



Bloom's Taxonomy, SLT and Engineering Solution

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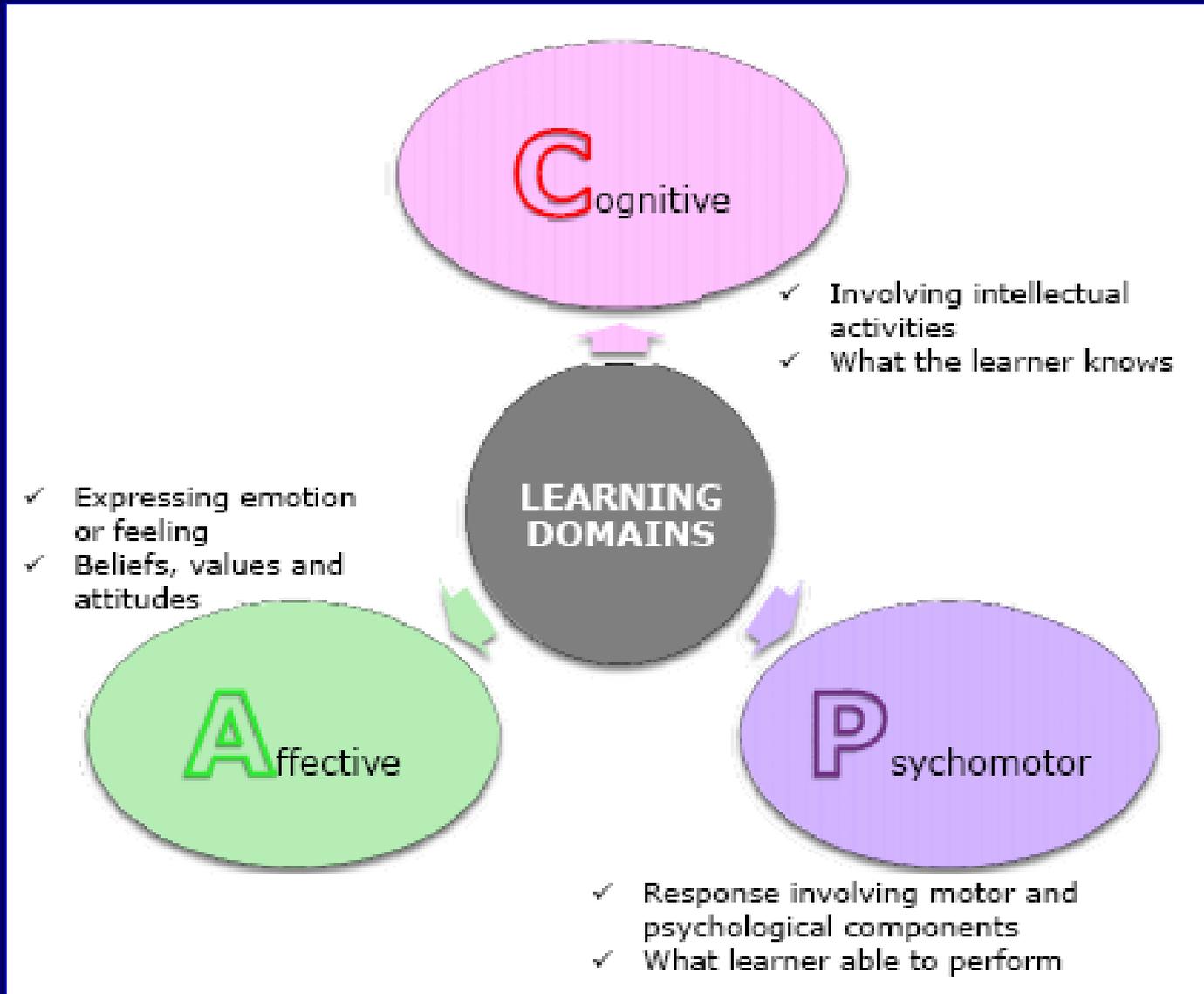
**Standing Committee on Engineering Education,
FEIAP**



