Journal of Engineering Education Transformations ,
Volume 38 , No. 2 , October 2024 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2024/v38i2/24192

Metrics With Performance Indicators Used For Calculating the Mapping Strength of Course Outcome With Program Outcome

Pradeep Yadav[1], Archana Tomar[2], Rishi Soni[3], Gaurav Dubey[4], Chandra Prakash Bhargava[5], Jyoti Kumari[6]
[1,2,3,4,5,6] Department of Computer Science and Engineering, Institute of Technology & Management, ITM Gwalior, M.P, India
[1]pradeep.yadav@itmgoi.in,
[2]archna.tomar@itmgoi.in,
[3]rishi.soni@itmgoi.in,
[4]gaurav.dubey@itmgoi.in,
[5]bhargavachandra1981@gmail.com,
[6]jyotikumari.asst@itmgoi.in

Abstract : Outcome-Based Education (OBE) worldwide plays a pivotal role in enhancing academic standards by equipping students with problem-solving skills. To effectively assess the quality of education, it is essential to intricately map courses with specific program objectives (POs). The AICTE introduced a comprehensive exam reform policy in 2018, aiming to enhance assessment methodologies. This innovative approach involves categorizing each Program Outcome (PO) into distinct competencies and subsequently breaking down each competency into a specific number of performance indicators. This innovation enables a more nuanced evaluation of educational outcomes. In this context, a developed metric proves instrumental in aligning the data structure course with relevant performance indicators (PIs). This systematic mapping ensures that educational programs align with desired outcomes, fostering a dynamic and responsive learning environment conducive to addressing complex challenges.

Pradeep Yadav
Department of Computer Science and Engineering,
Institute of Technology & Management, ITM Gwalior, India
pradeep.yadav@itmgoi.in,

Keywords : Performance indicators, Competencies, Course outcome, Program outcome

1. Introduction

Outcome-Based Education (OBE) is an educational approach that emphasizes what students should know and be able to do as a result of their educational experience. This method is designed to promote a more student-centered, goal-oriented, and holistic approach to education.

OBE focuses on student learning outcomes or the skills, knowledge, and attitudes that students should have gained from their education (Gundalia & Manoj, 2022). The predetermined learning outcomes guide curriculum which consists of courses. The development of skills in critical thinking and problem-solving is emphasized by OBE, as is student engagement and active learning. OBE is frequently compared to traditional education systems, which place more of an emphasis on curriculum coverage than on student learning outcomes. OBE is regarded as a more adaptable and flexible approach to education and is implemented in a variety of ways in various educational establishments. In the United States, William Spady Spady (Spady, William, 1994) proposed the idea of outcome-based education in the late 1970s and early 1980s. He has written a number of books and articles about OBE, one of which is titled

"Outcome-Based Education: "Designing and Implementing Outcome-Based Education" and "Critical Issues and Answers" (1994).Since June 13, 2014, the National Board of Accreditation (NBA) has recognized India as a permanent signatory, making it an official member of the Washington Agreement. The OBE was adopted by the All India Council for Technical Education (AICTE), a statutory body in India, to prepare engineering graduates for greater global mobility and acceptance (Ramchandra et al., 2014) . In India national educational policy (NEP) 2019 requires that programs and institutions should be accredited by 2022.

The exit learning outcomes that students should exhibit at the programs or course's conclusion serve as the basis for curriculum decisions in outcome-based education. (Dayananda et al., 2020). There are four levels of outcome-based education.

a. Program educational objectives: PEOs are broad statements that describe the professional and career activities for which the program is preparing graduates four to five years after graduation.

b. Program outcomes: Statements referred to as POs describe the expected abilities of engineering program graduates upon graduation.

c. Program-specific outcomes: PSOs are statements that state what a particular engineering program's graduates should be able to do upon graduation.

d. Course outcomes: Statements called COs to describe the tasks that students should be able to complete at the end of a course.

The architecture of outcome-based education is shown in figure no.1. The framework of OBE consists of different components.

Firstly the vision of the institute should be clearly defined which leads to the mission of the institute. The committee should frame the program's educational objectives. The program's educational objectives are the most important component of OBE, these are aligned with the overall mission and vision of the institution or universities. Program's educational objectives should be properly framed. Now after PEOs the PSOs will come.

The departmental academic planning committee (DAPC) should frame the program-specific outcomes. PSOs are used to evaluate and improve the quality of a program by providing a clear and measurable way to determine if a program is effectively preparing its students for their chosen career paths. PSOs are used to ensure that program graduates have the competencies and qualifications needed to succeed in their chosen profession.

