment tool

- Note that NBA [4, 5] has not stated anything categorically about how S_{ijk} can be obtained from students' performances in an assessment tool.

Evaluation of CO attainment (*Contd... 4*)

- An example of evaluating the attainment of individual COs is shown below:

Students' Roll No. and other detail	**Sessional Test I**				**Sessional Test II**				**Mid-Sem. Exam**				**End-Sem. Exam**			
	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4	CO_1	CO_2	CO_3	CO_4
MEB3001	4	4	8	4	8	9	5	–	8	7	9	8	14	14	14	8
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
MEB3060	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
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Total No.of students	60	60	60	60	60	60	60	–	60	60	60	60	57	57	57	57
Lowest % marks by $\geqslant$ 50% students	72%	80%	45%	25%	77%	55%	71%	–	75%	70%	65%	43%	73%	59%	52%	79%
Scored rubric value (S_{ijk}*)	**3**	**3**	**1**	**0**	**3**	**2**	**3**	–	**3**	**3**	**2**	**1**	**3**	**2**	**2**	**3**
	S_{i11}	S_{i21}	S_{i31}	S_{i41}	S_{i12}	S_{i22}	S_{i32}	S_{i42}	S_{i13}	S_{i23}	S_{i33}	S_{i43}	S_{i14}	S_{i24}	S_{i34}	S_{i44}

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MEB3001	4	4	8	4	8	9	5	–	8	7	9	8	14	14	14	8
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*S_{ijk} is the attainment of the jth CO of the ith Course in the kth assessment tool

- Note that NBA [4, 5] has not stated anything categorically about how S_{ijk} can be obtained from students' performances in an assessment process

Evaluation of CO attainment (*Contd... 5*)

- After evaluating S_{ijk} as above, finally the overall CO attainment of the ith Course in the form of a single percentage value can be evaluated as X_i through Eq. (1)

$$X_i = \left(\frac{1}{R_1 C_i} \sum_{j=1}^{C_i} x_{ij} \right) \times 100\% \tag{1a}$$

where,
$$x_{ij} = \frac{1}{a_{ij}} \sum_{k=1}^{A_i} S_{ijk} \tag{1b}$$

or,
$$x_{ij} = \sum_{k=1}^{A_i} w_{ik} S_{ijk} \quad \text{with} \quad \sum_{k=1}^{A_i} w_{ik} = 1 \tag{1c}$$

- In Eq. (1), a_{ij} = total no.of assessment tools by which the jth CO is evaluated, w_{ik} = weightage to the kth assessment tool, x_{ij} = overall attainment of the jth CO, A_i = total no.of assessment tools applied for the Course, C_i = total no.of COs of the Course, and R_1 = scale point of the rubric used.

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Evaluation of CO attainment (*Contd... 6*)

- Implementing Eq. (1), the CO attainment is illustrated below:

Course: ME999	Rubric value: Sessional Test I	Sessional Test II	Mid-Semester Exam	End-Semester Exam	Average (x_{ij})
CO1	3	3	3	3	3
CO2	3	2	3	2	2.5
CO3	1	3	2	2	2
CO4	0	–	1	3	1.33
				Overall average:	2.21
				CO attainment of the Course [%]	73.67%

- Note that NBA [4] has not mentioned how x_{ij} should be calculated in Tier-I Institutes, while categorically specified for weighted attainment of CO for Tier-II Institutes [5]

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				CO attainment of the Course, X_i	**73.67%**

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- Introduction to OBE system
- Design and evaluation of attainment of COs
- Design and evaluation of attainment of POs
- Implementation of the CO-PO attainment model
- References

Design and evaluation of attainment of POs

- Design and evaluation of PO attainment involve another series of jobs
  - Setting some expected POs of the Program (including *Program-Specific Outcomes* (PSOs), if any) by merging the COs of its Courses
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Setting of POs