ENGINEERING EDUCATION and BLOOM'S TAXONOMY



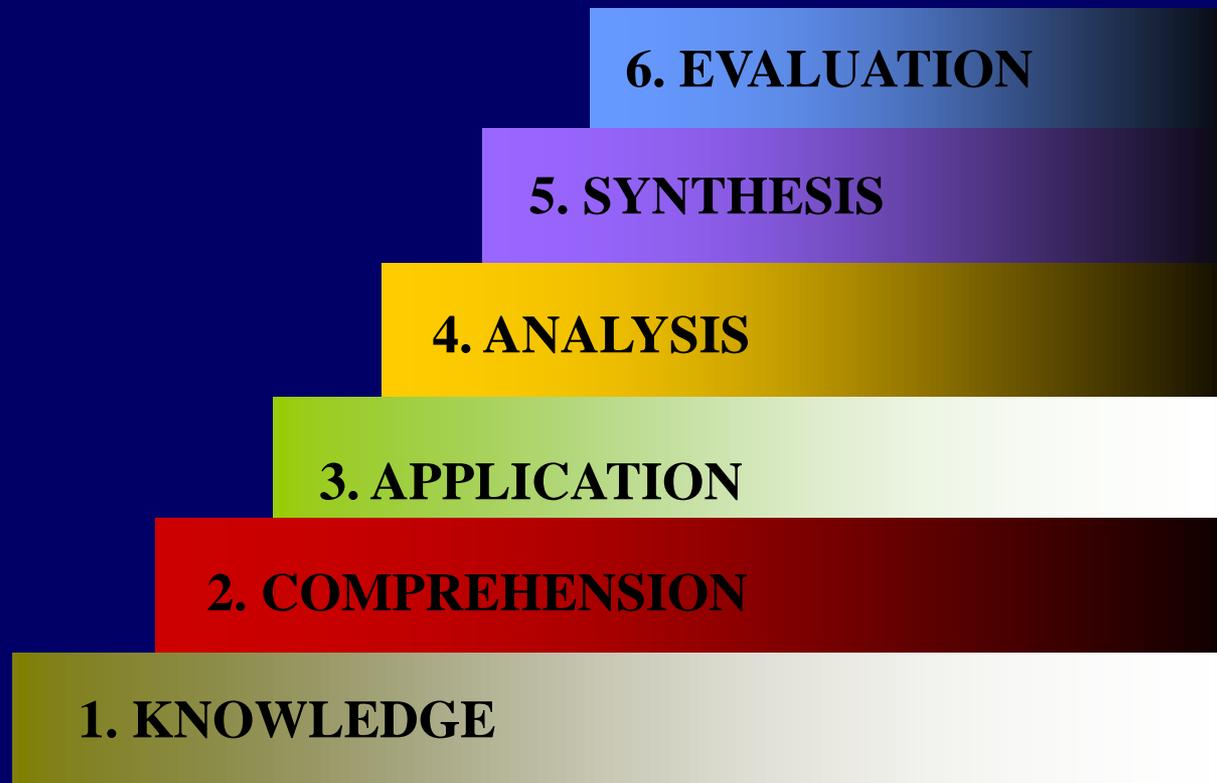
BLOOM'S TAXONOMY: 3 Domains





Cognitive Domain Categories

- Knowledge and the development of intellectual skills
- Includes the recall or recognition of specific facts, procedural patterns, and concepts





Affective Domain Categories

- Describes the way people react emotionally and their ability to feel another living thing's pain or joy.
- Typically targets the awareness and growth in attitudes, emotion, and feelings.





Psychomotor Domain Categories

- Describe the ability to physically manipulate a tool or instrument
- Usually focus on change and/or development in behavior and/or skills

1. IMITATION

2. MANIPULATION

3. PRECISION

4. ARTICULATION

5. NATURALISATION



Learning Taxonomies: Cognitive Domain (Bloom et al, 1956)

Complex

Increasing order of thinking skills

Evaluation	Makes a decision or judge based on criteria or rationale
Synthesis	Creates new ideas, or entity from component elements
Analysis	Separates whole into parts until relationships are clear
Application	Uses information in a familiar situation different from original context
Comprehension	Interprets, explains or summarizes given information
Knowledge	Recognition and recall of information

Simple



Cognitive Domain Categories

Increasing order of thinking skills

Simple



Complex

Category Order	Sample behavioral verbs
Knowledge	Define, describe, identify, list, recall, memorise, match, repeat, reproduce, relate, label, locate, state, show, outline, select, recognise, know, write, group, quote,...
Comprehension	Comprehend, convert, defend, distinguish, differentiate, estimate, explain, interpret, summarise, generalise, paraphrase, rewrite, select, review, translate, simulate,
Application	Apply, change, compute, construct, employ, initiate, produce, operate, use, discover, demonstrate, manipulate, prepare, modify, solve, ...
Analysis	Analyse, break down, compare, calculate, correlate, contrast, detect, diagnose, develop, differentiate, discriminate, distinguish, estimate, inspect, solve,...
Synthesis	Assemble, compile, compose, create, devise, design, develop, formulate, generate, modify, organise, plan, produce, propose, predict, revise, synthesise, ...
Evaluation	Appraise, assess, choose, compare, conclude, contrast, criticise, critique, defend, describe, discriminate, evaluate, judge, measure, revise, score, rate, validate, ...



Affective Domain Categories

Simple

Increasing order of thinking skills

Complex

Category Order	Sample behavioural verbs
Receiving	Acknowledge, ask, attend, discuss, describe, do, feel, follow, focus, hear, hold, listen, read, retain, take,...
Responding	Answer, assist, aid, clarify, contribute, cite, help, perform, present, react, recite, report, respond, seek, write ...
Valuing	Argue, challenge, confront, criticise, debate, justify, persuade, refute, ...
Organization	Adhere, arrange, build, combine, develop, defend, explain, formulate, integrate, modify, organise, prepare, prioritise, ...
Internalization	Act, display, influence, listen, perform, practice, propose, qualify, question, revise, serve, solve, verify, ...



