

Implementing an Application for Attainment Calculation of Program Outcomes and Course Outcomes for Courses of University-Affiliated Engineering Programs

Hasib Masud Shaikh, Arun Kumar



Abstract: The main goal of outcome-based education (OBE) is the achievement of program outcomes in a 4-year program. To achieve this, program outcomes need to be properly mapped with the course outcomes of courses of a particular program. Program Outcomes are the statements that describe what knowledge students will achieve by the time of graduation. OBE ensures that a graduate student not only possesses knowledge in a specific program but can also be globally accepted. The curriculum is designed in such a way that students get trained in all 12 program outcomes set by the National Board of Accreditation (NBA). Students gain knowledge through various teaching-learning methodologies like classroom lectures, laboratory experiments, workshops, guest lectures, and projects (mini project & megaproject). For each course, course outcomes have been designed by the university which gets mapped with program outcomes. The assessment of CO's & PO's is done by assessing the performance of students [1] using MS Excel software. This paper automates the manual excel work done for CO-PO attainment calculations [3]. After attainment calculations, it shows whether the program outcome has been achieved or not. For calculations, the system collects data such as CO-PO mapping, attainment level. The system also collects direct assessment data such as marks of each student for assignments, experiments, class tests, university marks, and indirect assessment data such as course exit survey. After calculations, it also generates a summary sheet that shows course outcome attainment for each course outcome. The system also generates program outcome attainment in the observation sheet.

Keywords: Course outcomes, Education, Engineering Education, Outcome Based Education, Program outcomes, University, Excel, National Board of Accreditation.

I. INTRODUCTION

Outcome-Based Education (OBE) is an educational model that forms the base of a quality education system. OBE helps students in achieving educational goals through various educational activities.

Various roles can be adopted by the faculties such as instructor, trainer, and mentor, based on the outcomes targeted. OBE mainly focuses on what the Institute provides to students [12]. It shows success by demonstrating outcomes using statements "able to do" in favor of students. OBE provides clear standards for observable and measurable outcomes. From 13 June 2014, India has become the permanent signatory member of the Washington Accord. The National Assessment and Accreditation Council (NAAC) and National Board of Accreditation (NBA) are the two autonomous bodies for promoting global quality standards for technical education in India. NBA has started accrediting only the programs running with OBE from 2013. The National Board of Accreditation mandates establishing a culture of outcome based education in institutions that offer Engineering, Pharmacy, Management program. Reports of outcome analysis help in finding gaps and improvement in next semester. This can be improved in next semester using seminars, guest lectures, and workshops to be conducted for that particular course. Figure 1 depicts an overview of OBE that shows the link between the program educational objectives (PEO), the program outcomes (PO) and the courses outcomes (CO).

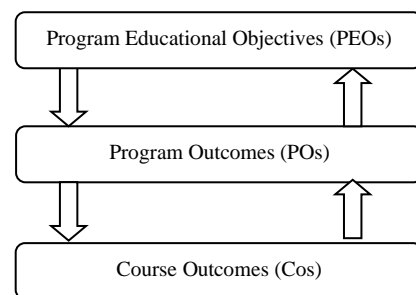


Fig. 1. Overview of OBE

A. Objective

The objective of the proposed system is to implement an automated attainment calculation system to calculate course outcome and program outcome attainment of a particular course. The user interface will allow users to enter CO-PO mapping, Target level, direct and indirect assessment data. After accepting all the data, the system generates a CO attainment summary sheet for each CO. The system also generates PO attainment in the observation sheet.