- An academic Program, e.g., UG in Mechanical Engineering, comprises a number of Courses for teaching over its entire time duration
- Accordingly, some POs can be set by merging the COs of those Courses, which (i.e., POs) are expected to meet on completion of the study of the Program
- Inversely, it is also possible to set the POs first and then to design some Courses by splitting the POs as their COs in a way that the completion of the Courses by students will mean the meeting of the POs
- In both modes for setting COs and POs, the COs of all the Courses of a Program should collectively cover all the POs of the Program
- Number of POs of a Program may usually be 4–12, but like in the case of the number of COs of a Course, it may also be fixed as per the requirement of an accrediting body or any other concerned authority, e.g., NBA [4, 5] has defined fixed and common 12 POs for all UG Engineering Programs

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Setting of POs (*Contd...*)

- A Program in higher education usually comprises a set of compulsory Courses; as well as some other sets of different types of Elective Courses, e.g., Program Elective I, Program Elective II, Open Elective I, Open Elective II, etc.
- Hence, POs of a Program may be set based on the COs of its Compulsory Courses (both Credit and non-Credit Courses) only, which is suggested by NBA [4, 5] also
- Reason is very simple and as follows:
  - Usually 2 or more Courses of similar nature are offered under each type of Elective Course, e.g., *Computer Programming* and *Application of Commercial Software Packages* are offered under Program Elective I as computation-based Courses
  - Since the COs of such Elective Courses are likely to be different, some students may miss the attainment of some POs if those are framed by covering the COs of all the offered Elective Courses, while the CO-PO articulation will be biased to some Courses if the POs are framed by covering the COs only of selective Courses

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Setting of POs (*Contd...*)

- A Program in higher education usually comprises a set of compulsory Courses; as well as some other sets of different types of Elective Courses, e.g., Program Elective I, Program Elective II, Open Elective I, Open Elective II, etc.
- Hence, POs of a Program may be set based on the COs of its compulsory Courses (both Credit and non-Credit Courses) only, which is suggested by NBA [4, 5] also
- Reason is very simple and as follows:
  - Usually 2 or more Courses of similar nature are offered under each type of Elective Course, e.g., *Computer Programming* and *Application of Commercial Software Packages* are offered under Program Elective I as computation-based Courses
  - Since the COs of such Elective Courses are likely to be different, some students may miss the attainment of some POs if those are framed by covering the COs of all the offered Elective Courses, while the CO-PO articulation will be biased to some Courses if the POs are framed by covering the COs only of Elective Courses

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CO-PO articulation or CO-PO correlation matrix

- Since the POs of a Program are framed by merging the COs of its Courses, attainment of the POs depends directly upon the attainment of individual COs as expressed by Eq. (1b), as well as upon the CO-PO correlations.
- CO-PO correlations, i.e., PO-wise weightage of COs indicating how strongly a CO is related to a PO, can be defined through another rubric system on a 3-point scale as below, which is suggested by NBA [4, 5] also

PO-wise weightage (relation) of CO	Rubric value
Substantial (High)	3
Moderate (Medium)	2
Slight (Low)	1
No correlation	–

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- As per above rubric system, the COs of a Course can be correlated to the POs of its Program in the form of a matrix, defined by NBA [4, 5] as the CO-PO articulation matrix or Course articulation matrix
- Such a CO-PO articulation matrix is illustrated below:

Course:	PO wise weightage of COs (y_{ijm}*)							
ME999	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	–	–	–	2	–	–	1
CO2	2	–	1	–	–	1	2	3
CO3	–	2	–	–	–	3	–	–
CO4	–	3	–	–	–	–	–	2

*y_{ijm} is the weightage of the jth CO of the ith Course to the mth PO

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CO3	–	2	–	–	–	3	–	–
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CO3	–	2	–	–	–	3	–	–
CO4	–	3	–	–	–	–	–	2

*y_{ijm} is the weightage of the jth CO of the ith Course to the mth PO

Evaluation of Course-wise attainment of POs

- After evaluating the CO attainment and defining the CO-PO articulation matrix, average attainment of individual POs against a Course can be evaluated by Eq. (2)

$$z_{im} = \frac{1}{R_2 l_{im}} \sum_{j=1}^{C_i} x_{ij} y_{ijm} \tag{2}$$

- In Eq. (2), z_{im} = attainment of the mth PO against the ith Course, x_{ij} = average rubric value attained against the jth CO of the ith Course, y_{ijm} = weightage of the jth CO of the ith Course to the mth PO, C_i = total number of COs in the ith Course, l_{im} = total number of COs of the ith Course correlated to the mth PO, and R_2 = scale point of the rubric system used for correlating COs to POs

