Enhancing Curriculum Compliance through CO-PO Mapping and Strategic Gap-Bridging in Outcome-Based Education

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***Abstract*— An organized method for making sure that academic programs meet industry standards, accreditation requirements, and well-defined learning outcomes is called outcome-based education (OBE). The methodical mapping of Course Outcomes (COs) to Program Outcomes (POs), a quantifiable indicator of curricular effectiveness, is a crucial component of OBE implementation. However, misalignment between program-level abilities and course-level objectives frequently results in gaps that could impede overall attainment. Through CO-PO mapping analysis, weak PO attainments are identified, the underlying reasons of CO-PO gaps are identified, and targeted curricular and co-curricular upgrades such content enrichment, assessment reform, and industry-integrated activities are introduced. The goal of the strategic initiative "Content Beyond the Syllabus" is to close the knowledge and skill gaps in engineering education. It draws attention to the proactive steps done to enhance the delivery of the curriculum, such as seminars, software training courses, Industry shadowing, peer mentoring, and personality development exercises. The careful "GAP analysis" method serves as the basis for this content enhancement. When taken as a whole, these studies offer insightful information about how engineering education is changing, highlighting the significance of constant development, flexibility, and alignment with industry demands. Stakeholder input was incorporated throughout the curriculum modification, demonstrating the dedication to upholding an efficient and well-balanced curriculum structure. This study offers a methodical approach to improving curriculum conformity using precise CO-PO mapping and well-thought-out gap-bridging techniques**

***Keywords*—Outcome Based Education; Compliance of Curriculum; Gap Bridging, Innovative Methods, CO, PO.**

***ICTIEE Track*—Assessment, Feedback, and Learning Outcomes**

I. INTRODUCTION

THE process of upgrading curriculum content to satisfy industry and technical demands and ever-evolving technological aspects is the educational fulfillment of nurturing curriculum content. Two essential components of contemporary education are the National Board of Accreditation (NBA) and Outcome-Based Education (OBE). OBE is a pedagogical approach that centers on defining specific learning outcomes for students and designing educational programs to achieve those outcomes effectively. It emphasizes competency-based learning, where students develop practical skills and knowledge relevant to their field of study. NBA's rigorous accreditation process ensures that institutions meet the prescribed standards, fostering excellence in technical and management education. Together, OBE and NBA activities play a crucial part in getting better the quality, relevance, and global competitiveness of educational institutions and their graduates.

For the education in engineering field, it becomes necessary for upgradation of curriculum content to serve the endeavors in technologies. The need of industry has to be looked after and find the extent of compliance of skills require for an employability [1].

Authors are experiencing the curriculum changes and extent of curriculum in academic delivery. This has been used to find the gaps that curium fulfilled will lead industry ready students. The National Board of Accreditation (NBA) ensures the educational quality benchmark for Institutes. During the Accreditation process authors have found the meetup and gap finding that could lead activities to work on for making students of skill ready to Industry. Authors are serving in

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polytechnic Institute of Maharashtra are in association with Maharashtra State Board of Technical Education (MSBTE). The curriculum is designed by following all the guidelines of outcome-based education. The curriculum is designed by well-known National Institute of Technical Teachers' Training and Research (NITTTR). The same curriculum is changed after every 5 years of duration after taking inputs from all stake holders like Course Experts, Institutes, Industry. Curriculum proportions the makeup of basic science and humanities, professional courses, moreover their distribution throughout core, elective, and breadth offerings.

This curriculum is used by all Polytechnic Institutes of Maharashtra State in INDIA [2].

However, the Academic delivery and the local Industry requirement meeting the employability & skill in vicinity if Institutes varies. So, the program skills requirement varies.

the Program skills achieved through the courses delivered in whole academic tenure. So, the courses mapping to PO serves the important aspect to find the skills that a program of respective Institutes will incorporate in students graduated FROM THAT INSTITUTE. THE ENVIRONMENT RELATED COURSES ARE designed specific to the program rather than just a general awareness level course was being offered earlier. The MSBTE course work is amended every five years with input from all stakeholders [3].

