Attainment of Engineering Team Attributes via Outcome Based Engineering Education

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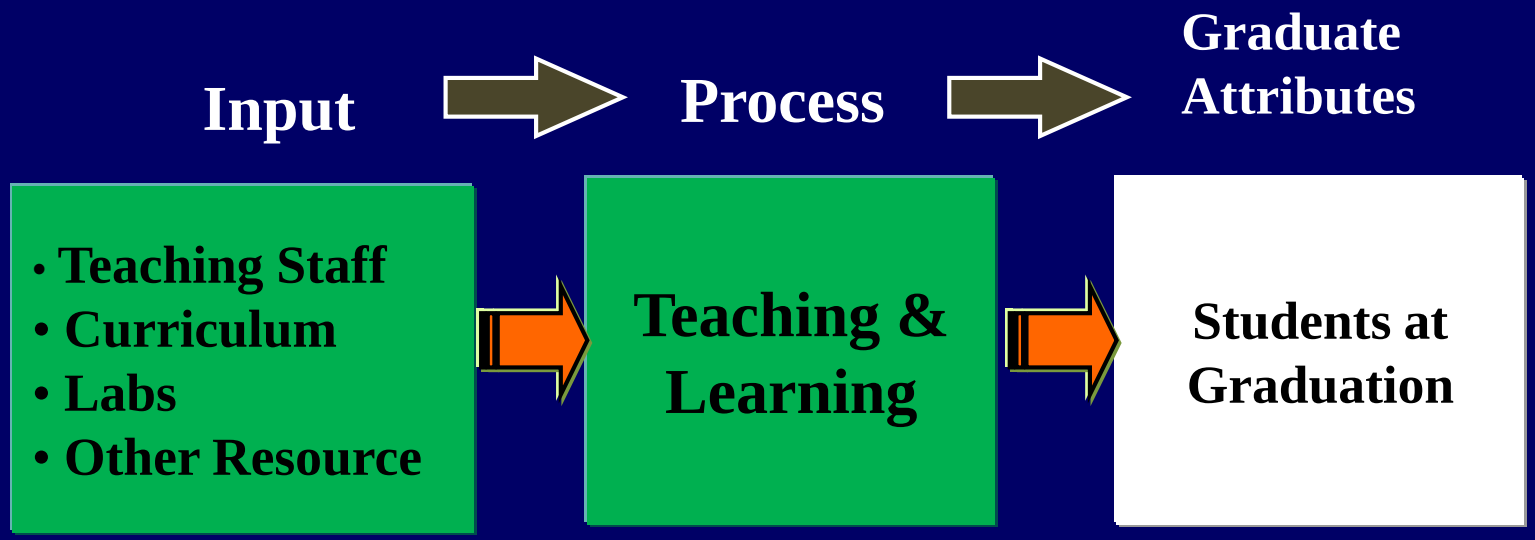
Outcome from the Workshop

At the end of this training, participants will be able to understand:

- Graduate Attributes for Engineering Team
- Outcome-Based Education (OBE)
- Programme Education Objectives (PEO'S), Programme Outcomes (PO's), Course Outcomes (CO) and Performance Indicators
- Bloom's Learning Taxonomy
- Assessment and Evaluation Methods
- Continual Quality Improvement Process

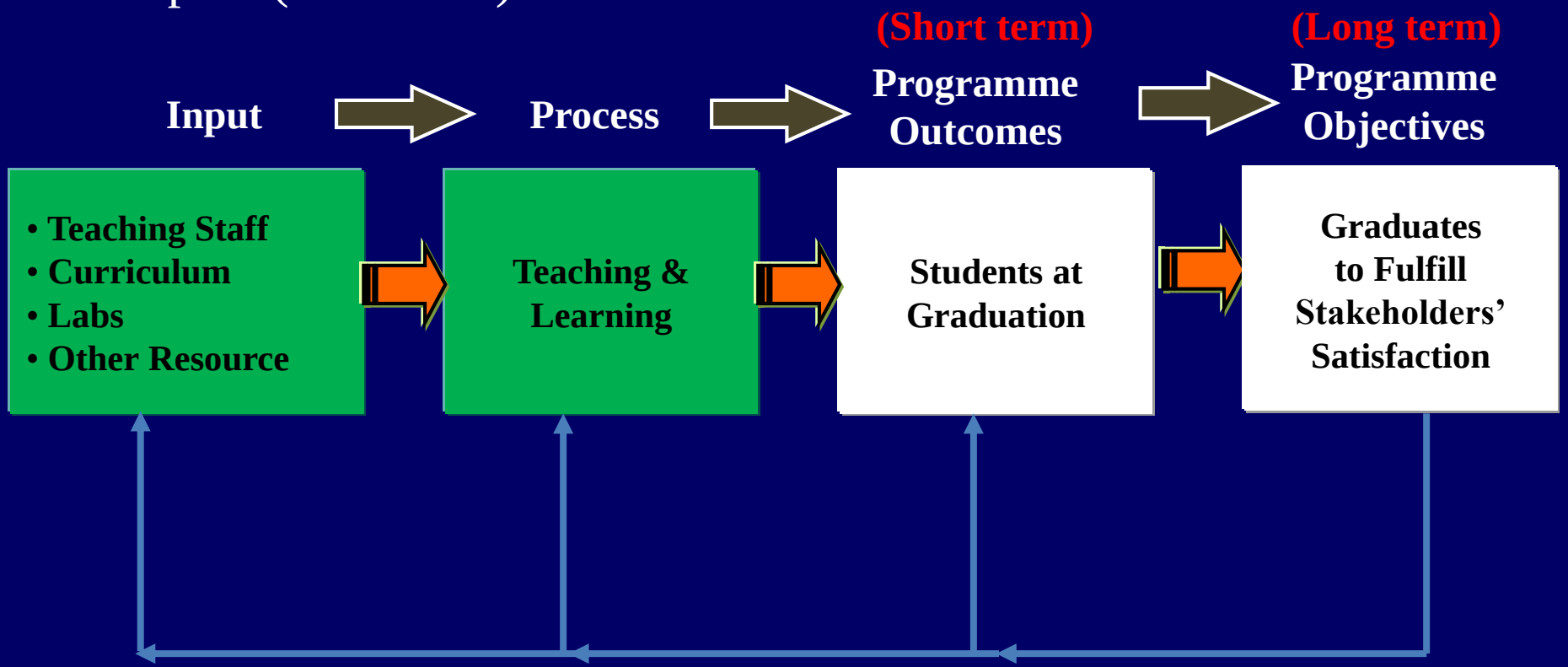
Input-Based Education



Open Loop
Focus on Input and Process
Little Feedback to Students
Assume Attainment of Graduate Attributes

Outcome-Based Education

- Shifting from measuring input and process to include measuring the outputs (outcomes)