The national board of accreditation has already suggested twelve program outcomes, which are common to all engineering branches. In the next component, the curriculum will come, in which each course is defined with course outcomes.

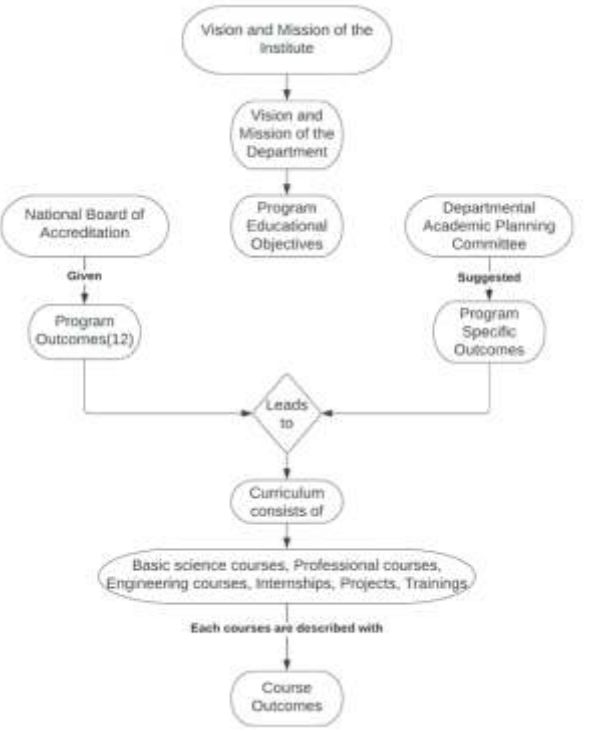

Fig. 1: OBE architecture

2. Literature Review

Several methods are used to calculate course outcomes and program outcomes.

(Hakan and Gurocak 2008) in their paper proposed direct measurement method in which scale from 1-to-5 for every course outcome is used.

(Turkmen et al. 2010) suggested two weighted parameters that emphasize the significance of each outcome's emphasis level and the amount of time spent on it.

Biney (Biney et al. 2005) in their paper focus on the critical analysis of every course in the program to determine which ones are intended to give students the most instruction and experience in the innumerable program outcomes. This enables the program to effectively identify specific courses that may be used to improve students' understanding of the several outcomes, allowing for the teaching of a small number of outcomes in each course and the direct evaluation of students' performance in these outcomes at the course level.

(Terang et al. 2015) shows the methodology to calculate program outcomes and course outcomes so that the weak students of the Electromechanical Energy Conversion II can find out. In this paper author memon (Memon et al. 2009) describes the program assessment method along with the component tools. This paper shows how knowledge levels are measured with the help of software program applications.

Nikita and arijit (Nikita and Arijit 2021) proposed software for calculating course attainment to replace manual labor and errors can be reduced. In this way, a proper record can be maintained. Similarly, literature (Rajak et al., 2018; Pavani et al., 2020) shows the attainment of course outcomes as well as program outcomes.

3. Methodology

Program educational objectives, program outcomes, program-specific outcomes and course outcomes are the main key components of OBE. During the curriculum designing of the courses Cos are provided in the syllabus, if not provided then teachers are required to frame the Cos. So before calculating the program attainment, course outcomes should be calculated

A. Course Outcomes

Students learn best when they know what they should be able to do by the end of a course. CO should be measurable, CO statement starts with an action verb from one of the cognitive levels, and occasionally by two action verbs from two bloom levels (Tiemeier et al., 2011).

The action verb enables you to tag a CO with a bloom levels. We can use the acronyms Like R-Remember, U-Understand, Ap-Apply, An-Analyse, Ev-Evaluate and Cr-Create.

B. Program Outcomes

The national board of accreditation has already defined the program outcome which is twelve in number.

1. Engineering knowledge
2. Problem analyses
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and teamwork
10. Communication
11. Project management and finance
12. Life-long learning

C. Course Attainment Flowchart

Course attainment is divided into direct and indirect components. Direct attainment includes both internal and external assessments. Internal assessments consist of midterm exams, assignments, ABCAs, and quizzes, while the external component comprises end-semester examinations. On the other hand, course exit surveys are categorized as part of indirect attainment, as illustrated in Figure 2. In this framework, twenty percent of the total weight is allocated to indirect attainment, while eighty percent is allocated to direct attainment. According to the university curriculum, seventy percent of the weight is given to the external component, and thirty percent to the internal component.

Total Attainment = 0.8 * DA + 0.2 * IA

Where DA stands for direct attainment and IA for indirect attainment.