The latest revision of curriculum named as K-scheme emphasizes on the philosophy of Outcome Based Education (OBE) advocated by NBA. The method of OBE curriculum revision is executed in reverse manner'. That is first, the Program Outcome, Course outcomes and Practical outcome are defined then the learning experiences are designed to achieve these outcomes. Whereas. during curriculum implementation, the teacher will analyses the contents and then develop the learning experiences which will ensure the accomplishment of outcome.

The affiliated board has given effective curriculum implementation guidelines for teachers and students in the aspects of Outcome Based Education. The Curriculum Implementation and Assessment Norms (CIAAN) is the guidelines used to evaluate and ensure uniform and smooth implementation of new "K" Scheme curricula. The newly designed CIAAN norms are focused on the respective Program Outcomes (POs), and their specific Program Educational Objectives (PEOs). This philosophy provides feedback at regular intervals from all stake holders. This will also be helpful to the institutions to manage the resources effectively and efficiently. The board has taken care of ensuring skill to students within OBE practices and framework. However, the academic delivery varies Institute to Institute. This creates a pocket in meeting the extent of curriculum for making student complete readiness to Industry employability [4,5].

II. PREPARATION OF PROGRAM ARTICULATION MATRIX

CO-PO/PSO mapping determines the contribution of the course to the program in developing knowledge, skill, and attitude. After a thorough study of the course curriculum, the course teacher prepared course outcome statements with Bloom's levels and CO-PO mapping of a particular course. In Table I, CO Statements & their mapping with PO for a sample course are demonstrated for a course name HPC. The CO-PO mapping levels are defined on the basis of competencies and performance indicators [6].

SS I
CO STATEMENT & MAPPING FOR SAMPLE COURSE

CO ID	CO Statement	Bloom's Level
22650-a	Use principles of fluid mechanics for energy conservation.	A
22650-b	Prepare a troubleshooting chart for centrifugal, reciprocating and other pumps used in fluid power system.	A
22650-c	Evaluate capacities of simple hydraulic and other pumping devices.	A
22650-d	Construct hydraulic and pneumatic circuits for relevant applications.	U
22650-e	Maintain components of hydraulic, pneumatic and hydro-pneumatic systems.	U
22650-f	Maintain hydraulic, pneumatic and hydro-pneumatic circuits and systems.	U

CO-PO/PSO Matrices: HPC (22650)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
CO1	3	3	1	1	-	3	-	1	-
CO2	3	1	-	1	-	2	2	2	1
CO3	3	2	-	1	-	2	-	1	2
CO4	3	3	3	3	3	-	3	1	2
CO5	3	-	-	3	-	2	-	3	-
CO6	3	-	-	3	-	2	-	3	-
Average Mapping	3	2.3	2	2	3	2.2	2.5	1.8	1.6

Each course CO-PO mapping is prepared, and further, the cumulative Course to PO mapping is provided for the articulation matrix included in Table II. The Articulation matrix determines the extent of curriculum delivery by the program's academic activities. Weak and strong areas of knowledge, skills, and attitude that will be attained by students will be understood by program articulation matrices. Sample fifth and sixth semester courses of Third Year are presented in Table II, containing all courses that have to be included, defining the articulation matrix [7].

TABLE II
PROGRAM ARTICULATION MATRIX OF AUTOMOBILE PROGRAM

AY/ Mapping	Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
TY 2021-2022	EST	3	2	3	3	3	3	3	-	-
	TMM	2.2	1.75	1	1.5	2	1	2.2	-	-
	ACD	3	2.8	2.2	1.6	1.2	2.4	2.2	1	1.2
	TTW	2.4	1.6	1	1.4	1.2	2	3	2.6	-
	ABE	2.67	1.75	2.67	3	2.2	3	2.5	2.67	2
	EDE	3	3	2	2.25	3	3	2.6	-	-
	CPP	2.8	2.6	1.5	2	1.33	3	2.75	1	2
	ITR	1.25	1.67	1	1.5	1.5	3	1.5	2	2
	MAN	-	1	-	-	2	3	2	1	1.6
	HPC	3	2.25	2	2	3	2.2	2.5	1.83	1.67
	AEE	2.8	1	1	2.6	2	2	2	3	-
	ETM	3	3	3	2	2.33	3	3	-	-
	AAC	3	3	2.17	3	1	2	3	3	1
	CPE	2.5	2.38	1.67	2	1.44	3	2.57	1	2
	VSM	2.6	2	-	2	1.2	2	3	3	-