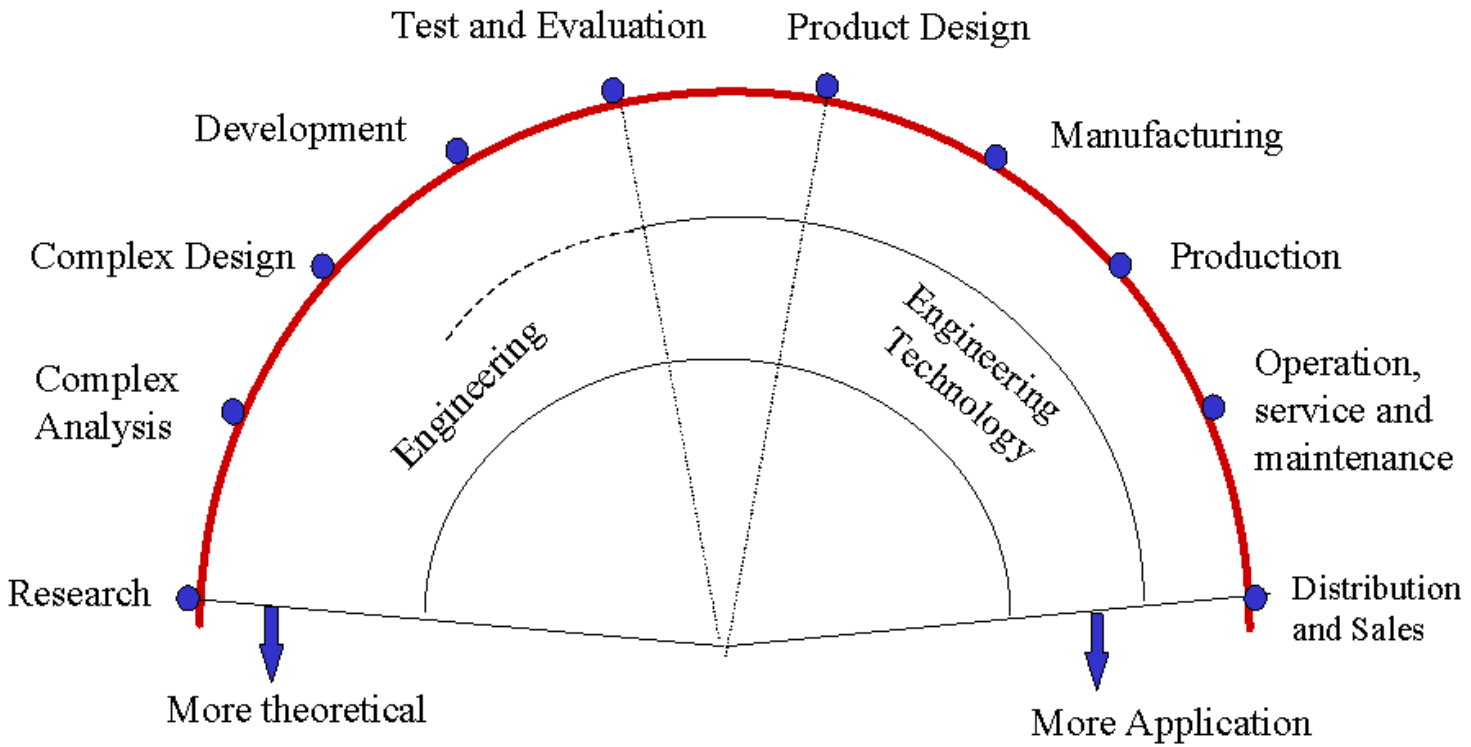
Feedback at all Levels for CQI
Focus on Measurable Outcomes

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



bing.com/images – engineering spectrum

Types of Engineering Problems

- Complex
- Broadly Defined
- Widely Defined

Complex Engineering Problems

	Complex Engineering Problems 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 or conflicting **technical, engineering and other issues**
Depth of analysis required	**WP3:** Have **no obvious solution** and require abstract thinking, originality in analysis to formulate suitable models
Familiarity of issues	**WP4:** Involve **infrequently** encountered issues
Extent of applicable codes	**WP5:** Are **outside problems** encompassed by standards and codes of practice for professional engineering

"Graduate Attributes and Professional Competencies" published by the International Engineering Alliance

Complex Engineering Problems

	Complex Engineering Problems have characteristic WP1 and some or all of WP2 to WP7*:*
Extent of stakeholder involvement and conflicting requirements	WP6: Involve **diverse groups of stakeholders with widely varying needs**
Interdependence	**WP 7:** Are **high level problems** including **many component parts or sub-problems**
Consequences	**EP1:** Have **significant consequences** in a range of contexts
Judgement	**EP2:** Require **judgement in decision making**

Broadly-defined Engineering Problem

	***Broadly-defined Engineering Problems* have characteristic SP1 and some or all of SP2 to SP7:**
Depth of Knowledge Required	**SP1:** Cannot be resolved without engineering knowledge at the level of one or more of SK 4, SK5, and SK6 supported by SK3 **with a strong emphasis on the application of developed technology**
Range of conflicting requirements	**SP2:** Involve a **variety of factors** which may impose **conflicting constraints**
Depth of analysis required	**SP3:** Can be solved by **application of well-proven analysis techniques**
Familiarity of issues	**SP4:** Belong to **families of familiar problems** which are solved in well-accepted ways
Extent of applicable codes	**SP5:** May be **partially outside** those encompassed by standards or codes of practice

Broadly-defined Engineering Problem

	***Broadly-defined Engineering Problems* have characteristic SP1 and some or all of SP2 to SP7:**
Extent of stakeholder involvement and conflicting requirements	**SP6:** Involve **several groups of stakeholders** with differing and occasionally conflicting needs
Interdependence	**SP7:** Are **parts of, or systems** within complex engineering problems
Consequences	**TP1:**Have consequences which are **important locally, but may extend more widely**
Judgement	**TP2:** Require **judgement in decision making**

Well-defined Engineering Problem

	Well-defined Engineering Problems have characteristic DP1 and some or all of DP2 to DP7:
Depth of Knowledge Required	**DP1:** Cannot be resolved without **extensive practical knowledge** as reflected in DK5 and DK6 supported by theoretical knowledge defined in DK3 and DK4
Range of conflicting requirements	**DP2:** Involve several issues, but with **few of these exerting conflicting constraints**
Depth of analysis required	**DP3:** Can be solved in **standardized ways**
Familiarity of issues	**DP4:** Are **frequently encountered** and thus **familiar to most practitioners** in the practice area

Well-defined Engineering Problem

	Well-defined Engineering Problems have characteristic DP1 and some or all of DP2 to DP7*:*
Extent of applicable codes	**DP5:** Are **encompassed by standards and/or documented codes of practice**
Extent of stakeholder involvement and conflicting requirements	**DP6:** Involve a **limited range of stakeholders with differing needs**
Interdependence	**DP7:** Are **discrete components of engineering systems**
Consequences	**NP1:** Have consequences which are **locally important and not far-reaching**

Engineering Activities

	Attributes	Complex Activities
1	**Preamble**	**Complex activities** means (*engineering)* activities or projects that have some or all of the following characteristics:
2	Range of resources	**EA1:** Involve the use of **diverse resources** (and for this purpose resources includes people, money, equipment, materials, information and technologies)
3	Level of interactions	**EA2:** Require **resolution of significant problems** arising from interactions between **wide-ranging or conflicting technical, engineering or other issues**
4	Innovation	**EA3:** Involve **creative use of engineering principles and research-based knowledge** in novel ways
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**

Engineering Activities

	Attributes	Broadly-defined Activities
1	**Preamble**	Broadly defined activities means (*engineering)* activities or projects that have some or all of the following characteristics:
2	**Range of resources**	**TA1:** Involve a **variety of resources** (and for this purposes resources includes people, money, equipment, materials, information and technologies)
3	**Level of interactions**	**TA2:** Require resolution of **occasional interactions** between technical, engineering and other issues, of which **few are conflicting**
4	**Innovation**	**TA3:** Involve the **use of new materials, techniques or processes in non-standard ways**
5	**Consequences to society and the environment**	**TA4:** Have **reasonably predictable cons**equences that are **most important locally**, but may extend more widely
6	**Familiarity**	**TA5:** Require a knowledge of **normal operating procedures and processes**