Here in table no.1 the course outcome of data

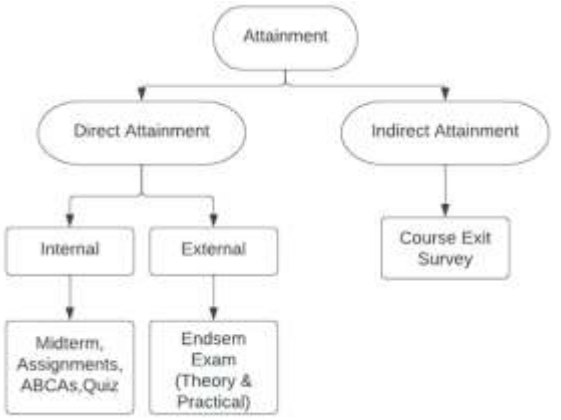

Fig. 2: CO Attainment

Table 1 : Course Name: C203 (Data Structure) Year of Study: 2020-21

C203.1	Ability to define, and understand concepts of different categories of data structures.
C203.2	Identify different parameters to analyze the performance of an algorithm.
C203.3	Design algorithms to perform operations with linear and nonlinear data structures
C203.4	Compare and contrast different implementations of data structures.
C203.5	Apply appropriate data structure to solve and implement various real-time problems.

structure is defined. For framing the course outcome, the action verbs are taken. Now after considering the course outcome our next target is to map these course outcomes with the program outcomes.

D. Course Outcome mapping with Program Outcome

In the above part course outcomes are properly framed, now in the next part these course outcomes should be mapped with program outcomes. Mapping of COs with POs should follow Exam Reform Policy 2018 provided by AICTE (Exam Reform Policy 2018). According to exam reform policy, each program outcome is divided into N no. of competencies and each competency is subdivided into N no. of performance indicators.

As shown in figure no.3 program outcome one is divided into three competencies and the first competency is divided into three performance indicators similarly the second competency is divided into two performance indicators and the third competency is divided into three performance indicators.

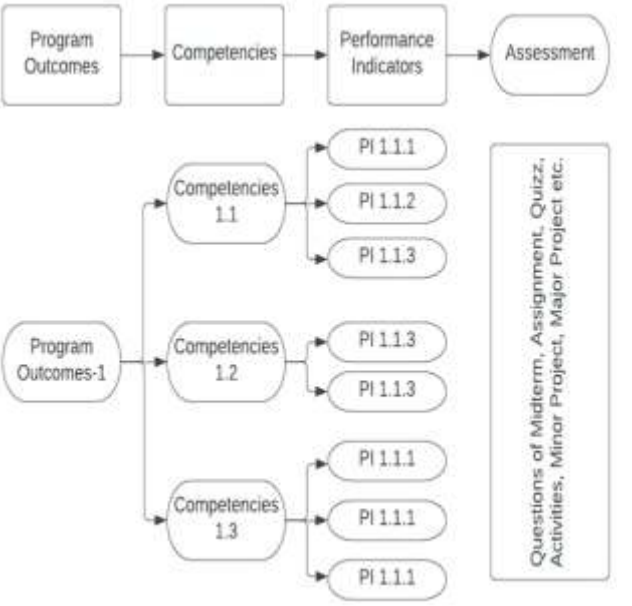

Fig. 3: PO-Competencies-Performance Indicators

The course's midterm papers, assignments, activities, and quizzes should be framed with performance indicators according to program outcomes. There are five performance indicators that are present in PO1, fourteen in PO2, fourteen in PO3, eight in PO4, six in PO5, two in PO6, four in PO7, three in PO8, seven in PO9, seven in PO10, five in PO11, six in PO12. Before calculating the strength of the CO-PO mapping matrix we need to map all the questions with performance indicators. For this, an excel sheet is prepared which is used for mapping questions with performance indicators shown in the appendix.

4. Metrics And Calculations

Course outcomes will be mapped with program outcomes with the help of competencies and performance indicators. In the course attainment process two methods are discussed, direct and indirect. Direct method is measured with the help of internal as well as external tool.

There are six learning levels according to bloom's taxonomy framework shown in below figure no. 4. The first three learning levels; remembering, understanding and applying and to some extent analyzing are used for fixed-hour examinations like midterms, end-semester exams, quizzes, etc. whereas the remaining learning level; analyzing, evaluating and creating are assessed through activities with no time limit, minor and major projects .