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Evaluation of Course-wise attainment of POs (*Contd...*)

- Individual PO values attained against the ith Course by applying Eq. (2) are illustrated below:

Course:	Attainment of Course-wise individual POs							
ME999	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
Attainment of POs, z_{im}	2.33	1.33	0.83	–	2.00	2.00	1.67	1.46
	z_{i1}	z_{i2}	z_{i3}	z_{i4}	z_{i5}	z_{i6}	z_{i7}	z_{i8}

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Overall PO attainment

- NBA [4, 5] suggests to evaluate PO attainment for a Program by two methods – direct and indirect attainment methods
  - *Direct attainment method*: It is essentially based on students performances on the compulsory Courses of the Program, which can be evaluated directly by measurable assessment tools, such as examinations, viva-voce, or showcasing knowledge or skill in some other specified forms
  - *Indirect attainment method*: It is based on surveys conducted among graduated students, employers of graduated students, co-curricular and extra-curricular activities of students, etc.
- After the evaluation by both the methods, the overall PO attainment can be obtained by summing up them with some weightage, e.g., 80% weightage to direct assessment and rest 20% weightage to the indirect assessment

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Evaluation of overall PO attainment by direct method

- On completion of the study of a batch of students in a Program, the direct attainment of individual POs of the Program for that particular batch of students can be evaluated by Eq. (3)

$$Z_m = \frac{1}{N} \sum_{i=1}^{N} z_{im} \tag{3}$$

- In Eq. (3), Z_m = direct attainment of the mth PO over the entire Program for a given batch of students, z_{im} = attainment of the mth PO against the ith Course as given by Eq. (2), and N = total number of Courses of the Program to be taken into account in the evaluation of PO attainment
- If it is not possible to complete the exercise with all the Courses, as suggested by NBA [4, 5], some selective Courses with at least one Course from each Semester, that will collectively cover all the POs, may also be considered for the exercise

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Evaluation of overall PO attainment by direct method (*Contd...*)

- Attainment of average POs by applying Eq. (3) against all the Courses of a Program for a particular batch of students is illustrated below:

Course	Course-wise attainment of POs							
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
ME999	2.33	1.33	0.83	–	2.00	2.00	1.67	1.46
ME980	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
ME940	...	...	...	...	...	...	...	...
ME900	...	...	...	...	...	...	...	...
Direct PO attainment, Z_m	2.52	2.89	1.98	2.01	2.20	1.36	1.80	2.43
	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8

Evaluation of overall PO attainment by direct method (*Contd...*)

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	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
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ME980	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
ME940	...	...	...	...	...	...	...	...
ME900	...	...	...	...	...	...	...	...
Direct PO attainment, Z_m	**2.52** Z_1	**2.89** Z_2	**1.98** Z_3	**2.01** Z_4	**2.20** Z_5	**1.30** Z_6	**1.80** Z_7	**2.43** Z_8

Overall Program attainment

- Individual POs are helpful in understanding the performance in different components of a Program and also to take corrective measures for improvement
- However, it may become difficult and also confusing to understand the overall attainment of a Program from multiple attainment values of its individual POs
- Hence, the overall attainment of the Program as a whole can be defined by a single percentage value as expressed by Eq. (4)

$$F = \left(\frac{1}{R_2 P} \sum_{m=1}^{P} Z_m \right) \times 100\% \tag{4}$$

- In Eq. (4), F = single percentage valued attainment of the Program, Z_m = attainment of its mth PO as given by Eq. (3), P = total no.of POs of the Program, and R_2 = scale point of the rubric system used in CO-PO correlation
- This single-valued attainment of the Program is illustrated below:

$$\text{Overall Program attainment} = \left(\frac{17.13}{3 \times 8} \right) \times 100\% = 71.37\%$$

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- Introduction to OBE system
- Design and evaluation of attainment of COs
- Design and evaluation of attainment of POs
- Implementation of the CO-PO attainment model
- References

Implementation of the CO-PO attainment model

- Finally, how to implement the proposed model in computer for evaluating the CO-PO attainment?
- Sequential steps for the same are presented below