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II. RELATED WORKS

The authors in [1] demonstrated the k-means clustering algorithm as a simple and efficient tool to monitor the progress of students' performance in higher institutions. It makes use of a clustering algorithm, which helps in improving future academic results. This paper [2] discusses the importance of course outcomes and program outcomes in outcome-based education. The authors demonstrated this with the help of the case study implemented in their own institute. Various automated assessment tools can be used to check the performance of students [3]. The authors in [4] discussed the process for the attainments of Program Outcomes and Program Educational Objectives for Undergraduate or Postgraduate program approved by AICTE, India. Attainment summary is also generated batch-wise which helps in comparing attainment of different batches. This paper [5] discusses the methodology for the assessment of the course outcome of an individual student against the pre-defined target. Individual student performance can be measured if the outcome is not achieved. The authors in [6] discuss an efficient way of defining COs based on POs and Bloom's taxonomy. The authors in [7] implemented an assessment methodology based on students' feedback on course outcomes. Based on the assessments of COs and COs vs. POs mapping, PO attainments were calculated. In [8], authors have proposed the need for redefining course outcomes and the limitations during the attainment of course outcomes. This paper [8] also discusses the improvement in the performance of the individual students in terms of attainment of course outcomes. In this paper [9], the authors have proposed a top-down approach that links the program outcomes to the outcomes of the course. The approach is based on an analysis of set theory between the program and the courses outcomes sets. It also examines the level of details that can be used when linking the program and the outcomes of the course. This paper [10] proposes a practical method of assessing course outcomes unit by unit of a particular course. It also discusses the mapping of course outcome to program outcome. In this paper [11], the authors proposed a simple and effective method of PO attainment calculation using excel software. Data such as CO-PO matrix, marks for direct and indirect assessment are entered in excel and CO-PO attainment is calculated. In this paper [12], the authors discuss the importance and benefits of OBE for technical educational institutes. It has been found that a focused teaching-learning process and an appropriate assessment have led to the attainment of expected POs to a level of more than 70%.

III. PROPOSED SYSTEM

The proposed automated system consists of two sections, namely inserting values and attainment calculation. User Interface is designed with staff and admin credentials. Admin has access to upload, edit and delete student lists for the current academic year. The staff has the option of inserting data such as CO-PO matrix, target values, direct and indirect assessment values. After accepting all values, the system generates CO and PO attainment sheet which shows whether the attainment has been achieved or not. This in turn can also help in designing the curriculum. CO-PO attainment calculation would help in assessing OBE. This attainment calculation would also help in revising program outcomes and course outcomes. The final

attainment is calculated using tools such as Direct and Indirect assessment. The Direct assessment consists of data such as Examination (Termtest and End semester examination), Assignments (Minimum 2), laboratory experiments, and Projects (if any). The indirect assessment generally includes components like a course exit survey which is taken at the end of the semester. Block diagram of the proposed system is shown in figure 2.

A. System Description

Staff will input details such as CO-PO mapping, Target attainment, Direct & Indirect assessment marks as described below:

1) CO-PO mapping

The COs are mapped against each question and CO analysis is carried out by faculty for each course. The contributions of COs are assessed in high (3), moderate (2), and low (1) levels, towards the attainment of PO.

2) Target attainment

Target is set based on the previous year's results. If the course is introduced for the first time, then the target is set as per the difficulty level of the subject and discussion with the head of the department.

3) Assessment tools

The Direct and Indirect assessment tools are used in the attainment calculation. The Direct assessment consists of data such as Examination (Termtest and End semester examination), Assignments (Minimum 2), laboratory experiments, and Projects (if any) [4]. The indirect assessment generally includes components like a course exit survey which is taken at the end of the semester for the respective course. The feedback is evaluated and used in attainments of POs & Cos.

4) Database

It is used to store CO-PO mapping, target attainment values, direct & indirect assessment data. It is also used to store the user credentials. It is accessed through the User interface.

B. System Features

- 1) Accepting the values of CO-PO mapping, target attainment, and direct & indirect assessment to the database.
- 2) Calculation of course outcome & program outcome attainment.
- 3) Displaying the CO & PO attainment on different screens.

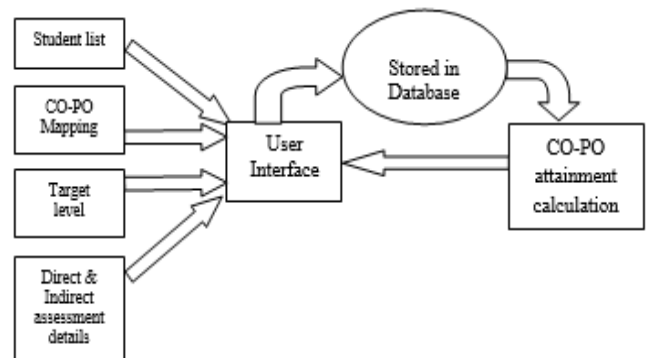


Fig. 2. Block diagram of CO-PO assessment calculation



IV. CO ATTAINMENT CALCULATION

Course outcome can be calculated with the help of direct & indirect assessment teaching-learning techniques [6]. Direct assessment includes term tests (evaluation by periodical tests), assignments, and laboratory experiments whereas indirect assessment includes a course exit survey where each staff conducts a feedback survey from students for their