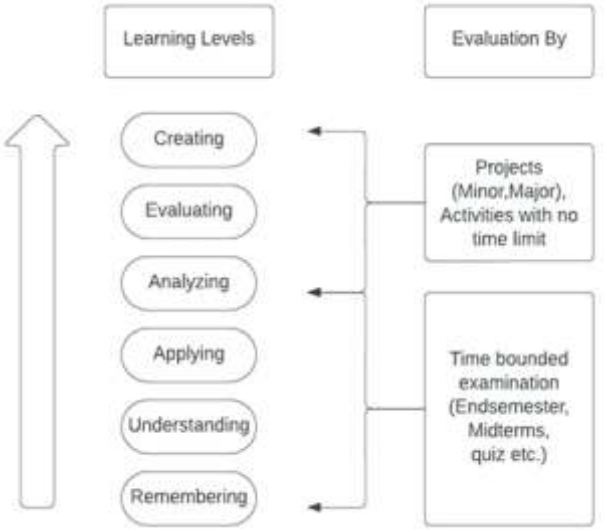

Fig. 4: Learning Bloom's Taxonomy Framework

Midterm, assignments, activities and quiz questions are framed according to these learning levels of bloom taxonomy. So while framing questions three points to be keep in mind.

a. Each questions should be mapped with a particular course outcome.

b. While framing questions action verbs should be included.

c. Bloom's learning level should be kept in mind while framing questions.

For mapping questions with program outcome one should properly go through the competencies of each program outcome and within a competencies he/she should go through the performance indicators for better understanding of a program outcome.

In figure no. 5 and figure no. 6 program outcomes PO1 and PO2 are discussed respectively. PO1 consists of four competencies and five performance indicators (PIs). Similarly, PO2 consists of four competencies and fourteen performance indicators. Now those questions according to specific COs that are mapping to particular PIs should be marked with 'YES' as shown in figure no.5. Now according to the course's instructor understanding all questions will be mapped with the specific PIs. Similarly, all the questions will be mapped with all the PIs.

Table no.2 shows the total mapped course outcomes with program outcomes. Whereas in table no.3 TPIs represents total performance indicators, MPIs represent mapped performance indicators and MS represents mapping strength. The mapping strength is calculated by using the below formula

$$MS = (MPIs / TPIs) * 100$$

If the percentage is in between 0 to 33 then MS value will be one. If the percentage is in between 34 to 66 then the MS value will be 2. If the percentage is in between 67 to 100 then the MS value will be 3. These values shows the strength of the matrix. One shows the low strength, two shows the moderate strength and three shows the high strength.

For achieving high strength, the proper mapping of the questions with performance indicators is needed. So before mapping one should know the program outcome and it's competencies with performance indicators very well.

5. Conclusion

In the present work, CO-PO mapping strength is calculated by using a metric in which questions of midterm, assignments, Quiz, and ABCA (Activity based continuous assessment) are mapped with the performance indicators. Program outcomes are divided into competencies and each competency is divided into n no. of performance indicators. Each performance indicator shows a clear view of program outcomes. So questions, which are framed using the action verbs and bloom taxonomy, should be properly mapped with the performance indicators. After mapping, the strength is calculated.

The main objective of this work is to increase the strength of the mapping and the strength can only be increased if we properly map questions with n no. of performance indicators. So this work helps in assessing the increased strength of the matrix.

DATA STRUCTURE

Program Outcomes	C.No.	Competencies	PI No.	Performance Indicators	CO1	CO2	CO3	CO4	CO5
PO1: Engineering Knowledge: apply knowledge of mathematics, science, engineering Fundamentals and an engineering specialization to the solution of complex engineering problems.	1.1	Demonstrate competence in mathematical modelling	1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solve problems.	YES				
			1.1.2	Apply the concepts of probability, statistics and queuing theory in modeling of computer-based system, data and network protocols.					
	1.2	Demonstrate competence in basic sciences	1.2.1	Apply laws of natural science to an engineering problem					
	1.3	Demonstrate competence in engineering fundamentals	1.3.1	Apply engineering fundamentals		YES	YES		
	1.4	Demonstrate competence in specialized engineering knowledge to the program	1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem	YES	YES	YES	YES	YES

