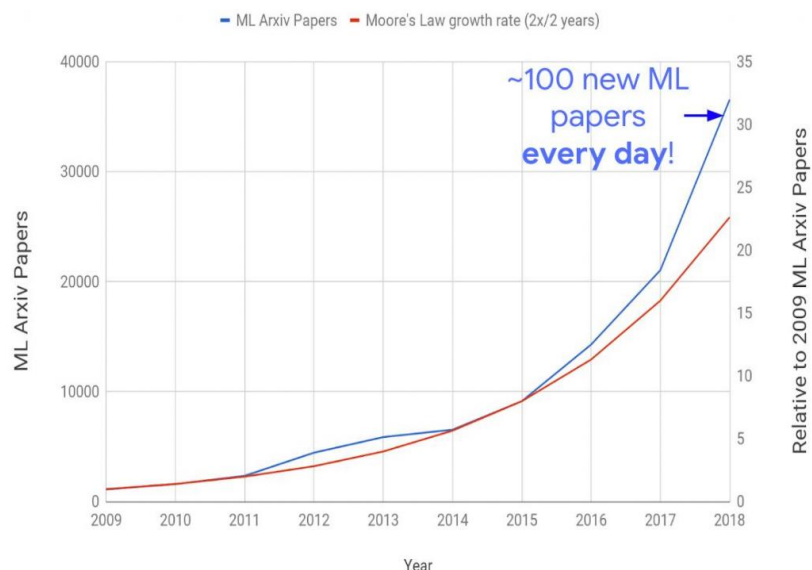# Integrating Research & Outcome Based Education in ML Curriculum

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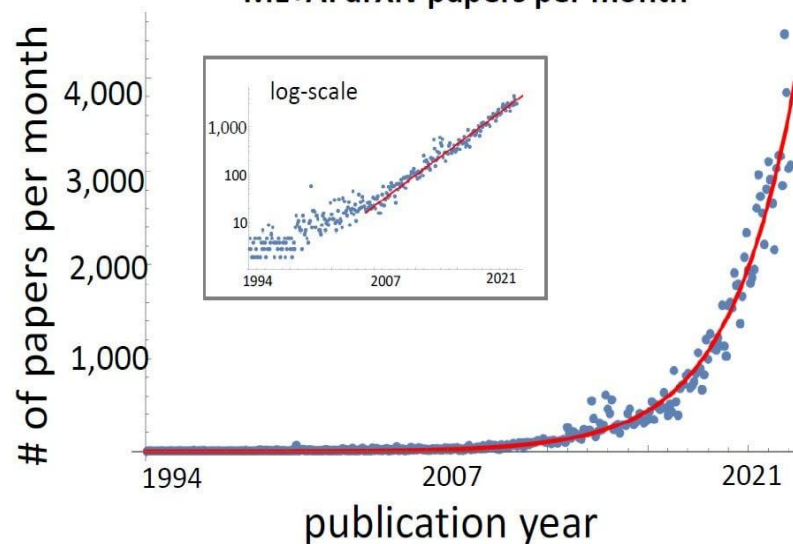
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Why Integrate Research in ML Curriculum?

Machine Learning Arxiv Papers per Year

- ML Arxiv Papers
- Moore's Law growth rate (2x/2 years)

~100 new ML papers **every day!**

ML+AI arXiv papers per month

log-scale

# of papers per month

publication year

- ML is a rapidly evolving research-driven discipline.

  – Exposure to research builds curiosity and critical thinking.

  – Students learn to handle ambiguity and open-ended problems.

  – Research-oriented learning improves analytical skills.

  – It prepares students for higher studies and innovation.

Traditional Assignments vs. Research Tasks

Traditional assignments have predefined solutions.

Research tasks are open-ended and exploratory.

Students formulate questions and hypotheses.

Evaluation focuses on reasoning and methodology.

Encourages deeper engagement with ML concepts.

Forms of Research Integration

Mini research projects within courses.

Paper reproduction and benchmarking studies.