Engineering Activities

	Attributes	Well-defined Activities
1	**Preamble**	Well-defined activities means (*engineering)* activities or projects that have some or all of the following characteristics:
2	**Range of resources**	**NA1:** Involve a **limited range of resources** (and for this purpose resources includes people, money, equipment, materials, information and technologies)
3	**Level of interactions**	**NA2:** Require resolution of interactions between **limited technical and engineering issues with little or no impact of wider issues**
4	**Innovation**	**NA3:** Involve **the use of existing materials, techniques, or processes in modified or new ways**
5	**Consequences to society and the environment**	**NA4:** Have consequences that are **locally important and not far-reaching**
6	**Familiarity**	**NA5:** Require a knowledge of practical procedures and practices for **widely-applied operations and processes**

Knowledge Profiles for Engineer Education

WK1: A systematic, theory-based understanding of the **natural sciences** applicable to the discipline
WK2: Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support **analysis and modelling** applicable to the discipline
WK3: Systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline
WK4: Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5: Knowledge that supports **engineering design** in a practice area
WK6: Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline
WK7: Comprehension of the role of **engineering in society** and identified issues in engineering practice in the discipline: **ethics and the professional responsibility** of an engineer to public safety; the **impacts of engineering activity: economic, social, cultural, environmental and sustainability**
WK8: Engagement with selected knowledge in the **research literature** of the discipline

Knowledge Profiles for Engineering Technologist Education

SK1: A systematic, theory-based understanding of the **natural sciences** applicable to the sub-discipline
SK2: Conceptually-based **mathematics**, numerical analysis, statistics and aspects of computer and information science to support analysis and **use of models** applicable to the sub-discipline
SK3: A systematic, theory-based formulation of **engineering fundamentals** required in an accepted **sub-discipline**
SK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for an accepted **sub-discipline**
SK5: Knowledge that supports **engineering design** using the **technologies of a practice area**
SK6: Knowledge of **engineering technologies** applicable in the **sub-discipline**
SK7: Comprehension of the **role of technology in society** and identified issues in applying engineering technology: **ethics and impacts: economic, social, environmental and sustainability**
SK8: Engagement with the technological literature of the discipline

Knowledge Profiles for Engineering Technician Education

DK1: **A descriptive, formula-based understanding** of the **natural sciences** applicable in a sub-discipline
DK2: **Procedural mathematics**, numerical analysis, statistics applicable in a sub-discipline
DK3: A coherent **procedural formulation of engineering fundamentals** required in an accepted sub-discipline
DK4: Engineering **specialist knowledge** that provides the body of knowledge for an accepted sub-discipline
DK5: Knowledge that supports **engineering design based on the techniques** and **procedures** of a practice area
DK6: **Codified practical engineering knowledge** in recognized practice area.
DK7: **Knowledge** of issues and approaches in engineering technician practice: ethics, financial, cultural, environmental and sustainability impacts

Graduate Attributes

- A set of individually assessable outcomes that indicate the graduate's potential to acquire competence to practise at the appropriate level (Engineer, Engineering Technologist and Engineering Technician)
- Each degree programme should thus set its own programme outcomes which are unique and measurable and in line with this general Graduate Attributes

Engineering Knowledge

Differentiation Characteristic	WA	SA	DA
Breadth and depth of education and type of knowledge, both theoretical and practical	**WA1: Apply knowledge of mathematics, natural science, engineering fundamentals** and an engineering specialization as specified in WK1 to WK4 respectively to the **solution of complex engineering problems**	**SA1: Apply knowledge of mathematics, natural science, engineering fundamentals** and an engineering specialization as specified in SK1 to SK4 respectively to **defined and applied** engineering **procedures, processes, systems or methodologies**	**DA1: Apply knowledge of mathematics, natural science, engineering fundamentals** and an engineering specialization as specified in DK1 to DK4 respectively to **wide practical procedures and practices**

Problem Analysis

Differentiation Characteristic	WA	SA	DA
Complexity of analysis	**WA2:** Identify, formulate, research literature and analyse ***complex*** **engineering problems** reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4)	**SA2:** Identify, formulate, research literature and analyse ***broadly-defined*** **engineering problems** reaching substantiated conclusions using analytical tools appropriate to the discipline or area of specialisation (SK1 to SK4)	**DA2:** Identify and analyse ***well-defined*** **engineering problems** reaching substantiated conclusions using codified methods of analysis specific to their field of activity (DK1 to DK4)

Design/Development of Solutions

Differentiation Characteristic	WA	SA	DA
Breadth and uniqueness of engineering problems i.e. the **extent to which problems are original and to which solutions have previously been identified or codified**	**WA3:** Design solutions for ***complex*** **engineering problems** and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5)	**SA3:** Design solutions for ***broadly-defined*** **engineering** technology problems and ***contribute*** *to* the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (SK5)	**DA3:** Design solutions for ***well-defined*** **technical problems** and ***assist*** *with* the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (DK5)

Investigation

Differentiation Characteristic	WA	SA	DA
Breadth and depth of investigation and experimentation	**WA4:** Conduct investigations of ***complex*** **problems** using **research-based knowledge** (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide **valid conclusions**	**SA4:** Conduct investigations of ***broadly-defined*** **problems**; **locate, search and select relevant data from codes, data bases and literature** (SK8), design and conduct experiments to provide valid conclusions	**DA4:** Conduct investigations of ***well-defined*** **problems**; locate and search relevant codes and **catalogues, conduct standard tests and measurements**

Tool Usage

Differentiating Characteristic : Level of Understanding of the Appropriateness of the Tool

Engineer-Washington Accord	Engineering Technologist – Sydney Accord	Engineering Technician-Dublin Accord
WA5: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to ***complex*** **engineering problems**, with an understanding of the limitations.(WK6)	**SA5: Select and apply** appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to ***broadly-defined*** **engineering problems,** with an understanding of the limitations (SK6)	**DA5: Apply** appropriate techniques, resources, and modern engineering and IT tools to ***well-defined*** **engineering problems**, with an awareness of the limitations (DK6)

The Engineer Team and the Society

Differentiation Characteristic	WA	SA	DA
Level of knowledge and responsibility	**WA6: Apply reasoning** informed by contextual knowledge to assess **societal, health, safety, legal and cultural issues** and the consequent **responsibilities relevant to professional engineering practice** and solutions to **complex** engineering problems (WK7)	**SA6: Demonstrate understanding** of the **societal, health, safety, legal and cultural issues** and the consequent **responsibilities** relevant to engineering technology practice and solutions to **broadly defined engineering problems** (SK7)	**DA6: Demonstrate knowledge** of the **societal, health, safety, legal and cultural issues** and the consequent **responsibilities** relevant to engineering technician practice and solutions to well defined engineering problems. (DK7)

Environment and Sustainability:
Type of Solution

Engineer-Washington Accord	Engineering Technologist – Sydney Accord	Engineering Technician-Dublin Accord
WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of **complex engineering problems** in **societal and environmental contexts** (WK7)	**SA7:** Understand and evaluate the sustainability and impact of engineering technology work in the solution of **broadly defined engineering problems** in societal and environmental contexts (SK7)	**DA7:** Understand and evaluate the sustainability and impact of engineering technician work in the solution of **well-defined engineering problems** in societal and environmental contexts (DK7)

Ethics

Differentiating Characteristic: Understanding and Level of Practice

Engineer-Washington Accord	Engineering Technologist – Sydney Accord	Engineering Technician-Dublin Accord
WA8: **Apply ethical principles** and commit to professional ethics and responsibilities and norms of engineering practice (WK7)	**SA8:** **Understand and commit to professional ethics** and responsibilities and norms of engineering technology practice (SK7)	**DA8:** **Understand and commit to professional ethic**s and responsibilities and norms of technician practice (DK7)