Fig. 5: Program Outcome (PO1) with Competencies and Performance Indicators

DATA STRUCTURE									
Program Outcomes	**C.No.**	**Competencies**	**PI No.**	**Performance Indicators**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
PO2: Problem Analysis: identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.1	Demonstrate an ability to identify and formulate complex engineering problem	2.1.1	Evaluate problem statements and identifies objectives.					
			2.1.2	Identify processes/modules/ algorithms of a computer-based system and parameters to solve a problem	YES	YES	YES	YES	YES
			2.1.3	Identify mathematical algorithmic knowledge that applies to a given problem					
	2.2	Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1	Reframe the computer-based system into interconnected subsystems					
			2.2.2	Identify functionalities and computing resources.Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions					
			2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions			YES		
			2.2.4	Compare and contrast alternative solution/methods to select the best methods					
			2.2.5	Compare and contrast alternative solution processes to select the best process					
	2.3	Demonstrate an ability to formulate and interpret a model	2.3.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance.					
			2.3.2	Identify design constraints for required performance criteria.					
	2.4	Demonstrate an ability to execute a solution process and analyze results	2.4.1	Applies engineering mathematics to implement the solution.					
			2.4.2	Analyze and interpret the results using contemporary tools.					
			2.4.3	Identify the limitations of the solution and sources/causes.					
			2.4.4	Arrive at conclusions with respect to the objectives			YES	YES	

Fig. 6 : Program Outcome (PO2) with Competencies and Performance Indicators

Table 2: Total no. of "YES" mapped with PIs

	CO1	CO2	CO3	CO4	CO5
PO1	2	2	2	1	1
PO2	1	1	3	2	1
PO3	0	0	0	0	1
PO4	1	0	0	1	2
PO5	0	0	0	1	0
PO6	0	0	0	0	0
PO7	0	0	0	0	0
PO8	0	0	0	1	0
PO9	0	0	0	0	0
PO10	0	0	0	1	2
PO11	0	0	0	0	0
PO12	0	0	0	0	0

Table 3: Mapping Strength

	Program Outcomes						
Course Outcomes		PO1			PO2		
		TPIs	MPIs	**MS**	TPIs	MPIs	**MS**
	CO1	5	2	**2**	14	1	**1**
	CO2	5	2	**2**	14	1	**1**
	CO3	5	2	**2**	14	3	**1**
	CO4	5	1	**1**	14	2	**1**
	CO5	5	1	**1**	14	1	**1**

Table 4 : CO PO Mapping Matrix

Course	Course Outcomes	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012
C203.1	Ability to define, and understand concepts of different categories of data structures.	2	1	-	1	-	-	-	-	-	-	-	-
C203.2	Identify different parameters to analyze the performance of an algorithm.	2	1	-	-	-	-	-	-	-	-	-	-
C203.3	Design algorithms to perform operations with linear and nonlinear data structures	2	1	-	-	-	-	-	-	-	-	-	-
C203.4	Compare and contrast different implementations of data structures.	1	1	-	1	1	-	-	1	-	1	-	-
C203.5	Apply appropriate data structure to solve and implement various real-time problems.	1	1	1	1	-	-	-	-	-	1	-	-
Average		1.60	1.00	1.00	1.00	1.00	-	-	1.00	-	1.00	-	-

References

Gundalia, Manoj. "Assessment of Course Outcomes Attainment using Confidence Limits." Journal of Engineering Education Transformations 35, no. 3, pp. 21-29. 2022.

Spady, William G. Outcome-Based Education: Critical Issues and Answers. American Association of School Administrators, 1801 North Moore Street, Arlington, VA 22209 (Stock No. 21-00488; $18.95 plus postage)., 1994.

Ramchandra, Shivakumar, Samita Maitra, and K. MallikarjunaBabu. "Method for estimation of attainment of program outcome through course outcome for outcome based education." In 2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE), pp. 7-12. IEEE, 2014.

Dayananda, P., Mrityunjaya V. Latte, Mahesh S. Raisinghani, and C. N. Sowmyarani. "New approach for target setting mechanism of course outcomes in higher education accreditation." Journal of Economic and Administrative Sciences 37, no. 1, pp. 79-89. 2020.

Gurocak, Hakan. "Direct measures for course outcomes assessment for ABET accreditation." In 2008 Annual Conference & Exposition, pp. 13-439. 2008.

Turkmen, N., A. R. A. Khaled, O. M. Al-Raghbi, G. Zaki, M. Siddique, A. Gari, and A. Bokhary. "A procedure to assess engineering courses based on program outcomes." In Proceedings of the 7th Saudi Engineering Conference (SEC&), Riyadh, Saudi Arabia, pp. 157-169. 2010.

Biney, Paul, and Milton Bryant. "A novel strategy for the direct assessment and improvement of engineering programs

developed and implemented by Prairie View A&M University." In 2005 Annual Conference, pp. 10-68. 2005.

Terang, Parveen P., Sanjiba Kr Bisoyi, and Vinay Kumar Chandna. "Weightage factor analysis between Programme Outcomes and Course Outcomes: A case study." In 2015 IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education (MITE), pp. 84-87. IEEE, 2015.