Psychomotor Domain Categories

Increasing order of thinking skills

Simple

Category Order	Sample behavioural verbs
Imitation	Copy, trace, follow, react, reproduce, imitate, respond, ...
Manipulation	assemble, calibrate, construct, dismantle, display, fasten, fix, mend, grind, heat, manipulate, measure, organise, sketch, ...
Precision	assemble, build, calibrate, construct, dismantle, display, fasten, fix, heat, perform
Articulation	Adapt, alter, change, rearrange, reorganise, revise, vary, combine, integrate...
Naturalisation	Arrange, build, combine, compose, construct, create, design, initiate, make, originate, automate ...

Complex



Bloom's Revised Taxonomy

- Taxonomy of Cognitive Domain
- 1950s- developed by Benjamin Bloom
- Means of expressing qualitatively different kinds of thinking
- Adapted for classroom use as a planning tool
- Continues to be one of the most universally applied models
- Provides a way to organise thinking skills into six levels, from the most basic to the higher order levels of thinking
- 1990s- Lorin Anderson (former student of Bloom) revisited the taxonomy
- As a result, a number of changes were made

(Pohl, 2000, *Learning to Think, Thinking to Learn*, pp. 7-8)



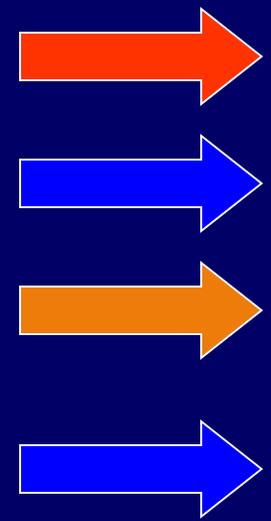
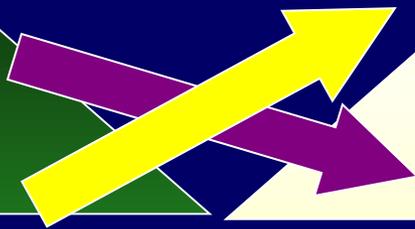
Bloom's Taxonomy

Original Terms

- Evaluation
- Synthesis
- Analysis
- Application
- Comprehension
- Knowledge

New Terms

- Creating
- Evaluating
- Analysing
- Applying
- Understanding
- Remembering





Revised Bloom's Taxonomy

Remembering : Can the students recall or remember the information?	Define, duplicate, list, memorize, recall, repeat, reproduce state
Understanding : Can the student explain ideas or concept ?	Classify describe, discuss, explain, identify, locate, recognize, report, select, translate, paragraph
Applying : Can the student use the information in a new way ?	Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write
Analyzing : Can the student distinguish between the different part ?	Appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test
Evaluating : Can the student justify a stand or a decision ?	Appraise, argue, defend, judge, select, support, value, evaluate
Creating : Can the student create new product or point of view ?	Assemble, contrast, create, design, develop, formulate, write



Student Learning Time (SLT)

- Effective learning time or student effort in learning or the learning volume (a quantitative measurement of **all** learning activities) in order to achieve the specified learning outcomes
- Include all learning activities - **formal and non-formal**
- Total time required by student to learn a particular component of curriculum: **Official Contact** Time + **Guided Learning** Time + **Self Study** Time (Independent learning) + **Assessment** Time
- Synonymous to student's academic load, e.g. credit hours



Student Learning Time (SLT)

Effective Learning Time or **Student Academic Load (SAL)** or **Learning Volume** can be in a variety of ways:

- **About 8 hours/day**
- **40-48 working hours/week**
- **560-670 hours/14 week semester**
- **Normally 15 – 16 credits per semester**
- **1 Credit Hour about 40 SLT (per semester)**



Student Learning Time (SLT)

- Management instrument for both the directed, guided and independent learning,
- Component of time management – SLT promotes ethics and discipline in student's effort towards learning
- Enhancing “life-long-learning” skills
- An indicator of effort in learning and study smart
- Educate on how the “learning by doing” in respect to effort in learning i.e. student-centred outcome-based approach
- Effective control of prescribed study duration



Guideline for Estimating SLT & CAL (Course Academic Load)

Teaching modality	Time (hr) per unit of teaching	Additional time to be added (hr)	Total time (hr) per unit of teaching
Lecture	1	1-2	2-3
Tutorial	1-2	1-2	2-4
Lab Practical	3	2-3	5-6
Small Group Discussion	1-2	1	2-3
Fixed Learning Module	3	0	3
Problem-based learning	2-3	2-3	4-6
Presentations	1	3-4	4-5
Each 2000 word written assignment	10-20	0	10-20
Case summary (per case)	3	0	3
Research Project (total)	240-400	0	240-400



Guideline for estimating SLT & CAL (Course Academic Load)