Individual and Collaborative Team work

Differentiation Characteristic	WA	SA	DA
Role in and diversity of team	**WA9:** Function effectively as an **individual**, and as a **member or leader** in **diverse teams** and in **multi-disciplinary** settings	**SA9:** Function effectively as an **individual**, and as a **member or leader** in diverse teams	**DA9:** Function effectively as an **individual**, and as a **member in diverse technical teams**

Communication

Differentiation Characteristic	WA	SA	DA
Level of Communication according to type of activities performed	**WA10:** Communicate effectively on ***complex*** engineering activities with the engineering community and with society at large, such as being able to **comprehend and write effective reports and design documentation**, make effective **presentations**, and **give and receive clear instructions**	**SA9:** Communicate effectively on ***broadly-defined*** engineering activities with the engineering community and with society at large, by being able to **comprehend and write effective reports and design documentation**, make effective **presentations**, and **give and receive clear instructions**	**DA9:** Communicate effectively on ***well-defined*** engineering activities with the engineering community and with society at large, by being able to **comprehend the work of others, document their own work, and give and receive clear instructions**

Project Management and Finance

Differentiation Characteristic	WA	SA	DA
Level of management required for differing types of activity	**WA11:** Demonstrate knowledge and understanding of **engineering management principles** and ***economic decision-making*** and **apply** these to one's own work, as a member and leader in a team, to **manage projects and in multidisciplinary environments**	**SA11:** Demonstrate knowledge and understanding of engineering management principles and **apply** these to one's own work, as a member or leader in a team and to manage projects in multidisciplinary environments	**DA11:** Demonstrate knowledge and understanding of engineering management principles and **apply** these to one's own work, as a member or leader in a technical team and to manage projects in multidisciplinary environments

Life Long Learning

Differentiation Characteristic	WA	SA	DA
Preparation for and depth of continuing learning	**WA12:** Recognize the need for, and have the preparation and **ability to engage in independent and life-long learning** in the broadest context of technological change	**SA12:** Recognize the need for, and have the **ability to engage in independent and life-long learning** in specialist technologies	**DA12:** Recognize the need for, and have the **ability to engage in independent updating** in the context of specialized technical knowledge

Acknowledgements

For graduate attributes, knowledge profiles and professional competency profiles, the main reference is **"Graduate Attributes and Professional Competencies" published by the International Engineering Alliance which are also adopted by FEIAP**

(https://www.ieagreements.org)

General Understanding of Outcome-Based Education (OBE)

Outcome-Based Education

- OBE is an educational philosophy that states education ought to aim at giving students a particular, minimum level of knowledge and abilities as the major educational outcomes

*"**OBE** is an educational process that involves **assessment and evaluation** practices to reflect the attainment of certain specified **outcomes (or attributes)** in terms of individual student learning. Once having decided what are the **key attributes or outcomes students should be able to do and master**, both **course structures and curricula** are designed to achieve those outcomes"*

The Origins of Outcome Based Education

5 Steps for Designing Curriculum by

John Franklin Bobbitt (early 1900)

- Analysis of Human Experience (Major Fields)
- Job Analysis (Specific Activities)
- Deriving Objectives
- Selecting Objectives
- Detailed Planning

The Origins of Outcome Based Education

Basic Tasks of an Educator by ***Ralph Tyler (1949)***

- Determining the Objectives which the course seeks to obtain
- Selecting Learning Experiences to bring about Attainment of the Objectives
- Organizing of Learning Experiences to provide Continuity and Sequence for Learner
- Assessing Attainment of the Objectives

The Origins of Outcome Based Education

William Spady (1988)

- Extension of Work by Joh F Bobbitt and Ralph W Tyler
- Coined the term Outcome-based Education

Outcomes Based Engineering Education I: Theory and Practice in the Derivation of Outcomes" A European Historical Perspective

John Heywood (1997)
University of Dublin - Department of Teacher Education

"…It is concluded that there is no real difference between the objectives movement of yesterday and the "outcomes" movement of today."

Paradigm Shift in The Education Philosophy

From teacher-centre	→	To a student-centre
Traditional teaching: Teacher "owns" the knowledge and convey it to students	→	Modern teaching: Student (trainee) takes initiative to learn
Teacher brings the content and the answer into the training room	→	Teacher as a facilitator who asks questions and provides guidelines for the acquisition of knowledge

Outcome-Based Education

Glossaries

Term	Definition
Programme	The sequence of structured educational experience undertaken by students leading to completion, on satisfactory assessment of performance.
Course	Subject offered in the Programme
Continual Quality Improvement (CQI)	Spirit of OBE for continuous improvement of programme

Outcome-Based Education

Glossaries

Term	Definition	Common Term
Programme Education Objectives (PEO)	PEOs are statements that describe the expected achievements of graduates in their career and professional life a few years after graduation.	Goals, Attributes, Programme Objectives
Programme Outcomes (PO)	POs are statements that describe what students are expected to know and be able to perform or do by the time of graduation. These relate to the knowledge, skills and attitudes that students acquired through the programme.	Standards
Course Outcomes (CO)	COs are statements that describe what students are expected to know and be able to perform or do upon completion of a course.	Learning Outcomes

Outcome-Based Education

Glossaries

Term	Definition
Performance Indicators	Specific and measurable statements that describe the required performance of students to meet the programme outcomes (through confirmable evidence)
Assessment	Processes that identify, collect, use and prepare data for evaluation of achievement of programme outcomes or programme objectives.
Evaluation	Processes for review and analysis of data and evidence from assessment practices that determine the program outcomes are achieved, or result in further actions to improve programme.

Outcome -Based Education

OBE focuses on what students can actually do after they are taught with the following key questions:

- **What** do we want the students to learn or be able to do? *(Outcomes and Motivation)*
- **How** best can we help students to learn or achieve it? *(Delivery and Resources)*
- **How** will we know whether the students have learnt or achieved it? *(Assessment and Evaluation)*
- **How** do we close the loop for further improvement? *(Continuous Quality Improvement (CQI))*

Approaches to OBE

- In the OBE approach, given the more specific nature of its course and programme outcomes, it would be necessary to develop a range of teaching and learning activities that are aimed at achieving these particular outcomes.

- The question to ask:

  NOT ‘What do I want to “cover” today?’,

  BUT ‘What teaching/learning activities do I need to do in order for the students to achieve the intended outcomes?’

Approaches to OBE

- Aim to change the students rather than simply have them learn
- Help students to demonstrate a skill or attribute (OUTCOME) which is meaningful and relevant to their present and future life
- Sometimes take a “back seat” in the learning process
- Remain ‘in control’ of the class
- Develop a skill or concept sequentially