Memon, Qurban A., and Adnan Harb. "Developing electrical engineering education program assessment process at UAE University."

Australasian Journal of Engineering Education 15, no. 3, pp. 155-164. 2009.

Gupta, Nikita, and Arijit Ghosal. "Automation of attainment calculation in outcome-based technical education (OBTE)." In Computational Intelligence in Digital Pedagogy, pp. 113-135. Springer, Singapore, 2021.

Rajak, Akash, Ajay Kumar Shrivastava, and Divya Prakash Shrivastava. "Automating outcome based education for the attainment of course and program outcomes." In 2018 Fifth HCT Information Technology Trends (ITT), pp. 373-376. IEEE, 2018.

Lokare, Varsha T., and Prakash M. Jadhav. "Course Outcomes Attainment for Data Structure Course Using Direct and Indirect Methods." Journal of Engineering Education Transformations 30, no. Special Issue, pp. 1-5. 2016.

Mukherjee, Debaprasad, Gour Sundar Mitra Thakur, and Sandip Chakraborty. "A Minimalist Algorithm for Learning Outcome Attainment Large-scale Computation equivalent to the Canonical Algorithm for Outcome-Based Education Courses & Programs." Available at SSRN 4038707, pp. 1-17. 2022.

Admuthe, L. S., and Deepali Yoginath Loni. "Course Outcome-Program Outcome Mapping Matrix & Attainment-Issues and Model Based Solutions for Tier II Category." Journal of Engineering Education Transformations 29, no. Special Issue (2016).

Sawant, Pragati. "Course outcomes attainment analysis using automated tool-IONCUDOS." Journal of Engineering Education Transformations 30, no. Special Issue, pp. 1-5. 2017.

Kulkarani, G., and R. Barot. "Attainment of course outcomes and program outcomes: A case study in an Engineering Course." International Journa of Science Technology & Engineering 5, pp. 40-45. 2019.

R Thakkar, Rushali, and Irfan Landge. "Attainment of Course Outcome and Programme Outcome: Direct and Indirect Method." Irfan, Attainment of Course Outcome and Programme Outcome: Direct and Indirect Method (February 4, 2022), pp. 91-95. 2022.

Kumar, KS Ananda, Bekele Worku, Balakrishna R. Sisay Muleta Hababa, A. Y. Prasad, Jyoti R. Munavalli, P. A. Vijaya, Priya R. Sankpal et al. "Outcome-Based Education: A Case Study on Course Outcomes, Program Outcomes and Attainment for Big Data Analytics Course." Journal of Engineering Education Transformations 35, no. 2, pp. 63-72. 2021.

Prakash, R. Vijaya. "An Effective Tool for the Attainment of Course Outcomes and Programme Outcomes." Journal of Engineering Education Transformations 28, no. 4, pp. 78-82. 2015.

Toney, G., Bhat, S., Kaliveer, V., Binu, K. G., D'Silva, R., Yathish Kumar, K., Shetty, A., & Singh, A. B. "Nurturing future Engineers through Industry-Oriented Training: The imperative of Core Competencies" Journal of Engineering Education Transformations, 37(Special Issue 2), 931–938, 2024.

Kumbhar, P. D., Patil, Y. M., & More, S. K. "Comparative Study on Students' Performance Using Gallery Walk and Poster Presentation Techniques" Journal of Engineering Education Transformations, 37(Special Issue 2), 326–333, 2024.

Mulla, A. A., Shah, A. P., Gaikwad, N. C., Choudhari, V. B., & Pharne, J. J. "Course Attainment and Program Attainment in Education Systems with the Average and Threshold Aspect" Journal of Engineering Education Transformations, 37(Special Issue 2), 432–438, 2024.

Patil, L. R., & Bhadri, G. N. "Strengthening the Attainment of Major Competencies of Program Outcomes through Open-ended Experiment using Statistical Designs" Journal of Engineering Education Transformations, 37(Special Issue 2), 189–196, 2024.

Swamy, K. V., Radhika, V., & Aouthu, S. "Engineering Course Development Process to meet Outcome Based Education" Journal of Engineering Education Transformations, 37(2 Special Issue), 67–72, 2024.

Mythiri, B., & Karthika, V. K. "Integrating CRTWC's

Anchor Competencies Framework into an ESP Syllabus for Fostering Social Emotional Learning Skills" Journal of Engineering Education Transformations, 37(4), 71–84, 2024.