III. RELEVANCE STRONGLY MAPPED POS THROUGH CURRICULUM

The articulation matrix gives extent of program curriculum contribution to program PO skills. There are various domains in the program courses; discipline group domain wise course details are as shown in Figure 1.

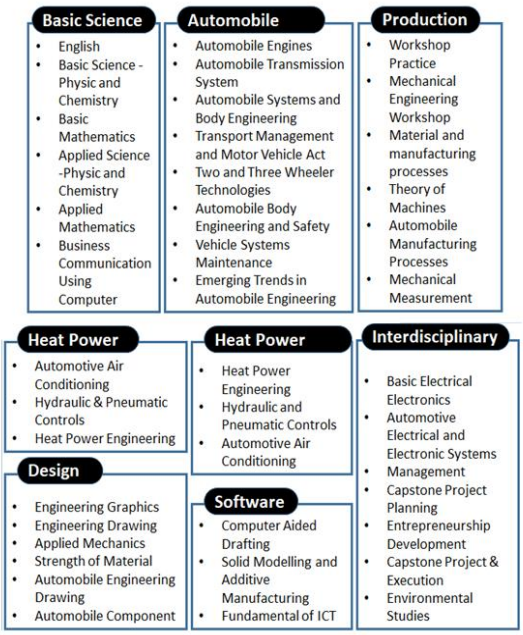

Fig. 1. Discipline Group Domain Wise Course details

After preparation of Program Articulation Matrix for an Automobile Program, number of course which gives extent of knowledge about group can be find and further focused to the target attaining PO respective skills.

Figure 2 shows bar chart of the percentage of courses from total courses in program highly mapped to respective PO statements. Here we come to know, which PO has gained less weightage from the program academic delivery? This will be useful to take additional effort to meet the deficiency of PO skills [8].

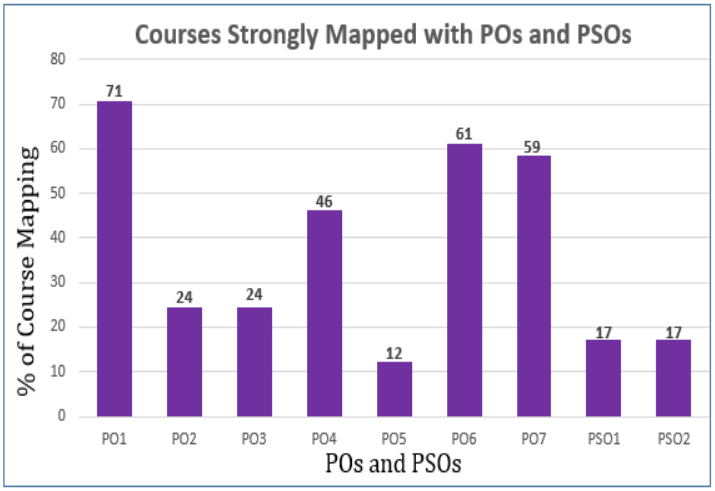

Fig. 2. Percentage of Courses strongly mapped to POs & PSOs

IV. CURRICULUM COMPLIANCE PROCEDURE

Program curriculum is well defined from the inputs of various stakeholders and revised after every five years. This revision is stated as K Scheme (here K is alphabet determines revision from first time syllabus stated since A, B, C…) Curriculum maintains the balance in the composition of basic science, humanities, professional courses and their distribution in core, elective and breadth offerings. The approach of curriculum design and transfer of course content to program skill is shown in Figure 3 course detailing. From topic learning outcome, lab learning outcome, course learning outcome, competency developed to program outcome respectively.