Outcome-Based Education

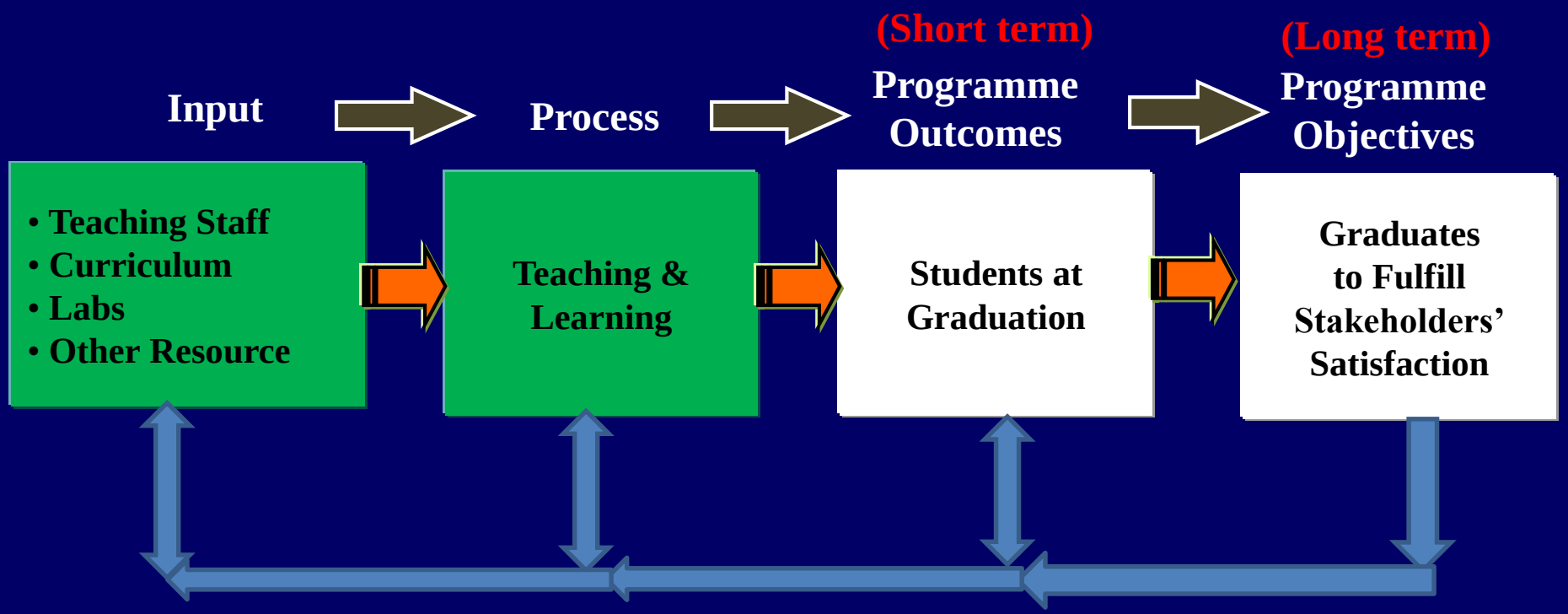
OBE develops:

- Lifelong Learner
- A knowledgeable person with deep understanding
- Complex Thinker
- Creative Person

- Active Investigator
- Effective Communicator
- Participant in an Interdependent World
- Reflective and Self-Directed Learner

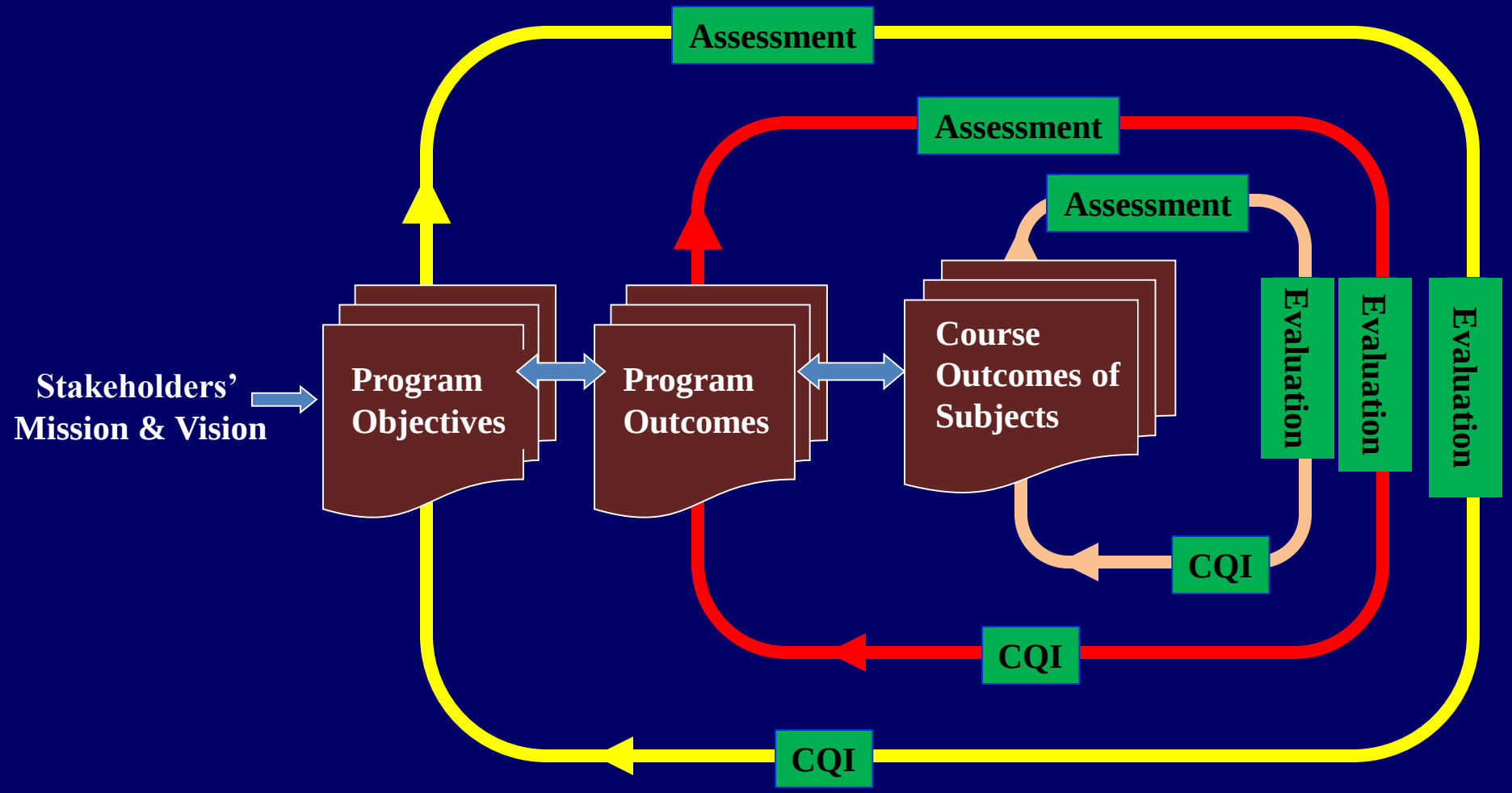
Outcome-Based Education

- Shifting from measuring input and process to include measuring the outputs (outcomes)