Montero, L. C., Velarde, K. G., Arrué, A. R., & Del Savio, A. A. "Online learning environments for the promotion of undergraduate research in pandemic times: A case study in an engineering program" Journal of Engineering Education Transformations, 36(4), 161–171, 2023.

Sumathi, R., Savithramma, R. M., & Ashwini, B. P. "Curriculum Compliance Improvement Model for Addressing Program Outcomes in Engineering Education. Journal of Engineering Education Transformations, 37(1), 7–19, 2023.

Nandhitha, N. M., & Roslin, S. E. "OBE Framework for Assessing Laboratory / Practical Courses in Engineering Programmes" Journal of Engineering Education Transformations, 37(3), 121–142, 2024

Mulla, A. A., Jadhav, H. S., & Shah, A. P. "A Case Study on Course Outcome & Program Outcome Mapping Levels Based on Competency & Performance Indicators. Journal of Engineering Education Transformations, 36(Special Issue 2), 326–331, 2022.

Rajeswari, K., & Ananthi, G. "Facilitating Portfolio for holistic Engineering Education: An alternative Perspective" Journal of Engineering Education Transformations, 36(Special Issue 1), 89–93, 2022.

Mawandiya, B. K., Joshi, S., Modi, B., Patel, K., Lakhera, V., Patel, R., & Mahajan, A. "A New Comprehensive Methodology for Evaluation of Course Outcomes and Programme Outcomes" Journal of Engineering Education Transformations, 36(1), 95–103, 2022.

Choudhari, V. B., Gaikwad, N. C., Kulkarni, A. M., Gaikwad, S. D., & Patil, S. H. "Curriculum Delivery, Learning and Evaluation by Average Course Outcome Attainment & Program Outcome Attainment Method" Journal of Engineering Education Transformations, 36(Special Issue 2), 121–126, 2022.

Kulkarni, P., & Ramdasi, D. "Project-Based Learning Technique for Holistic Development of Students" Journal of Engineering Education Transformations, 36(Special Issue 1), 56–62, 2022.

Moharir, M., Agavekar, R., Bhore, P., Kadam, H., & Bewoor, A. "Effective Implementation of Peer Review as an Active Learning Technique to Attain Course Outcome: A Case Study" Journal of Engineering Education Transformations, 36(Special Issue 1), 63–72, 2022.

Forero-García, E., Castañeda, D. P., Corredor-Cely, J., & Paternina, J. L. "Energetic Competencies in Electronic Engineering Education: A Sustainable Social Commitment" Journal of Engineering Education Transformations, 36(2), 55–66, 2022.

Thiruvengadam, S. J., Baskar, S., Jeyamala, C., & Abirami, A. M. "Systematic Approach in Assessment of Course Outcomes/Program Outcomes for Undergraduate Engineering Programs-A Case Study" Journal of Engineering Education Transformations, 35(Special Issue 1), 270–276, 2022.

Ana, A., Kustiawan, I., Ahman, E., Zakaria, S., Muktiarni, M., Dwiyanti, V., & Khoerunnisa, I. "Defining Vocational Teacher Competencies in Industry 4.0 from the Perspective of Teachers and Lecturers." Journal of Engineering Education Transformations, 35(Special Issue 2), 39–46, 2022.

Agrawal, E., Tungikar, V., & Joshi, Y. "Method for assessment and attainment of course and program outcomes for tier-i institutes in India" Journal of Engineering Education Transformations, 34(3), 35–41, 2021.

Rajagopal Reddy, B., Karuppiah, N., Asif, M. D., & Ravivarman, S."A case study on the assessment of program quality through co-po mapping and its attainment" Journal of Engineering Education Transformations, 34(Special Issue), 104–111, 2021.

Kumar, K. S. A., Worku, B., Hababa, S. M., Balakrishna, R., & Prasad, A. Y. "Outcome-based education: A case study on course outcomes, program outcomes and attainment for big data analytics course" Journal of

Engineering Education Transformations, 35(2), 63–72, 2021.

Khandare, A., Patil, M., & Furia, P. "Moving towards quality academic project development using program specific research activities in engineering education" Journal of Engineering Education Transformations, 35(Special Issue), 9–17, 2021.

Mukunda Vani, M., Baig, Y. M., Wesley, C., & Iqbal, S. R. "Sustainable project-based learning: A more practical approach" Journal of Engineering Education Transformations, 34(Special Issue), 718–724, 2021.

Kulkarni, V. N., Gaitonde, V. N., Kottursheettar, B. B., & Jangali Satish, G. "An approach to develop and integrate existing curriculum to theme based curriculum structure for strengthening postgraduate studies in engineering education" Journal of Engineering Education Transformations, 33(3), 26–36, 2020.