Teaching modality	Time (hr) per unit of teaching	Additional time to be added (hr)	Total time (hr) per unit of teaching
Industrial training (total)	320 (should be at least 2 months)	0	320
Demonstration per session	1-2	0	1-2
Electronic/Online learning per session	3-5	0	3-5
Clinical per session	Whatever time that has been allocated	0	Whatever time that has been allocated
Field work per session	Whatever time that has been allocated	0	Whatever time that has been allocated



Roles of Engineering Personnel

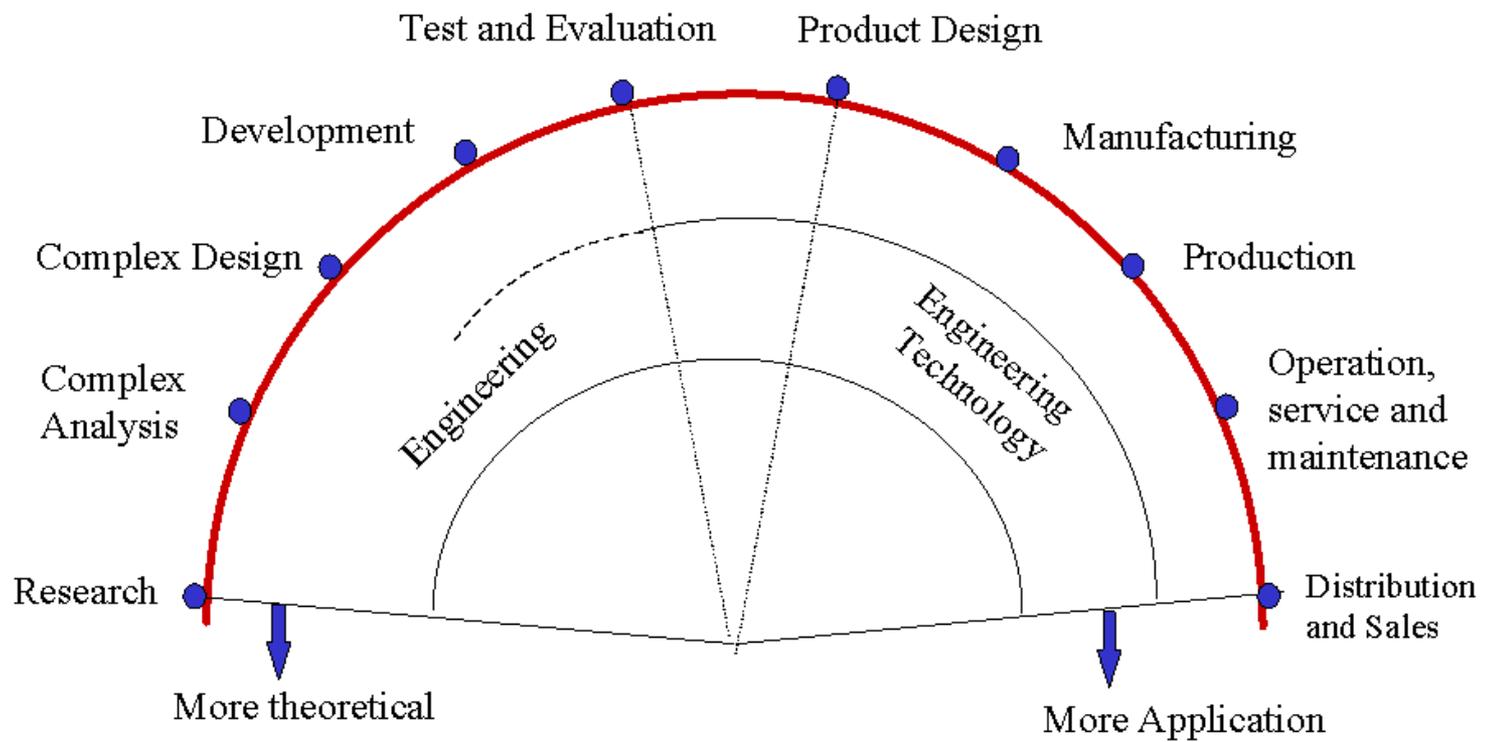


Engineer Graduate	Engineering Technologist Graduate	Engineering Technician Graduate
Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization respectively to the solution of complex engineering problems	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to defined and applied engineering procedures, processes, systems or methodologies	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to wide practical procedures and practices