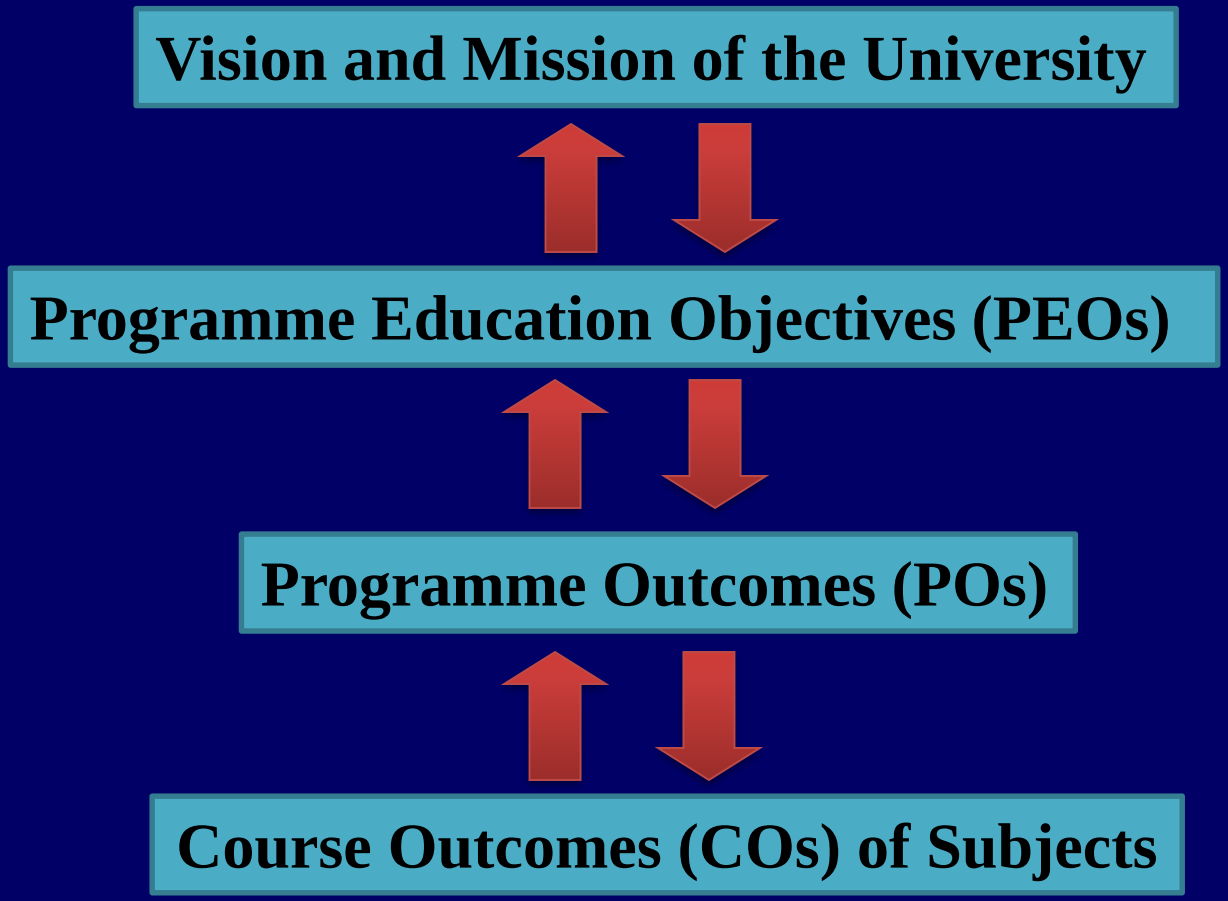
Stakeholders:
Accreditation Board, Employers, External Examiners Industry Advisors, Academic Staff, Public and Parents, Students, Alumni

Outcome-Based Education



Outcome-Based Education

A Model Hierarchy



Characteristics of OBE curricula

1. It has programme education objectives (PEOs), programme outcomes (POs), course learning outcomes or unit learning outcome (ULO/CO) and **performance indicators**

2. It is objective and outcome driven, where every stated objective and outcomes can be **assessed and evaluated**

3. It is centered around the needs of the students and the **stakeholders** (example: Internal : teacher, student and university; External : employer, alumni, Regulatory body)

Characteristics of OBE curricula (Cont'd)

4. Every learning outcome is **intentional** and therefore the outcomes must be assessed using suitable performance indicators.

5. Programme objectives (PEO) address the graduates attainment a few years (say **5 years)** after their graduation.

6. Programme outcomes, which consist of **abilities** to be attained by students before they graduate are formulated based on the programme objectives.

Characteristics of OBE curricula (Cont'd)

7. Programme outcomes address **Knowledge, Skills and Attitudes** to be attained by students

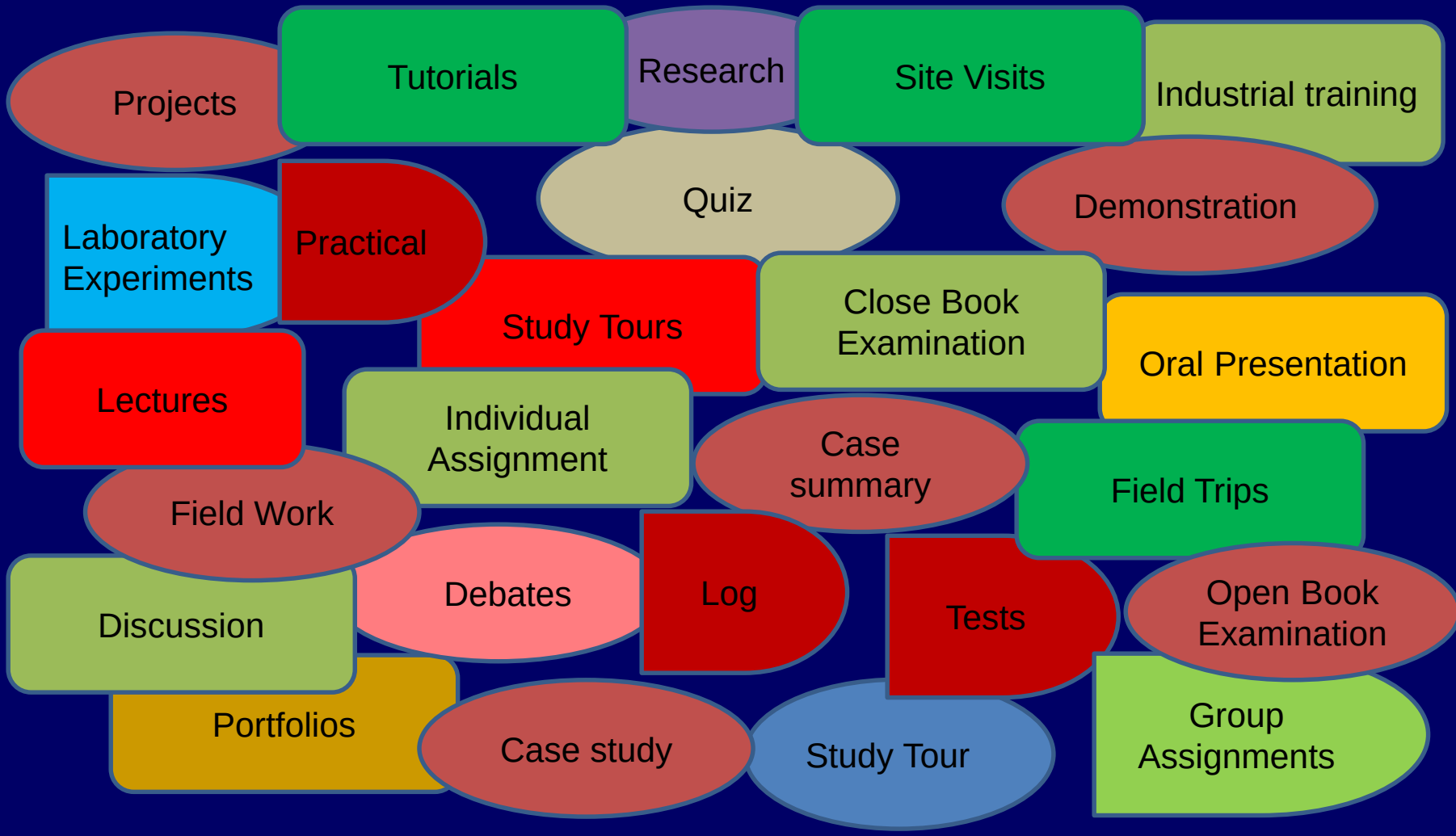
Cognitive Domain (thinking, knowledge)	Psychomotor Domain (doing, skills)	Affective Domain (feeling, attitudes)

8. Course outcomes (COs) must satisfy the stated programme outcomes. There is **no need** for **ANY(individual)** course to address all programme outcomes

9. Teaching or Learning method may have to be **integrated** to include **different delivery methods** to complement the traditional Lecture method.