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Attainment of COs

- Read the following input data:
  (a) N : Number of Courses participated in the evaluation of attainment of COs and POs
  (b) C_i : Number of COs of the ith Course, $i = 1$ to N
  (c) A_i : Number of assessment tools applied to the ith Course, $i = 1$ to N
  (d) a_{ij} : Number of assessment tools by which the jth CO of the ith Course is evaluated, $j = 1$ to C_i, $i = 1$ to N
  (e) w_{ijk} : Weightage to the kth assessment tool in the evaluation of CO attainment of the ith Course, $k = 1$ to A_i, $i = 1$ to N (required only if different weightages are given to different assessment tools)
  (f) S_{ijk} : Attainment value of the jth CO of the ith Course as per the kth assessment tool, $k = 1$ to A_i, $j = 1$ to C_i, $i = 1$ to N
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  (f) S_{ijk} : Attainment value of the jth CO of the ith Course as per the kth assessment tool, $k = 1$ to A_i, $j = 1$ to C_i, $i = 1$ to N
  (g) R_t : Scale point of the rubric system used for evaluating CO attainment

Attainment of COs

- Read the following input data:
  (a) N : Number of Courses participated in the evaluation of attainment of COs and POs
  (b) C_i : Number of COs of the ith Course, $i = 1$ to N
  (c) A_i : Number of assessment tools applied to the ith Course, $i = 1$ to N
  (d) a_{ij} : Number of assessment tools by which the jth CO of the ith Course is evaluated, $j = 1$ to C_i, $i = 1$ to N
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  (f) S_{ijk} : Attainment value of the jth CO of the ith Course as per the kth assessment tool, $k = 1$ to A_i, $j = 1$ to C_i, $i = 1$ to N
  (g) R_t : Scale point of the rubric system used for evaluating CO attainment

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  (f) S_{ijk} : Attainment value of the jth CO of the ith Course as per the kth assessment tool, $k = 1$ to A_i, $j = 1$ to C_i, $i = 1$ to N
  (g) R_l : Scale point of the rubric system used for evaluating CO attainment

Attainment of COs

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  (g) R_l : Scale point of the rubric system used for evaluating CO attainment

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  (g) R_t : Scale point of the rubric system used for evaluating CO attainment

Attainment of COs

- Read the following input data:
  (a) N : Number of Courses participated in the evaluation of attainment of COs and POs
  (b) C_i : Number of COs of the ith Course, $i = 1$ to N
  (c) A_i : Number of assessment tools applied to the ith Course, $i = 1$ to N
  (d) a_{ij} : Number of assessment tools by which the jth CO of the ith Course is evaluated, $j = 1$ to C_i, $i = 1$ to N
  (e) w_{ik} : Weightage to the kth assessment tool in the evaluation of CO attainment of the ith Course, $k = 1$ to A_i, $i = 1$ to N (required only if different weightages are given to different assessment tools)
  (f) S_{ijk} : Attainment value of the jth CO of the ith Course as per the kth assessment tool, $k = 1$ to A_i, $j = 1$ to C_i, $i = 1$ to N
  (g) R_1 : Scale point of the rubric system used for evaluating CO attainment

Attainment of COs (*Contd...*)

- With the above input data, calculate the following:
  1. x_{ij} : Attainment of the jth CO of the ith Course by Eq. (1b) or Eq. (1c) as required, $j = 1$ to C_i, $i = 1$ to N
  2. X_i : Overall CO attainment of the ith Course in the form of a single percentage value by Eq. (1a), $i = 1$ to N
- Note that, out of x_{ij} and X_i calculated above, only x_{ij} is required in the evaluation of PO attainment

Attainment of COs (*Contd...*)

- With the above input data, calculate the following:
  (1) x_{ij} : Attainment of the jth CO of the ith Course by Eq. (1b) or Eq. (1c) as required, $j = 1$ to C_i, $i = 1$ to N
  (2) X_i : Overall CO attainment of the ith Course in the form of a single percentage value by Eq. (1a), $i = 1$ to N
- Note that, out of x_{ij} and X_i calculated above, only x_{ij} is required in the evaluation of PO attainment