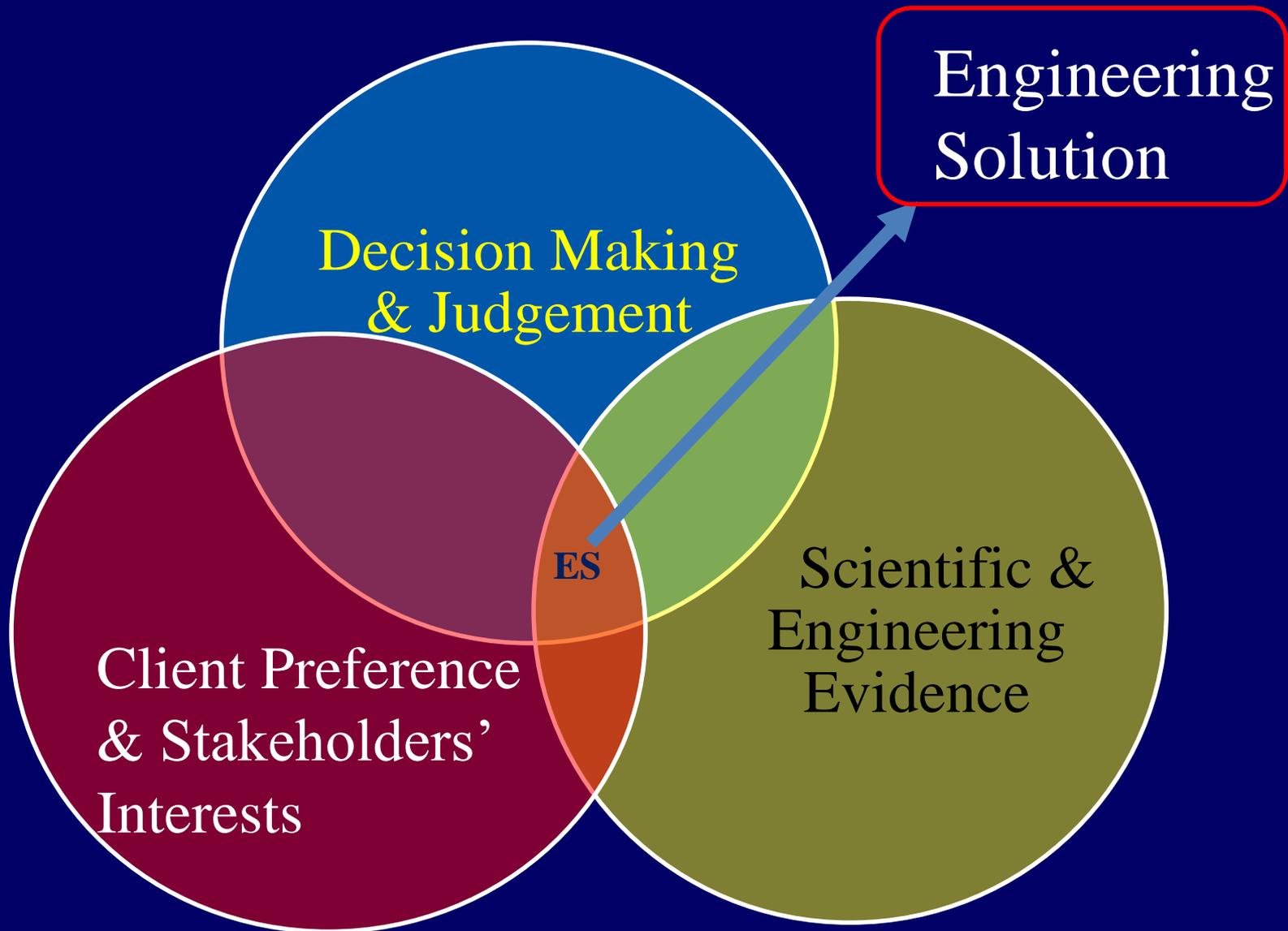


Engineering and Engineering Technology

Spectrum of Technical Job Functions



Engineering Solution for a Complex Problem

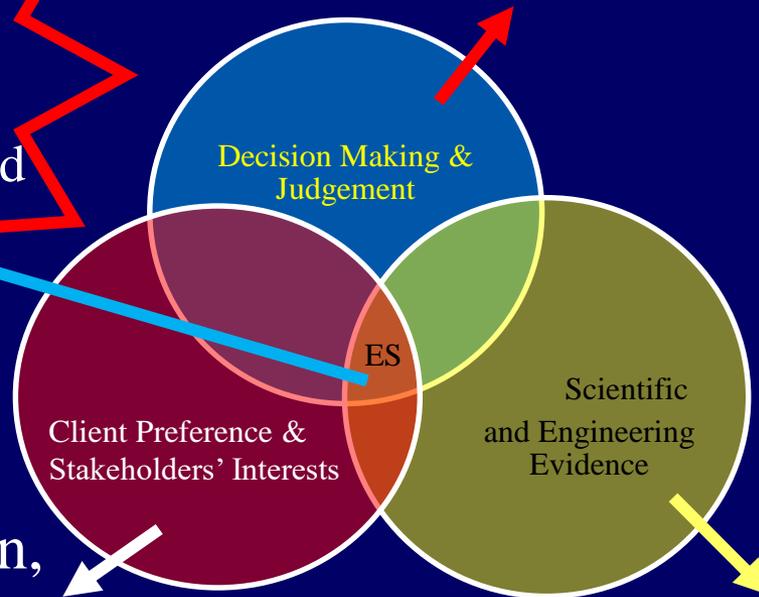




Engineering Solution

Comparison of Solutions, Cost Effectiveness,
Using Relevant Tools, Selection of Best
Solution,
Judgement, Decision Making