Outcome-Based Education

*Types of Teaching/Learning Delivery Activities**



**Any assessment of learning activities and outcomes must come with systematic assessing criteria and marking scheme*

Outcome-Based Education

Delivery

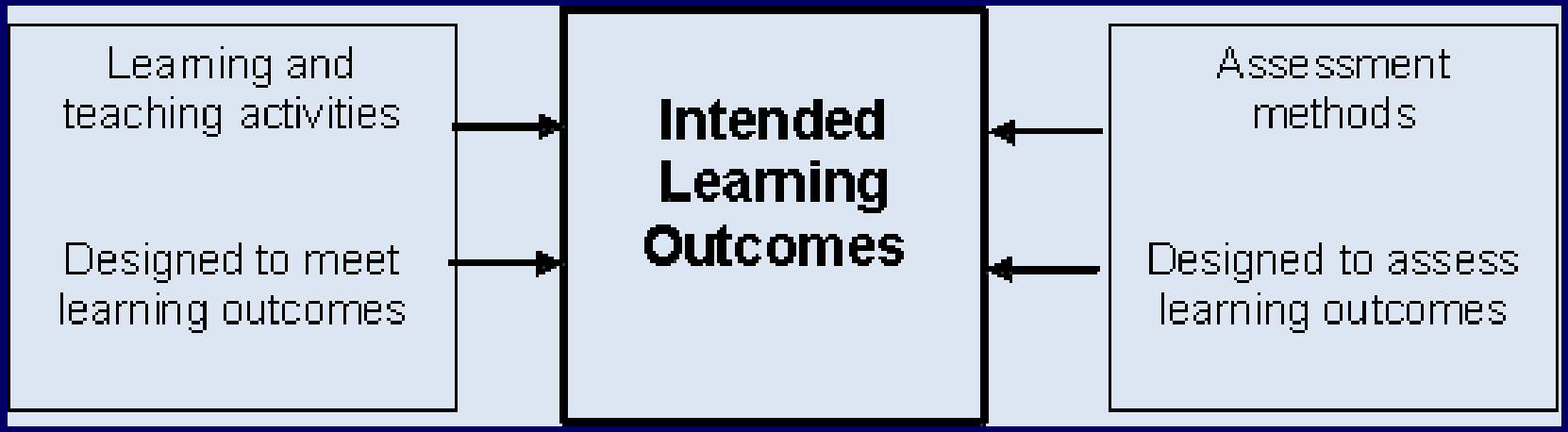
1. develop soft skills and core skills within all curriculum
2. 'translate' CO's into learning experiences
3. develop learner centredness
4. make institutional based outcomes (derived from vision of university) as the foundation
5. develop outcomes utilising intellectual quality, relevance (or connectedness), socially supportive classroom environment and recognition of difference

Planning to Achieve Learning Outcomes. Aug 2009.Roz.

Outcome-Based Education

Delivery & Assessment

Aligning *course outcomes, learning and teaching activities and the assessment*



Adapted from Biggs, 1999 p. 27

Planning to Achieve Learning Outcomes. Aug 2009.Roz.

Requirements for the Students

- ✓ **Active role** – must come prepared for each class; contribute by teaching others, actively participating, taking risks, learning from instructor or classmates

- ✓ **Ethics** – respect, trust and openness

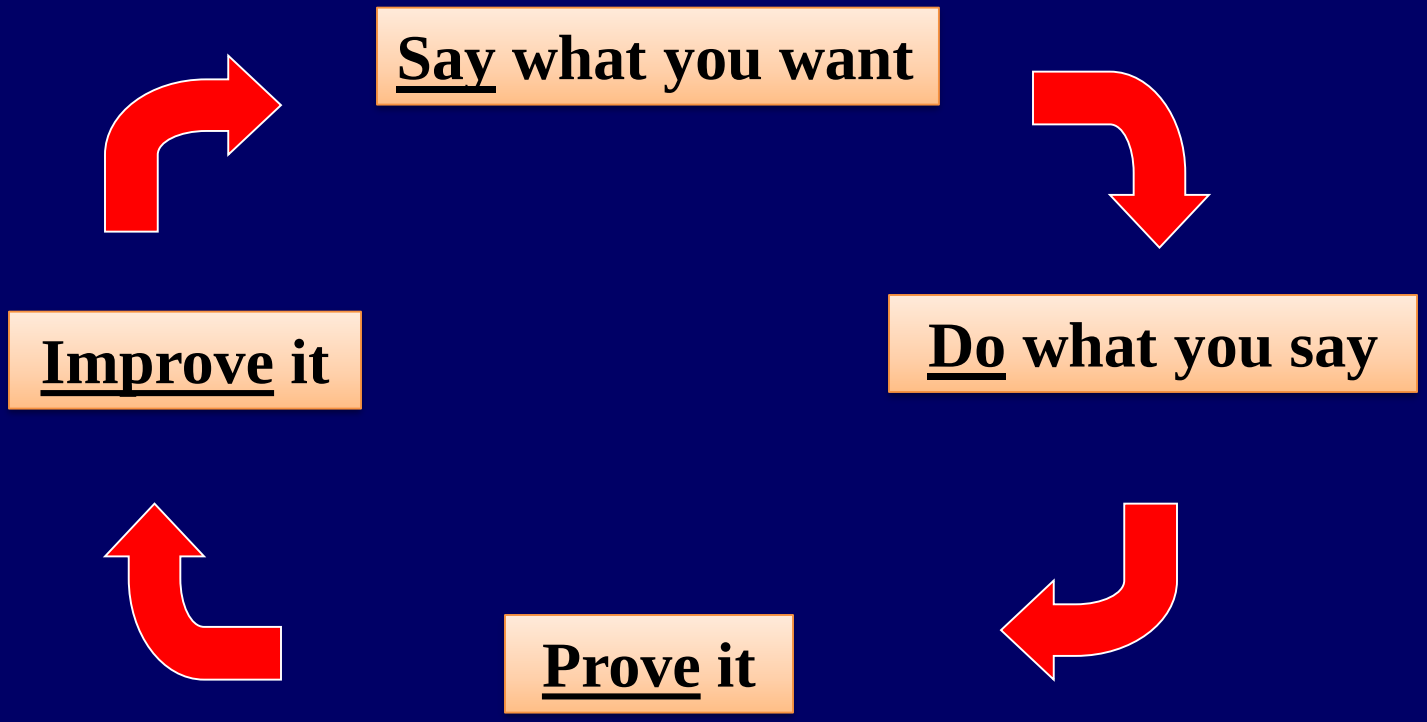
- ✓ **Committed to learning** – continual improvement

Instructors/Supervisors

- Pedagogical skills
- Scientific skills
- Time management
- Project based on staff research