Attainment of COs (*Contd...*)

- With the above input data, calculate the following:
  (1) x_{ij} : Attainment of the jth CO of the ith Course by Eq. (1b) or Eq. (1c) as required, $j = 1$ to C_i, $i = 1$ to N
  (2) X_i : Overall CO attainment of the ith Course in the form of a single percentage value by Eq. (1a), $i = 1$ to N
- Note that, out of x_{ij} and X_i calculated above, only x_{ij} is required in the evaluation of PO attainment

Attainment of COs (*Contd...*)

- With the above input data, calculate the following:
  (1) x_{ij} : Attainment of the jth CO of the ith Course by Eq. (1b) or Eq. (1c) as required, $j = 1$ to C_i, $i = 1$ to N
  (2) X_i : Overall CO attainment of the ith Course in the form of a single percentage value by Eq. (1a), $i = 1$ to N
- Note that, out of x_{ij} and X_i calculated above, only x_{ij} is required in the evaluation of PO attainment

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
  (d) x_{ij} : Attainment of the jth CO of the ith Course, $j = 1$ to C_i, $i = 1$ to N (calculated in CO attainment)
  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_2 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
  (d) x_{ij} : Attainment of the jth CO of the ith Course, $j = 1$ to C_i, $i = 1$ to N (calculated in CO attainment)
  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_0 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
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  (g) R_0 : Scale point of the rubric system used for correlating COs with POs

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- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
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  (g) R_0 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
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  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_0 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
  (d) x_{ij} : Attainment of the jth CO of the ith Course, $j = 1$ to C_i, $i = 1$ to N (calculated in CO attainment)
  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_5 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
  (d) x_{ij} : Attainment of the jth CO of the ith Course, $j = 1$ to C_i, $i = 1$ to N (calculated in CO attainment)
  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_0 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
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  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_t : Scale point of the rubric system used for correlating COs with POs

Attainment of POs

- Read the following input data:
  (a) P : Number of POs of the Program
  (b) N : Number of Courses participated in the evaluation of attainment of COs and POs (same as used in CO attainment)
  (c) C_i : Number of COs of the ith Course, $i = 1$ to N (same as used in CO attainment)
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  (e) l_{im} : Number of COs of the ith Course correlated to the mth PO, $m = 1$ to P, $i = 1$ to N
  (f) y_{ijm} : Weightage of the jth CO of the ith Course to the mth PO, $m = 1$ to P, $j = 1$ to C_i, $i = 1$ to N
  (g) R_2 : Scale point of the rubric system used for correlating COs with POs

Attainment of POs (*Contd...*)

- With the above input data, calculate the following:
  1. z_{im} : Attainment of the mth PO against the ith Course by Eq. (2), $m = 1$ to P, $i = 1$ to N
  2. Z_m : Direct attainment of the mth PO over the entire Program for a given batch of students by Eq. (3), $m = 1$ to P
  3. F : Single percentage valued attainment of the Program by Eq. (4)

Attainment of POs (*Contd...*)

- With the above input data, calculate the following:
  (1) z_{im} : Attainment of the mth PO against the ith Course by Eq. (2), $m = 1$ to P, $i = 1$ to N
  (2) Z_m : Direct attainment of the mth PO over the entire Program for a given batch of students by Eq. (3), $m = 1$ to P
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Attainment of POs (*Contd...*)

- With the above input data, calculate the following:
  (1) z_{im} : Attainment of the mth PO against the ith Course by Eq. (2), $m = 1$ to P, $i = 1$ to N
  (2) Z_m : Direct attainment of the mth PO over the entire Program for a given batch of students by Eq. (3), $m = 1$ to P
  (3) F : Single percentage valued attainment of the Program by Eq. (4)

Attainment of POs (*Contd...*)

- With the above input data, calculate the following:
  (1) z_{im} : Attainment of the mth PO against the ith Course by Eq. (2), $m = 1$ to P, $i = 1$ to N
  (2) Z_m : Direct attainment of the mth PO over the entire Program for a given batch of students by Eq. (3), $m = 1$ to P
  (3) F : Single percentage valued attainment of the Program by Eq. (4)

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Thanks a lot

for your patience

in listening

The tedious presentation!!