Engineering Solution
based on Sound
Judgement – Education
Outcomes Demonstrated



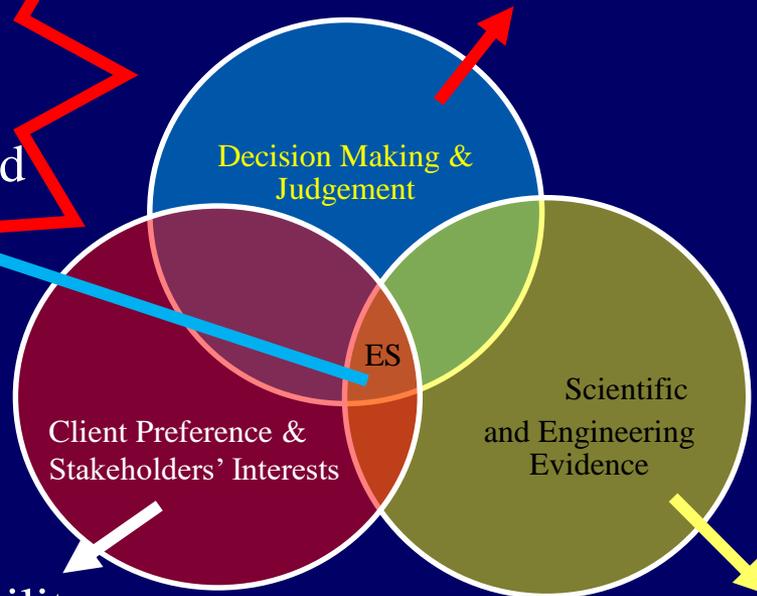
Collecting Information,
Negotiation, Values,
Resolving Conflicting Issues
& Interests,
Convincing Stakeholders

Research, Experiences of Others,
Relevant Engineering Principles and
Scientific Theories and Methods

Education Outcomes: Engineering Solution

Design & development of Solution,
Modern Tool Usage, Individual &
Teamwork, Project Management &
Finance

Engineering Solution
based on Sound
Judgement – Education
Outcomes Demonstrated



Engineer & the World,
Environment & Sustainability,
Ethics, Individual & Teamwork.
Communication, Project
Management & Finance

Engineering Knowledge,
Problem Analysis,
Investigation, Lifelong Learning



In Line with UN Sustainable Development Goals



Goal 1: No Poverty

Goal 2: Zero Hunger

Goal 3: Good Health and Well Being

Goal 4: Quality Education

Goal 5: Gender Equality

Goal 6: Clean Water and Sanitation

Goal 7: Affordable and Clean Energy

Goal 8: Decent Work and Economic Growth

Goal 9: Industry, Innovation and Infrastructure

**via Best Practices in Engineering Profession/Projects,
and Innovative Engineering Solutions**



In Line with UN Sustainable Development Goals



Goal 10: Reduced Inequalities

Goal 11: Sustainable Cities and Community

Goal 12: Responsible Consumption and Production

Goal 13: Climate Action

Goal 14: Life Below Water

Goal 15: Life on Land

Goal 16: Peace, Justice and Strong Institutions

Goal 17: Partnerships for the Goals

**via Best Practices in Engineering Profession/Projects,
and Innovative Engineering Solutions,**

**Mobility of Engineering Personnel for Development
and Smart Partnership**



Complex Problem



Need to think broadly and systematically
and **see the big picture**

Complex Problem

Difficult Decision

Uncertain Strategy

Confusing Idea

Contentious Product

Intractable Change



Difficulty & Uncertainty

- **Complexity** – the problem contains a large number of diverse, dynamic and interdependent elements
- **Measurement** – it is difficult or practically unfeasible to get good qualitative data
- **Novelty** – there is a new solution evolving or an innovative design is needed