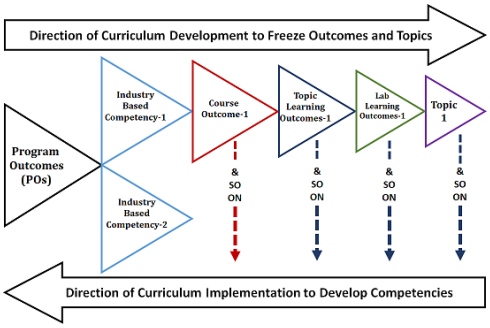

Fig. 3. Curriculum design and transfer (CIAAN.)

If some components that are essential to obtain COs/POs are not covered in the curriculum offered by the affiliated board or university, the institution makes further efforts to convey such information by covering topics through "Contents Beyond Syllabus". The additional content beyond the syllabus is added after the GAP analysis. The process of finding gaps and meeting the extent of compliance to the program curriculum is show in Figure 4. A flow chart can be used to identify gaps that could affect the extent of compliance with the curriculum, where the courses are less contributing to program skills. The process

starts with gathering feedback on curriculum gaps from stakeholders, followed by analyzing the data by the course teacher. Findings from data analysis from course teacher are discussed to identify weakly addressed POs, PSOs, and gaps in the DAB meeting. A list of identified gaps is prepared, and content beyond the existing syllabus is developed by approval from DAB committee [3,6].

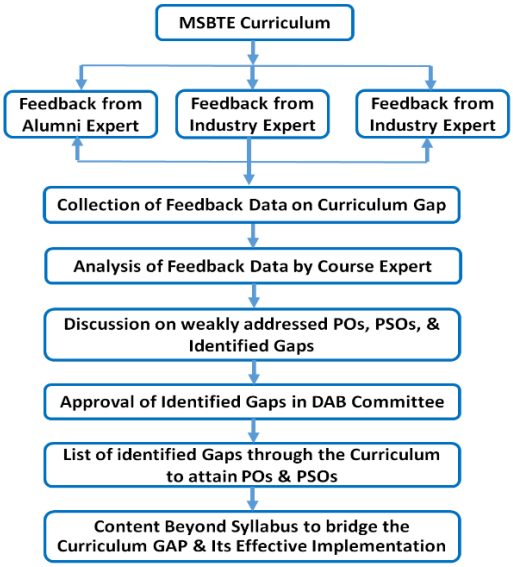

Fig. 4. Curriculum Compliance Process Flowchart

A. *Feedback on extent of compliance:*

Feedback is taken from the various stakeholders of program to understand the extent of compliance of the curriculum for attaining the Program Outcomes (POs) and Program Specific Outcomes (PSOs). The following figure 5 shows the demographic information about the participants of this feedback.

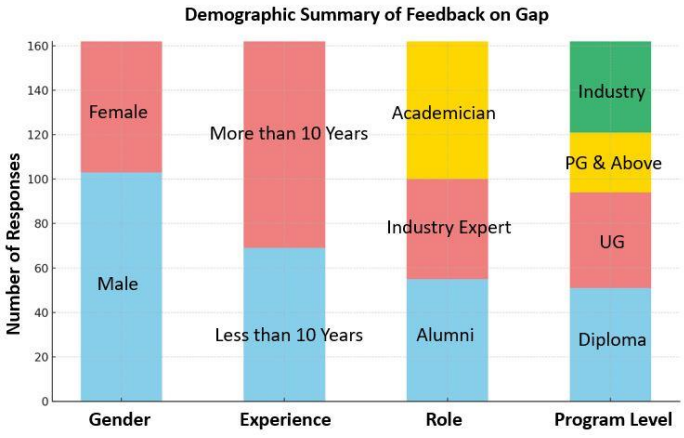

Fig. 5. Demographic information of the participant

The questionnaire used for the feedback to understand the extent of compliance of the curriculum for attaining the Program Outcomes (POs) and Program Specific Outcomes (PSOs). is as follows:

1. Professional Experience in years.
Response: Belo 10 Years, Above 10 Years
2. What is your Role in this feedback?
Response: Alumni, Industry Expert, Academician
3. Which program level do you handle?
Response: Diploma, UG, PG and Above and Industry
4. Are there any relevant topics/contents that are not adequately covered in the current syllabus?
Response: Yes, No, Mention (If yes)
5. Are any emerging technologies or recent trends missing from the curriculum?
Response: Yes, No, Mention (If yes)
6. Do you feel the curriculum has any redundant or outdated topics?
Response: Yes, No, Mention (If yes)
7. Are practical sessions/projects sufficient to bridge the gap
Response: Yes, No, Mention (If yes)
8. Are there any pre-requisite knowledge gaps (Vertical Gaps)?
Response: Yes, No, Mention (If yes)
9. Are there horizontal gaps (lack of integration) between courses taught in the same semester?
Response: Yes, No, Mention (If yes)

All collected responses from 162 stakeholders on the feedback to understand the extent of compliance of the curriculum for attaining the Program Outcomes (POs) and Program Specific Outcomes (PSOs) are as shown in Figure 6 below:

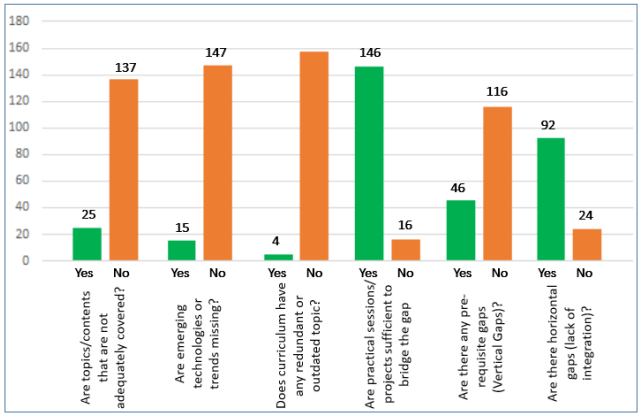

Fig. 6. Responses collected to identify extent of compliance of the curriculum

B. *GAPS IDENTIFIED AND INNOVATIVE ACTIONS TAKEN:*

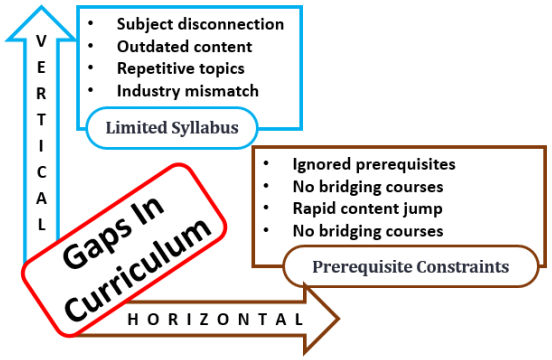

Fig 7: Types of Gaps in Curriculum

The Figure 7 shows two directions of Gap finding one is vertical Gap which is due to Prerequisite contrarian and the other is Horizontal Gap which is due to limited syllabus. These two gaps meet the extent of curriculum:

1. Horizontal Gap: The course instructor thoroughly examines the curriculum. A common forum where the connections between different courses are discussed is

formed following discussions with other course teachers. The gaps in knowledge and curriculum are noted, and a plan is developed to close these deficiencies [8,9].

2. Vertical Gap: Discussions with departmental faculty members and feedback from stakeholders reveal recent advancements in the business. The talk also emphasizes how important it is that students understand these developments. [8,9]. Thus, programs for software and soft certification programs, industry shadowing, peer mentoring refresher courses, symposiums, seminars, workshops, entrepreneurship development, skill imbibing, and personality development are set up [10].

Table III shows sample gaps identified and structured approach and innovative methods implemented to bridge specific curriculum gaps identified across different automobile engineering courses. These actions collectively aim to enhance student understanding, skill development, and industry readiness to meet the extent of curriculum essential for achieving Program Outcomes (POs) and Program Specific Outcomes. (PSOs) [11].