Ana, A., Kustiawan, I., Ahman, E., Zakaria, S., Muktiarni, M., Dwiyanti, V., Saripudin, S., & Kahoerunnisa, I. "Defining vocational teacher competencies in industry 4.0 from the perspective of policymakers" Journal of Engineering Education Transformations, 34(Special Issue), 159–167, 2020.

Ingaleshwar, S. S., & Jamadar, A. M. "Enhancing faculty competencies through engineering exploration & design project course" Journal of Engineering Education Transformations, 33(Special Issue 1), 55–59, 2019.

Srikanth, I., Pulavarthi, V. R. S. V. B., Metri, R. A., & Bhattar, C. L. "The learning perspective for the course of instrumentation technique through project based learning" Journal of Engineering Education Transformations, 33(Special Issue), 451–455, 2020.

Pavani, K., Vasanth Babu, K., Arun, Y., & Tarangini, K. "Improved attainment through outcome based education and a case study" Journal of Engineering Education Transformations, 33(Special Issue), 352–359, 2020.

Tiemeier, Amy M., Zachary A. Stacy, and John M. Burke. "Using multiple choice questions written at various Bloom's Taxonomy levels to evaluate student performance across a therapeutics sequence." INNOVATIONS in pharmacy 2, no. 2, pp. 1-11. 2011.

AICTE Exam Reform policy (2018). https://www.aicteindia.org/sites/default/files/ExaminationReforms.pdf

Appendix

ACTIVITY (DRY RUN)

Q.No	Question	Marks	Course Outcome	Bloom Level	Performance Indicator
1	Given an array of 6 elements: 15, 19, 10, 7, 17, 16, sort it in ascending order using Bubbl e sort . 1 Repeat Steps 2 and 3 for K = 1 to N – 1 2 Set PTR := 1 (Initializes pass pointer PTR) 3 Repeat while PTR ≤ N - K If DATA[PTR] > DATA[PTR+ 1] Interchange DATA[PTR] and DATA[PTR + 1] Set PTR := PTR + 1 4 Exit.	5	CO5	L3,L4	1.4.1,2.1.2,2.2.3,4.1.2,10.1.2

2	Given an array of 8 elements: 15, 19, 10, 7, 17, 16, 5,20 sort it in descending order using Bubble sort. 1 Repeat Steps 2 and 3 for K = 1 to N-1 2 Set PTR := 1 (Initializes pass pointer PTR) 3 Repeat while PTR ≤ N-K If DATA[PTR] > DATA[PTR+ 1] Interchange DATA[PTR] and DATA[PTR + 1] Set PTR := PTR + 1 4 Exit.	5	CO5	L3,L4	1.4.1,2.1.2,2.2.3,4.1.2,10.1.2
3	1.Consider an array arr = {1, 5, 7, 8, 13, 19, 20, 23, 29}. Find the location of the item 23 in the array,using binary Search. 1 SET BEG=LB,END=UB & MID=INT((BEG+END)/2) 2 Repeat Steps 3 & 4 While BEG<=END & DATA[MID]≠ITEM 3 IF ITEM <DATA[MID],SET END=MID-1 ELSE SET BEG=MID +1 4 SET MID=INT ((BEG+END)/2) 5 IF DATA[MID]=ITEM,SET LOC=MID ELSE SET LOC=NULL 6 EXIT	5	CO5	L3,L4	1.4.1,2.1.2,2.2.3,4.1.2,10.1.2
4	Input : arr[] = {10, 20, 80, 30, 60, 50, 110, 100, 130, 170} Search 110 using Linear Search. 1 SET DATA[N+1]=ITEM (Insert ITEM at the end of DATA) 2 SET LOC=1 (Initialize Counter) 3 Repeat While DATA[LOC]≠ITEM LOC=LOC+1(End of Loop) 4 IF LOC=N+1,SET LOC=0 (Successful?) 5 Exit	5	CO5	L3,L4	1.4.1,2.1.2,2.2.3,4.1.2,10.1.2
5	To search 39 from an STACK of 10 elements 9 19 29 39 49 59 69 79 89 99 1) Set PTR=START 2) Repeat step 3 while PTR≠NULL 3)If ITEM<INFO[PTR],then Set PTR=LINK[PTR] Else if ITEM=INFO[PTR]Set LOC=PTR and Exit Else: Set LOC = NULL,and Exit 4) Set LOC=NULL 5)Exit	5	CO2,CO5	L3,L4	1.4.1,2.1.2,2.2.3,4.1.2,10.1.2