course [11]. This feedback is then evaluated and used in the attainment calculation of course outcomes and program outcomes. The sample excel sheet is shown in fig. 3. The attainment calculations are done as per the target defined in the target sheet. The sample target sheet is shown in fig. 4.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S																		
	FEC102.1							FEC102.2		FEC102.3				FEC102.4																							
	Marks Obtained							Marks Obtained		Marks obtained				Marks obtained																							
	CT 1 10M	Expt.1 10M	Expt.2 10M	Expt.3 10M	Assign1 10M	Total CO1 (50)	CT 1 10M	Assign 1 10M	CT 2 9M	Expt.4 10M	Expt.5 10M	Assign 2 10M	CT 2 11M	Expt.6 10M	Assign 2 10M	University exam (60)																					
6	SR.NO.	NAME OF STUDENT																																			
8	IT01	Chaudhary Mohd Farooq Asgar Ali																		3	10	8	10	7	38	6	7	8	8	8	6	9	8	28			
9	IT02	Chauhan Sumeet Shyam																		6	10	6	6	5	33	6	5	9	5	6	8	5	7	8	8		
10	IT03	chavan Yashraj Ashok																		6	6	6	6	4	28	4	4	4	5	7	5	0	4	7	0	24	
11	IT04	Dhanjal Jagdish Singh Gurudev																		7	6	5	6	4	28	6	4	7	4	5	0	3	6	0	24		
12		No of students scored above 50%		3	4	4	4	2	4	3	2	4	3	4	2	1	4	2	3	No of students scored above 40% in univ																	
13		Total no of students		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	Total no of students																	
14		% of students scoring above 50%		75	100	100	100	50	100	75	50	100	75	100	50	25	100	50	75	% of students scoring above 40%																	

Fig. 3. Sample excel sheet for course

Attainment Levels Versus Target (IT)			
CO Attainment Method	Attainment Level		
	1	2	3
University Examination	50% student scoring more than or equal to 40% marks in the final examination	55% student scoring more than or equal to 40% marks in the final examination	60% student scoring more than or equal to 40% marks in the final examination
Internal Assessment	55% students score more than or equal to 50% marks in the internal assessment	60% students score more than or equal to 50% marks in the internal assessment	65% students score more than or equal to 50% marks in the internal assessment
Course Exit Survey	60% weightage in course exit analysis	70% weightage in course exit analysis	80% weightage in course exit analysis

Fig. 4. Target Sheet

In the sample excel sheet shown in fig. 3, we have distributed marks for each course outcome. For FEC102.1 – 50 marks (10 marks for classtest1, 30 marks for 3 experiments, 10 marks for assignment 1. Similarly 20 marks for FEC102.2, 39 marks for FEC102.3 and 30 marks for FEC102.4. As per the target sheet (fig. 4), we have applied COUNTIF(H11:H14,">=25") formula. For FEC102.1, total marks is 50 so we have taken ">=25" as target for internal assessment is 50% marks. The attainment calculation for FEC102.1 is marked with yellow color in fig. 2. Similarly for university examination, total marks is 60 and target for university examination is 40% marks so we have applied COUNTIF(R11:R14,">=24") formula. The attainment calculation for university examination is marked with green color in fig. 3. The indirect assessment generally includes components like a course exit survey which is taken at the end of the semester for the respective course. A feedback is taken from the students to understand the extent to which outcome is achieved. The staff member prepares a survey form which includes questions related to each course outcome. The survey may also include the questions related to mode of delivery of lectures (chalk-board, PPT presentation, group discussion, video lectures etc). The analysis is then done by inputting the values in the excel sheet. Sample course exit survey form [2] is shown in fig. 5. All the above excel data is inserted in our system and course outcome attainment is then calculated [5]. CO attainment is calculated as 80% of direct level + 20% of indirect level of that CO. The system generates a summary sheet which

displays CO attainment for individual CO. System generated summary sheet is shown in fig. 6.