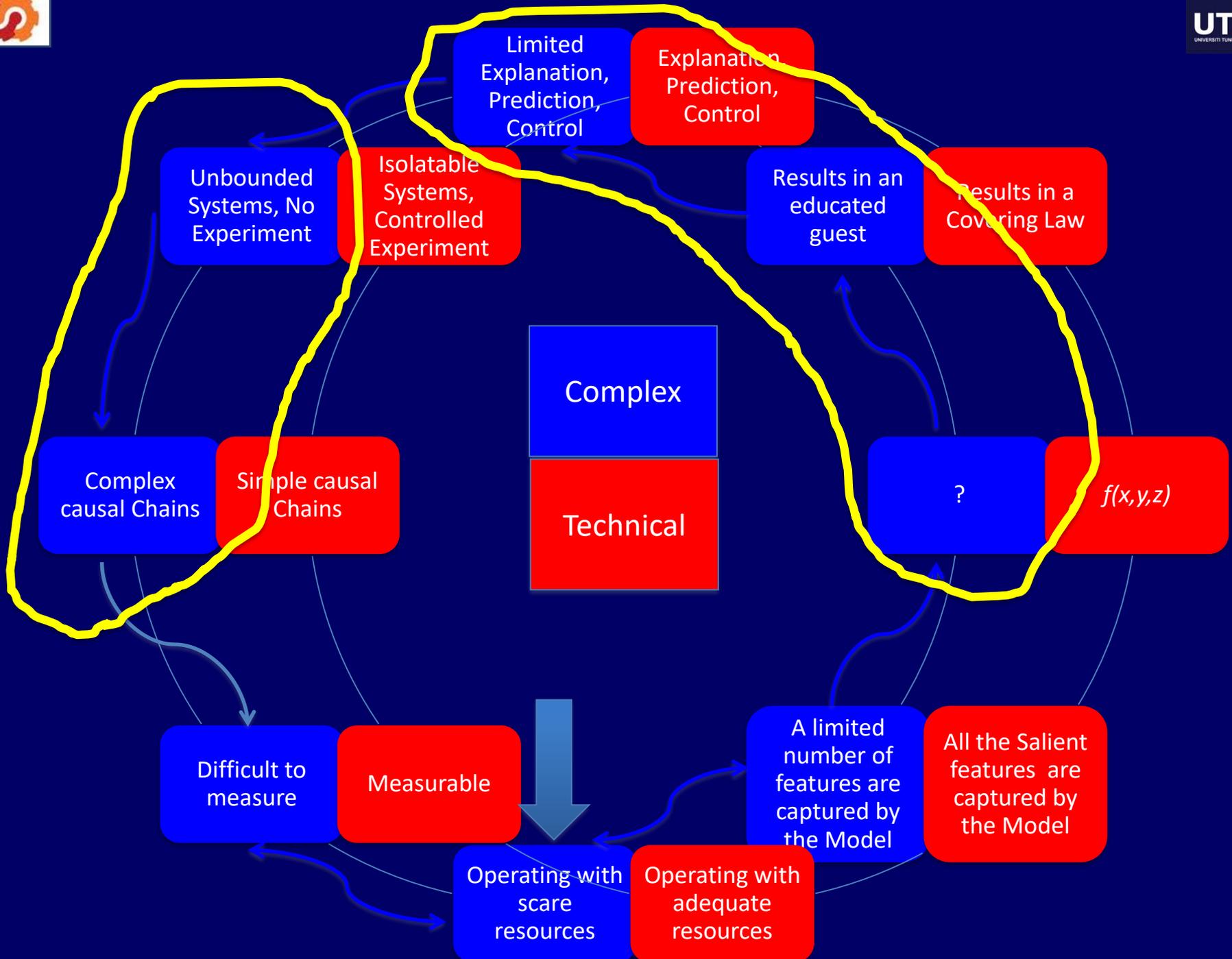
Characteristics of Problems

Technical Problems

- Isolatable boundable problem
- Universally similar type
- Stable and/or predictable problem parameters
- Multiple low-risk experiments are possible
- Limited set of alternative solutions
- Involve few or homogeneous stakeholders
- Single optimal and testable solutions
- Single optimal solution can be clearly recognised

Complex Problems

- No definitive problem boundary
- Relatively unique or unprecedented
- Unstable and/or unpredictable problem parameters
- Multiple experiments are not possible
- No bounded set of alternative solutions
- Multiple stakeholders with different views or interest
- No single optimal and/or objectively testable solution
- No clear stopping point





Complex Problem

**Scientific/Technical
Problems
can combine to
form**



**A
Complex Problem**



Complex Engineering Problems

	<i>Complex Engineering Problems</i> have characteristic WP1 and some or all of WP2 to WP7 :
Depth of Knowledge Required	WP1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach
Range of conflicting requirements	WP2: Involve wide-ranging and/or conflicting technical, non-technical issues (such as ethical, sustainability, legal, political, economic, societal) and consideration of future requirements
Depth of analysis required	WP3: Have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate suitable models
Familiarity of issues	WP4: Involve infrequently encountered issues or novel problems
Extent of applicable codes	WP5: Address problems not encompassed by standards and codes of practice for professional engineering



Complex Engineering Problems

	<i>Complex Engineering Problems</i> have characteristic WP1 and some or all of WP2 to WP7 :
Extent of stakeholder involvement and conflicting requirements	WP6: Involve collaboration across engineering disciplines , other fields, and/or diverse groups of stakeholders with widely varying needs
Interdependence	WP 7: Address high level problems with many components or sub-problems that may require a systems approach

Require **Judgement in Making Decision**, which has **significant consequences to society and the environment** in a range of contexts

“Graduate Attributes and Professional Competencies” published by the International Engineering Alliance which are also adopted by FEIAP (<https://www.ieagreements.org>)