TABLE III
SAMPLE CURRICULUM GAPS IDENTIFIED AND INNOVATIVE ACTIONS TAKEN

Method	Course and Description	Action Taken
1. Content not included in curriculum but required to attain POs & PSOs.		
Value-added / Bridge Courses	Short-term certification courses are designed to bridge the gap between student skills, knowledge, and industry needs.	30-hour software training course on CATIA V5R17 for T.Y. Students 40-hour training course on SAP for S.Y. Students
2. Content in syllabus but not enough weightage.		
Internal Micro-Projects	ATS (22309): A clear understanding of the specifications of tyres used in automobiles.	A Case Study on Tyre Selection for a Passenger Car Based on Load, Speed, Vehicle Compatibility, Road Conditions, Comfort, and Fuel Efficiency.
3. Content covered in theory; practical knowledge is also necessary but not included in the practical list.		
Industry Shadowing	MMP (22307): The Syllabus does not cover the melting and casting processes used in the foundry industries.	Conducted shadow programs at Shriram Foundry, Shiroli MIDC, Kolhapur for observational learning experiences to see real-life applications in the foundry industries
4. Content covered in practical's but not included in theory.		
Theory-Practical Integration and Case Study	AEN (22308):): The Syllabus does not cover theory on hand tools used for assembly and dismantling of various automobile components..	Conducted 15 min pre-practical theory sessions before lab on hand tools used in Automobile Workshop. Case study activity on Tool kit familiarization activity by visiting an Automobile Workshop.
5. Gap of basic knowledge to the lateral entry students		
Foundation Modules/ Peer mentoring	AED (22023): Basic knowledge of Engineering Graphics to the direct second year students.	Foundation Module Plan of 15 hours (3 weeks) through refresher classes of the AED course for direct second-year students. Peer mentoring or buddy support activity observed in the class.

V. EFFECTIVENESS OF CURRICULUM GAP-BRIDGING METHODS

The effectiveness of curriculum gap-bridging methods was assessed through student feedback. Quantities data analysis with the help of the radar chart shown in fig 8. It indicated a positive impact on learning and skill development. Lateral entry students particularly appreciated the foundation modules, which strengthened their basic concepts and boosted confidence in advanced subjects. Overall, the feedback highlighted that these methods effectively supported outcome-based education and better preparedness for industry demands. Feedback form includes both quantitative (Likert scale) and qualitative (open-ended) questions to get a holistic view [12].

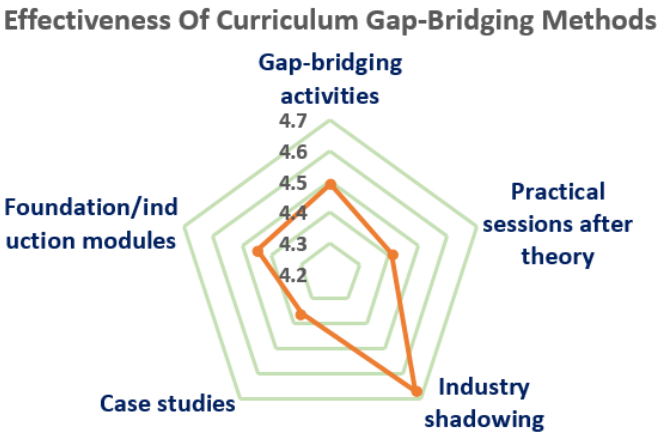

Fig. 8. Radar chart of effectiveness of gap bridging methods

Figure 9 shows qualitative data analysis with the pie chart that visually represents the perceived usefulness of various educational or training methods used for effective curriculum gap-bridging. The chart suggests that practical, real-world exposure such as industry shadowing and applied learning methods like case studies, are valued more by participants compared to introductory or preparatory activities [13]