Sr. No.	Particulars	Good (5)	Fair (4)	Satisfactory (3)	Average (2)	Poor (1)
1	Question 1 (Related to CO1)					
2	Question 2 (Related to CO2)					
3	Question 3 (Related to CO3)					
4	Question 4 (Related to CO4)					
5	Grade the effectiveness of mode of delivery in understanding the subject.					
	Chalk and Board					
	Power point presentation					
	Role Play					
	Group Discussion					
	Video Lecture					

Fig. 5. Sample course exit survey form

CO	DA Tools	LA Level of Course Outcome in %	LA Level	Average of LA Level	ESEA in %	ESEA in level	Total LA in level	Indirect Assessment	LA Attainment	Total Attainment CO
FEC101	Exptment.1	100.0	3							
	Class Test.1	75.0	3	2.3	75.0	3	2.86	85	3	2.89
	Assignment.1	50.0	0.91							
FEC102	Class Test.1	75.0	3	1.95	75.0	3	2.79	80	3.0	2.83
	Assignment.1	50.0	0.91							
FEC103	Exptment.2	87.5	3							
	Class Test.2	100.0	3	2.3	75.0	3	2.86	90	3	2.89
	Assignment.10	50.0	0.91							
FEC104	Exptment.3	100.0	3							
	Class Test.2	25.0	0.45	1.45	75.0	3	2.69	70	2.0	2.35
	Assignment.2	50.0	0.91							

Fig. 6. Sample Course Exit Survey Form

V. PO ATTAINMENT CALCULATION

Program outcome calculation is based on the marks of each COs for each student [7]. CO-PO mapping is done in terms of high (3), moderate (2), and low (1) levels as shown in fig. 7 [9].



This mapping is done by the staffs who are teaching that particular course. Based on CO attainment values, the PO attainment is calculated by the weighted mean average method [11]. In the

CO-PO mapping sheet (fig. 7), we have mapped FEC102.1 with PO1, PO2, and PO5 with levels 3, 2, and 1 respectively.

CO – PO Matrix												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
FEC102.1	3	2			1							
FEC102.2	3	2			1							
FEC102.3	3	2			1							
FEC102.4	3	2			1							
FEC102 (avg)	3	2			1							

Fig. 7. Sample CO-PO mapping

Similarly, mapping is done for FEC102.2, FEC102.3, and FEC102.4. FEC102.1 is mapped with levels 2 and 1 with PO2 and PO5, but the attainment we got for FEC102.1 is 2.89 (fig.6), hence we will multiply 2.89 with 0.66 ($2.89 \times 0.66 = 1.93$) for level 2 calculation and 2.89 with 0.33

($2.89 \times 0.33 = 0.96$) for level 1 PO attainment calculation. Similar calculations are done for FEC102.2, FEC102.3, and FEC102.4 [13]. System generated PO attainment sheet is shown in fig. 8.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
FE1231	2.89	1.93	0.0	0.0	0.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1232	2.83	1.89	0.0	0.0	0.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1233	2.89	1.93	0.0	0.0	0.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1234	2.55	1.7	0.0	0.0	0.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Fig. 8. PO attainment sheet generated by the system

System also generates observation sheet, which shows whether the targeted PO attainment has been achieved or not. System generated observation sheet is shown in fig. 9. We say target is achieved if and only if the difference between the target set and attainment is less than or equal to 0.02, else target is not achieved. In our sample example in fig. 9, target level for PO1, PO2 and PO5 is 3, 2 and 1 respectively. But the attainment achieved is 2.79, 1.86 and 0.93, hence we say target is not achieved (as the difference is 0.21, 0.14 and 0.07 which are all greater than 0.02).

	Target Level	Attainment Level	Observation
PO 1	3.0	2.79	The target is not achieved
PO 2	2.0	1.86	The target is not achieved
PO 5	1.0	0.93	The target is not achieved

Fig. 9. Observation sheet generated by the system

VI. PO ATTAINMENT CALCULATION

The effectiveness of the system is measured using the time taken by the system to:

- 1) User Login
- 2) Inserting data
- 3) Displaying results

The 3 possible conditions for login are discussed below:



a) Admin login

The login page identifies whether the person trying to log in is the user or admin. This is done by trying to match the entered credentials with the admin table of the database first. If there is a match, then the logged-in person is the admin, who is directed to the home page of the admin.

b) Staff login

If no match is found in the admin table then, the user entered credentials are matched with the user table of the database. If the match is found, then the logged-in person is said to be one of the users of the system, he is then redirected to the home page of the staff.

c) Invalid login

If there is no match found in both the admin table and user table then it is said to be invalid login by the system. Login screen is shown in fig. 10.