Attributes	Complex Activities
1 Preamble	Complex activities means (<i>engineering</i>) activities or projects that have some or all of the following characteristics:
2 Range of resources	EA1: Involve the use of diverse resources including people, data and information, natural, financial and physical resources and appropriate technologies including analytical and/or design software
3 Level of interactions	EA2: Require optimal resolution of interactions between wide-ranging and/or conflicting technical, non-technical, and engineering issues
4 Innovation	EA3: Involve creative use of engineering principles, innovative solutions for a conscious purpose, and research-based knowledge
5 Consequences to society and the environment	EA4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
6 Familiarity	EA5: Can extend beyond previous experiences by applying principles-based approaches



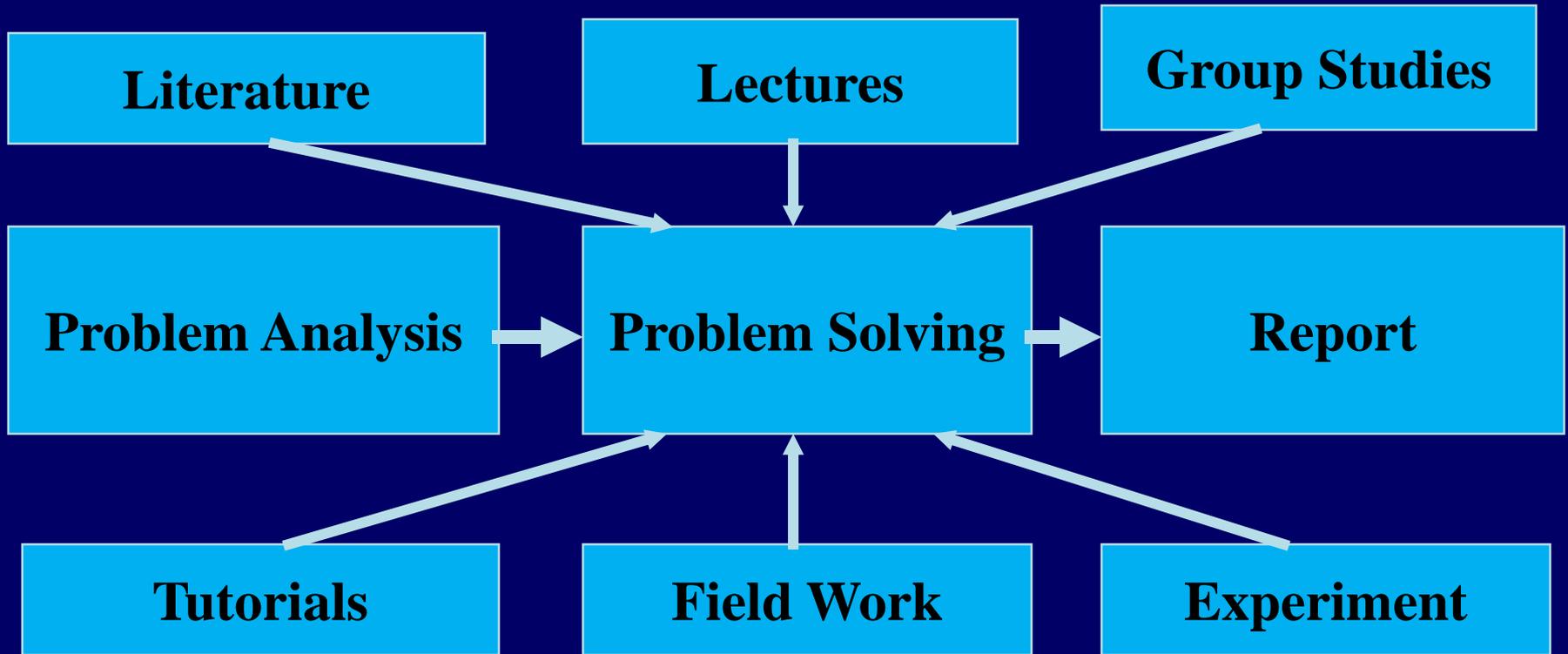
Problem Oriented, Team-Based Project Work as a Learning/Teaching Device

1. Problem-oriented project-organized education deals with the solution of theoretical problems through the use of any relevant knowledge, whatever discipline the knowledge derives from. We are dealing with **KNOW WHY** (Research Problems)
2. In design-oriented project work, the students deal with **KNOW HOW** problems that can be solved by theories and knowledge they have acquired in their previous lectures (Design Problems)





Problem Organised Project Work or POPBL (Project Oriented Problem Based Learning)





How are UN Sustainable Development Goals integrated into the curriculum?

- Final Year Project – Real-life *Problem Solving*
- Industrial Placement
- Design Project – Real-life *Engineering Activities*
- General Courses
 - Core & Specialist (Engineering) Courses
 - Elective Courses

with Open-ended Questions and Assignment, CEA



Some Lessons learnt from Accreditation Activities

- Does not know the Teaching Plan
- Done without Referring to the Plan
- Does not know How to Translate Plan into Assessment
- Assessing at Low-Medium level (not Challenging)
- No Feedback to Students except at the End of Semester
- Does not know How to Relate Assessment to Expected Outcomes
- Traditional Assessment
- Non-Technical Skills neglected



THANK YOU
FOR LISTENING