Dataset exploration and insight generation.
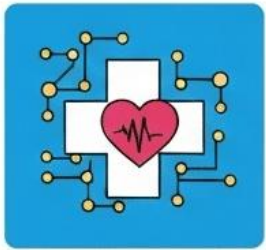
Interdisciplinary ML applications

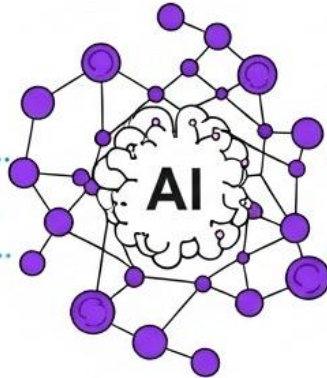Survey and literature review assignments.

Research-Oriented ML Projects

APPLICATIONS OF ARTIFICIAL INTELLIGENCE
WITH REAL WORLD EXAMPLES

HEALTICARE

FINANCE

AI

AUTONOMOUS
VEHICLES

AGRICULTURE

Research-Oriented ML Projects

Seven Pillars of India AI Mission

India AI Compute
Enhancing computational resources for AI development.

India AI Dataset Platform
Providing a comprehensive platform for AI datasets.

India AI Future Skills
Equipping the workforce with necessary AI skills.

Safe & Trusted AI
Ensuring the ethical and secure use of AI.

India AI Innovation Centre
Fostering innovation and research in AI technologies.

India AI Application Development Initiatives
Supporting the development of AI applications across sectors.

India AI Startup Financing
Providing financial support to AI Startups.

Collaborative Project Design

- Teams of 3–4 students

  – Clearly defined roles and responsibilities.

  – Regular milestones and reviews.

  – Emphasis on collaboration and documentation.

  – Faculty mentoring throughout the project.

  – Students engage with real-world datasets

  – Focus on fairness, ethics, and impact.

  – Integration of research papers into coursework.

  – Assessment based on analysis and reflection.

  – Improved awareness of responsible AI.

Why Assessment Needs Redesign?

- Written exams assess recall, not competence.

  – ML learning requires evaluation of process.

  – Skills such as analysis and interpretation are critical.

  – Assessment should reflect real-world practice.

  – OBE demands measurable learning outcomes.

- **Rubric** is a structured scoring guide.

  – It defines criteria and performance levels.

  – Enhances transparency and fairness.

  – Aligns assessment with learning outcomes.

  – Supports consistent grading.

Outcome Based Education - OBE

- What do Engineers do?
  - Prepare/ Make products/systems (plan, design, develop, manufacture, test, install, operate, maintain)
  - Offer technical services and solve socially relevant complex technical problems
  - All the above activities are to be performed under well – defined professional and ethical standards
- Characteristics of Good Engineer considered important by the industries:
  - Have sound knowledge of engineering sciences and technologies
  - Ability to solve well defined and ill-defined problems
  - Have awareness of customers' needs and market trends
  - Have an interest and awareness in all facets of engineering activities
  - Ability to work in a team
  - Ability to document, plan and communicate effectively.
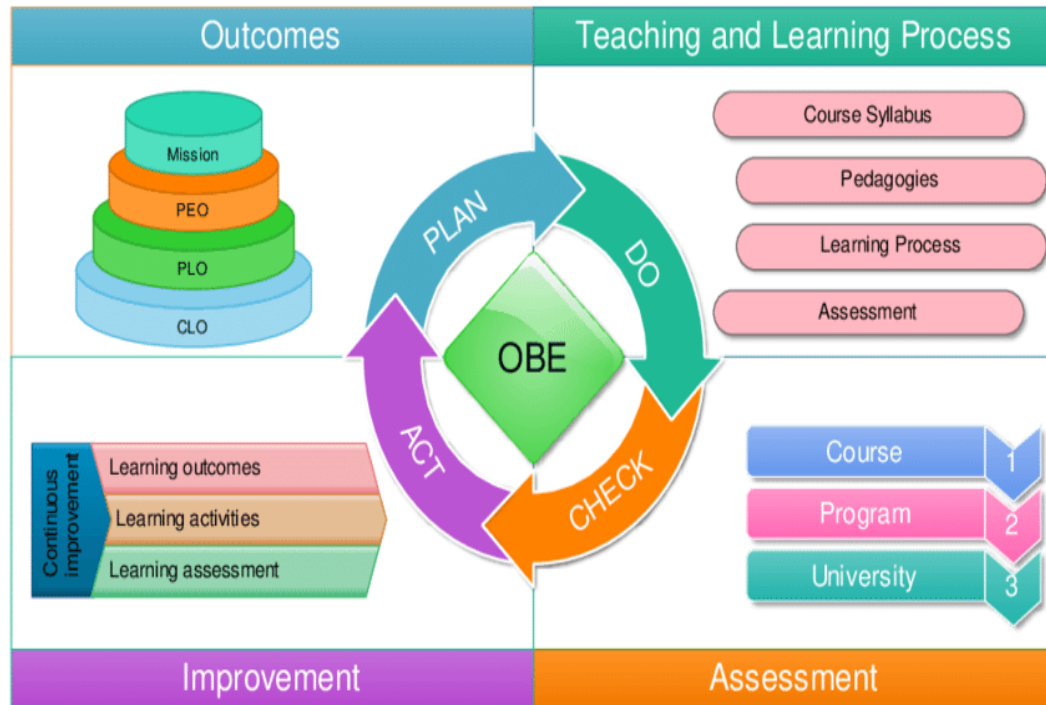 - Willingness and ability to learn on the job.