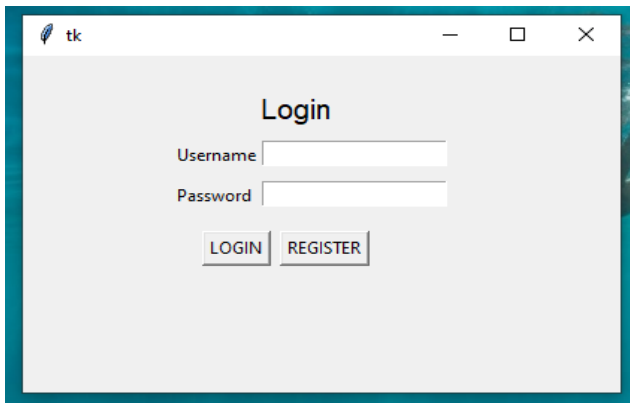


Fig. 10. Login page

2) Inserting data

In case of Admin login, admin will upload student roll list for the current academic year for all branches and divisions (if any). Admin has to select the year, branch, and division and upload the roll list. The roll list can also be modified and updated if required. If a user is a staff, he has to enter course information for which the attainment is to be calculated.

Flow of the system:

- Course information like course code, year, name & branch of the subject, the total number of Cos, select semester and university marks for that course. Subject/Course information screen is shown in fig. 11.

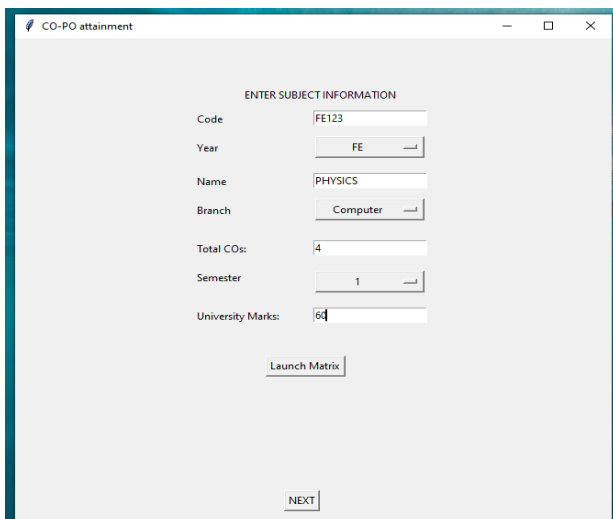


Fig. 11. Enter course information screen

- After filling in course information, staff has to click next to enter CO-PO mapping for that course as shown in fig.12.

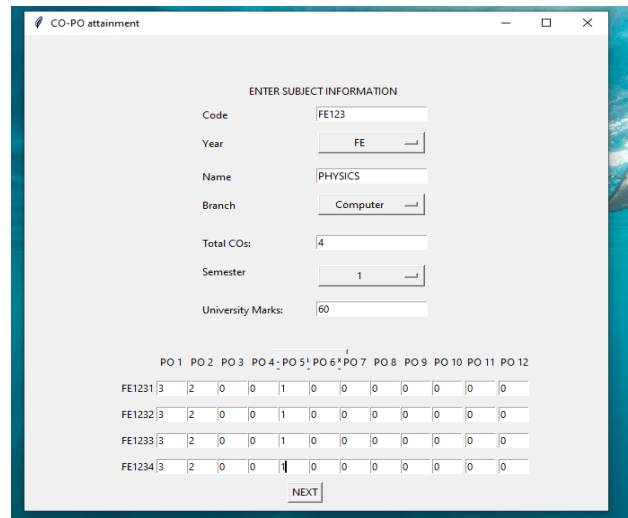


Fig. 12. Enter CO-PO matrix screen

- After filling the CO-PO matrix, staff has to click next to enter the marks (direct & indirect assessment) allotted for individual CO as shown in fig. 13. The staff has to enter marks for each CO one by one by clicking on insert. Finally, click on proceed for attainment level vs. target sheet.

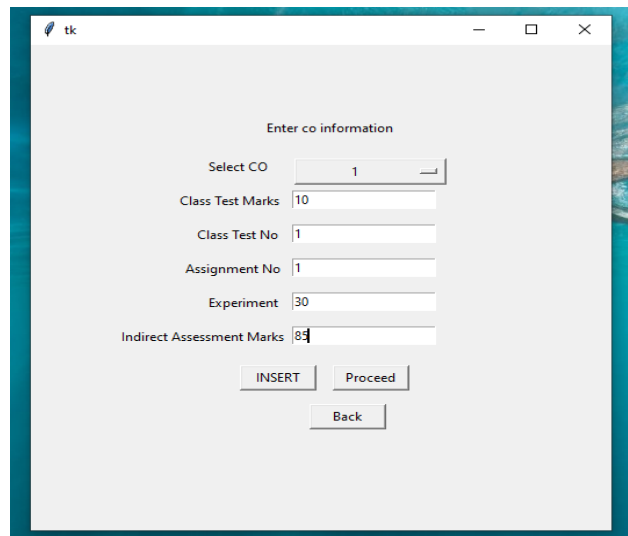


Fig. 13. Enter marks for each CO

- On clicking proceed; the attainment level vs. target sheet will open where staff has to enter the attainment levels for the University examination, internal assessment, and course exit survey. Attainment level vs. target sheet is shown in fig. 14.