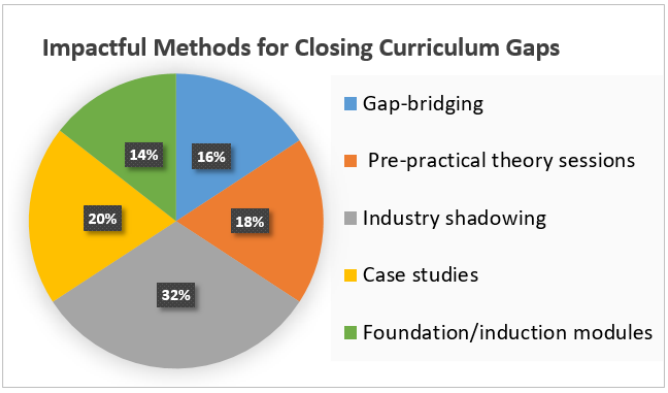

Fig. 9. Impactful Methods for Closing Curriculum Gaps

CONCLUSION

In conclusion, this research underscores the dynamic process of continuous curriculum improvement in engineering education, with a strong emphasis on alignment with evolving industry demands. Outcome-Based Education (OBE) and the National Board of Accreditation (NBA) play pivotal roles in shaping modern educational standards. Mapping Course Outcomes (COs) to Program Outcomes (POs) quantifies students' acquired knowledge and skills.

This method is an effective mechanism for quantifying curriculum effectiveness and identifying skill gaps in engineering education.

Innovative methods such as industry shadowing, case studies, foundation modules, foundation module, peer mentoring and short-term certification courses contribute directly to the industry readiness of students.

The paper's comprehensive approach empowers institutions to optimize curriculum delivery. In essence, this research contributes valuable insights for engineering education, enriching curriculum design and fostering industry-ready graduates.

REFERNCES

ABET. (N.D.). ABET ACCREDETATION.: https://www.abet.org › accreditation

CIAAN. (n.d.). Curriculum Implementation and Assessment Norms. Retrieved from https://acmon.msbte.ac.in/msbteacmon/acmon_s_22_23_bak/

MSBTE. (n.d.). MSBTE. Retrieved from https://msbte.org.in/portal/curriculum- search/: https://msbte.org.in/portal/curriculum-search/

Selamat, S. M., Ali, A., Baharuddin, F. N., Musa, A. H., Nasir, H. M., & Beta, R. M. D. M. (2025). Aligning Academic Curriculum with Industry Demands: Dilemma of Graduates. International Journal of Academic Research in Progressive Education and Development, 14(3), 1026-1031.

Bhattacharya, S. (2024, April 15). The Imperative for Higher Education Curriculums to Align with Rapidly Evolving Industry Trends. https://doi.org/10.35542/osf.io/3wbjc

Mulla, A. A., & Jadhav, H. S. (2023, January). A Case Study on Course Outcome & Program Outcome Mapping Levels Based A Case Study on Course Outcome & Program Outcome Mapping Levels Based. Journal of Engineering Education Transformations, 36. doi:10.16920/jeet/2023/v36is2/23048

NBA. (Oct 2019). NBA SAR National Board of Accreditation Self-Assessment.

Schoenfeld, A. H. (2020). Addressing Horizontal and Vertical Gaps in Educational Systems. European Review, 28(S1), S104–S120. doi:10.1017/S1062798720000940

Dumbuya, Emmanuel, Curriculum Review: Evidence-Based Practices for Continuous Improvement (November 09, 2024). Available at SSRN: https://ssrn.com/abstract=5018484 or http://dx.doi.org/10.2139/ssrn.5018484

Kurukwar, A. (2022). An overview of outcome based education, graduate's attributes and program outcomes. Monograph. https://doi.org/10.26524/royal.135

Outcome based education (OBE) (2022).: Defining the process and practice for engineering education. IEEE Access, 10, 108158-108178. https://doi.org/10.1109/access.2022.3219477

Sumathi, R., Savithramma, R. M., & Ashwini, B. (2023). Curriculum compliance improvement model for addressing program outcomes in engineering education. Journal of Engineering Education Transformations, 37(1). https://doi.org/10.16920/jeet/2023/v37i1/23127

Kumar, A. B. R. (2023). Handbook of outcome-based education model (OBE): Best practices and formats for OBE implementation in technical higher education programs. In Book Chapter. https://doi.org/10.9734/bpi/mono/978-81-19315-93-2/ch0