Traditional view vs OBE view

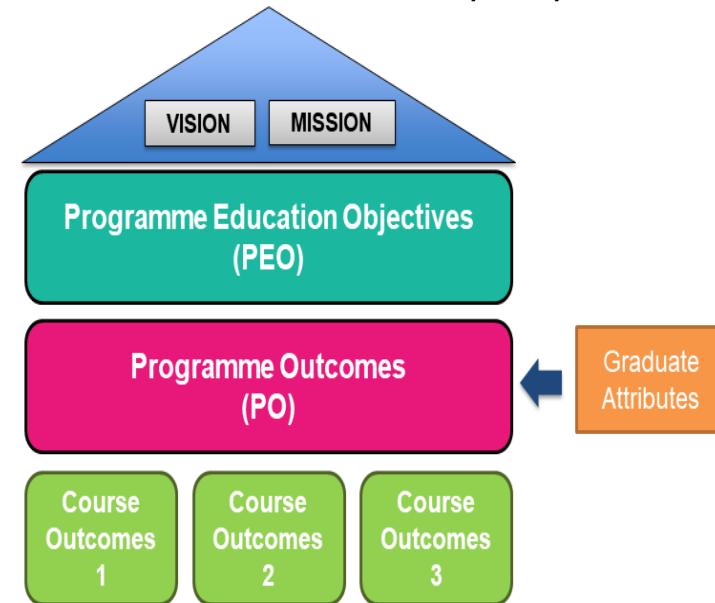| Traditional View	Outcome Based Education View
Instruction	Learning
Inputs and Resources	Learning Outcomes
Knowledge is transferred by the teacher	Knowledge already exists in the mind of the learners
Teacher dispenses knowledge	Teachers are designers of methods
Teachers and students are independent and in isolation	Teacher and students work in terms.

Outcome Based Education - OBE

- Outcome-based education is an approach to education in which decisions about the **curriculum are driven by the exit learning outcomes** that the students should demonstrate at the end of the program/ course.

- Levels of Outcomes:

  - Program Outcomes: **POs** are statements that describe what the students graduating from engineering programs should be able to do at the time of graduation.

  - Program Specific Outcomes: **PSOs** are statements that describe what the graduates of a specific engineering program should be able to do at the time of graduation.

  - Course Outcomes: **COs** are statements that describe what students should be able to do at the end of a course.