CO attainment method	ATTAINMENT LEVEL		
	1	2	3
University Examination	Target for attain1 50 %	Target for attain2 55 %	Target for attain3 60 %
	40 %		
Internal Assessment	55 %	60 %	65 %
	50 %		
Course exit survey	60 %	70 %	80 %

Fig. 14. Attainment level vs Target sheet screen

- After filling the attainment level vs. target sheet, staff has to click on proceed to enter the marks for individual students. Student name and roll no. will be displayed automatically as it is being entered by admin through admin login initially. Staff will enter the direct assessment marks one by one for each student by clicking on the insert tab as shown in fig. 15.

3) Displaying results

Now, staff has to click on next (fig. 16) for the CO-PO attainment sheet. After clicking on next in the CO attainment summary sheet, the CO PO attainment sheet will be generated as shown in fig. 17.

- PO attainment sheet will be generated at the end which will show whether the target has been achieved or not [10]. PO attainment sheet is shown in fig. 18.

Year: FE Semester: 1
 Branch: Computer Subject: PHYSICS
 Roll no: IT01 Name: Chaudhary Mohd Farooq Asgar Ali

FE123.1 Class Test: 3 Assignment: 7 Experiment: 10 Experiment: 8 Experiment: 10	FE123.3 Class Test: 8 Assignment: 8 Experiment: 8 Experiment: 8	<input type="button" value="INSERT"/> <input type="button" value="STATS"/> <input type="button" value="Back"/>
FE123.2 Class Test: 6 Assignment: 7	FE123.4 Class Test: 6 Assignment: 8 Experiment: 6 University: 24	

Fig. 15. Enter marks for each students screen

- Once marks for all students have been entered staff needs to click on STATS which will display the attainment for individual CO. CO attainment summary sheet is shown in fig. 16.

VII. CONCLUSION AND FUTURE WORK

The proposed system is able to accept values and calculate the attainment. This system will be used by various colleges & universities for PO attainment calculation. At the same time, this system can also be used to redesign course outcomes and program outcomes to stay updated with the industry requirements. This system is secured with user and admin credentials.

Currently, this system only generates attainment for program outcomes. In the future, AI & ML techniques can be used to display the action that needs to be taken if a program outcome is not achieved [8].

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
FE1231	2.89	1.93	0.0	0.0	0.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1232	2.83	1.89	0.0	0.0	0.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1233	2.89	1.93	0.0	0.0	0.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE1234	2.55	1.7	0.0	0.0	0.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Fig. 16. CO attainment summary sheet

C.O.	D.A Tools	I.A Level of Course Outcomes in %	I.A Level	Average of I.A Level	ESE.A in %	ESE.A in level	Total.A in level	Indirect Assessment	I.A Attainment	Total Attainment CO
FE123.1	Experiment.1	100.0	3							
	Class Test.1	75.0	3	2.3	75.0	3	2.86	85	3	2.89
	Assignment.1	50.0	0.91							
FE123.2	Class Test.1	75.0	3	1.95	75.0	3	2.79	80	3.0	2.83
	Assignment.1	50.0	0.91							
	Experiment.2	87.5	3							
FE123.3	Class Test.2	100.0	3	2.3	75.0	3	2.86	90	3	2.89
	Assignment.10	50.0	0.91							
	Experiment.3	100.0	3							
FE123.4	Class Test.2	25.0	0.45	1.45	75.0	3	2.69	70	2.0	2.55
	Assignment.2	50.0	0.91							

Fig. 17. CO-PO Attainment Sheet

Target Level	Attainment Level	Observation
PO 1 3.0	2.79	The target is not achieved
PO 2 2.0	1.86	The target is not achieved
PO 5 1.0	0.93	The target is not achieved

Fig. 18. PO Attainment Sheet



Prof. Arun Kumar, a PhD in Computer Science and Engineering with special interest in computer vision and data mining, has been working with Sir Padampat Singhania University, Udaipur for the last eleven years and is presently the Dean of School of Engineering.

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