Outcome Based Education - OBE

Sample Course Design

- Program: B.Tech (AI)
- Course Code: AI401
- Credit Hours: 3
- Course Title: Business Applications of AI & ML

Course Learning Outcome (CLO)	Description	PO1	PO2	PO3	PO5	PO8
CO1	Elaborate on business applications of Machine Learning and Artificial Intelligence	3 (High)	2 (Medium)	2 (Medium)	2 (Medium)	–
CO2	Discuss technical concepts of Machine Learning and Artificial Intelligence	2 (Medium)	3 (High)	–	1 (Low)	–
CO3	Apply ML and AI techniques to solve real-world business problems	1 (Low)	–	1 (Low)	–	3 (High)

Sample Course Design

Mapping of COs with Assessment Components:

Assessment Component	CO1	CO2	CO3	Total
Quizzes (best 2 out of 3)	-	10	10	20
Group Assignment	7	7	6	20
Class Test	8	-	12	20
Term End Exam	13	13	14	40
Total Marks	28	30	42	100

Rubrics for Individual Assessment Components

Rubric Table for Course Learning Outcomes (COs):

CO	Assessment Criterion	Exceeds Expectations	Meets Expectations	Below Expectations
CO-1 Elaborate on business applications of ML & AI	Understanding of managerial and business implications of ML/AI	Always able to clearly articulate managerial and business implications of ML/AI in decision-making contexts, with relevant examples.	Most of the time able to explain business implications with reasonable clarity and relevance.	Occasionally able to explain implications; explanations lack depth, relevance, or clarity.
CO-2 Discuss technical concepts of ML & AI	Explanation of ML/AI algorithms and technical concepts	Always able to clearly explain technical concepts, algorithms, and their importance using correct terminology and logical reasoning.	Most of the time able to explain technical concepts with minor inaccuracies or omissions.	Sometimes able to explain concepts; explanations contain conceptual gaps or misconceptions.
CO-3 Apply ML & AI to solve real-world problems	Selection of appropriate ML/AI technique for a given problem	Always selects the most appropriate ML/AI technique with strong justification based on problem context and data characteristics.	Usually selects an appropriate technique with partial or limited justification.	Sometimes selects an appropriate technique; justification is weak, generic, or incorrect.

Rubrics for Individual Assessment Components

Hall Examination (Term End + Class Test) (40% + 20%):

Criterion	Exceeds (>65%)	Meets (51–65%)	Below (40–50%)
Relevance of Answer	Complete answer with sufficient detail and accuracy.	Answer generally correct but may lack depth.	Incomplete or irrelevant; misses aspects of the question.
Completeness & Logic	Fully addresses the question with clear, logical flow.	Most necessary details present; some organizational issues.	Few relevant points; lacks coherence and logical progression.
Mechanics of Writing	Clear, readable, no grammatical issues.	Minor mechanical errors but understandable.	Major errors; poor readability.

Rubrics for Individual Assessment Components

Group Assignment / Mini Project (20%):

Criterion	Exceeds Expectations	Meets Expectations	Below Expectations
Problem Understanding & Objective Clarity	Demonstrates clear understanding of the problem; objectives are well-defined and aligned with dataset and ML task.	Problem and objectives are mostly clear but lack refinement or precision.	Problem understanding is weak; objectives are vague or poorly defined.
Data Handling & Tool Usage (Python / R)	Correct and effective use of tools; data preprocessing is appropriate and well-documented.	Tools used correctly with minor issues in preprocessing or documentation.	Incorrect or minimal tool usage; poor data preprocessing.
Quality of Analysis & Output	Analysis is thorough; results are accurate, meaningful, and aligned with objectives.	Analysis is adequate but lacks depth or insight.	Analysis is superficial, incorrect, or incomplete.
Presentation & Visual Appeal	Slides are clear, professional, and visually engaging; insights are communicated effectively.	Presentation is understandable but contains minor clarity or design issues.	Presentation lacks clarity, structure, or visual effectiveness.
Team Contribution & Coordination	All members contribute meaningfully; roles and coordination are evident.	Most members contribute; coordination is adequate.	Uneven contribution; lack of coordination among members.

Rubrics for Individual Assessment Components

Rubric for Quizzes (20%):

Performance Level	Score Range	Descriptor
Exceeds Expectations	> 65%	Demonstrates strong understanding of ML/AI terminology, concepts, and definitions with high accuracy.
Meets Expectations	51% – 65%	Demonstrates reasonable understanding of core concepts with minor gaps or misconceptions.
Below Expectations	< 50%	Demonstrates partial understanding; several conceptual gaps evident.

Thank You

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