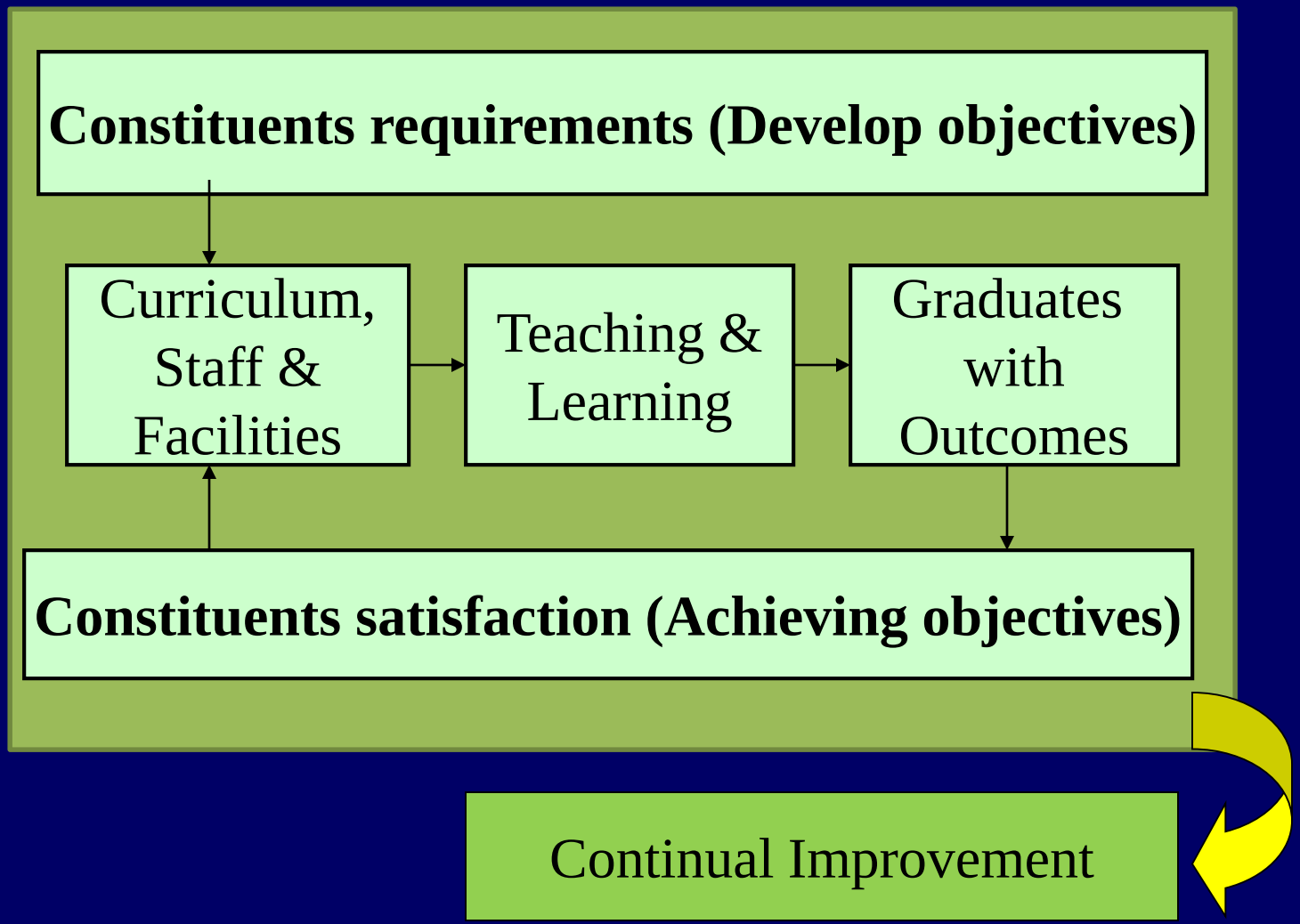
Outcome-Based Education

Continuous Quality Improvement (CQI)



Outcome-Based Education

Continual Quality Improvement (CQI)



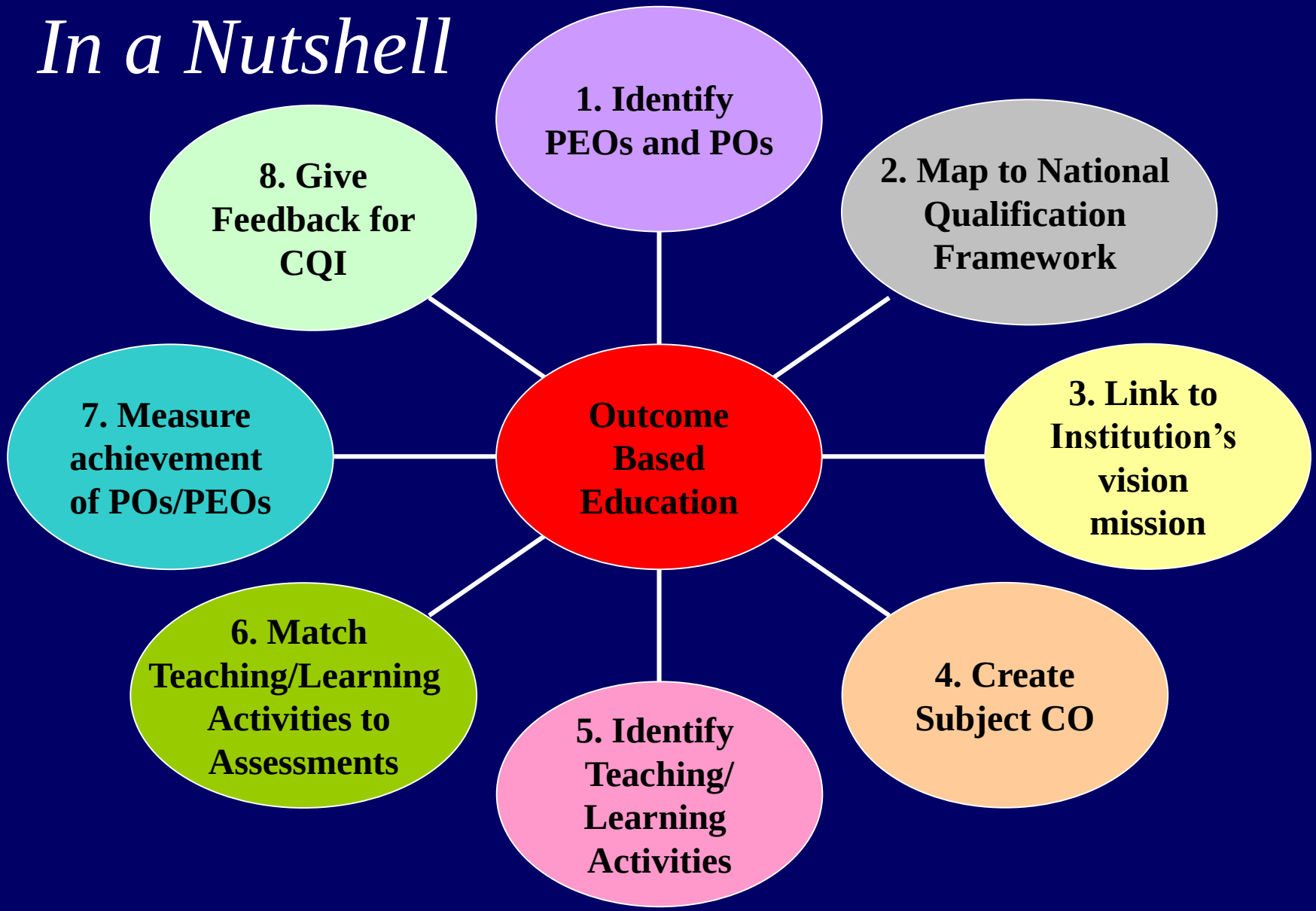
Outcome -Based Education

Essentials for OBE's success

- The desired outcomes are determined first with the curriculum, instructional materials and assessments designed around to support and facilitate the intended outcomes
- All curriculum and teaching decisions are made based on how best to facilitate achievement of the desired final outcomes
- The student's achievement is based on demonstrable measurables
- Multiple instructional and assessment strategies need to be utilized to meet the needs of each and every student
- Adequate time and needed assistance is to be provided so that each student can reach the maximum potential

Outcome -Based Education

In a Nutshell



Programme Education Objectives (PEO’S)
Programme Outcomes (PO’s)
Course Outcomes (CO)

Different Levels of Outcomes

1. **Program Educational Objectives (PEOs)**
   - Few years after Graduation (5 years)

2. **Programme Outcomes (POs)** - Upon graduation

3. **Course or Unit Outcomes (COs)** - Upon subject completion

4. **Weekly or Topic Outcomes** - Upon weekly/topic completion

Programme Education Objectives

What is expected a few years (say 5 years) graduation (What the programme prepares graduates in their career and professional accomplishments)

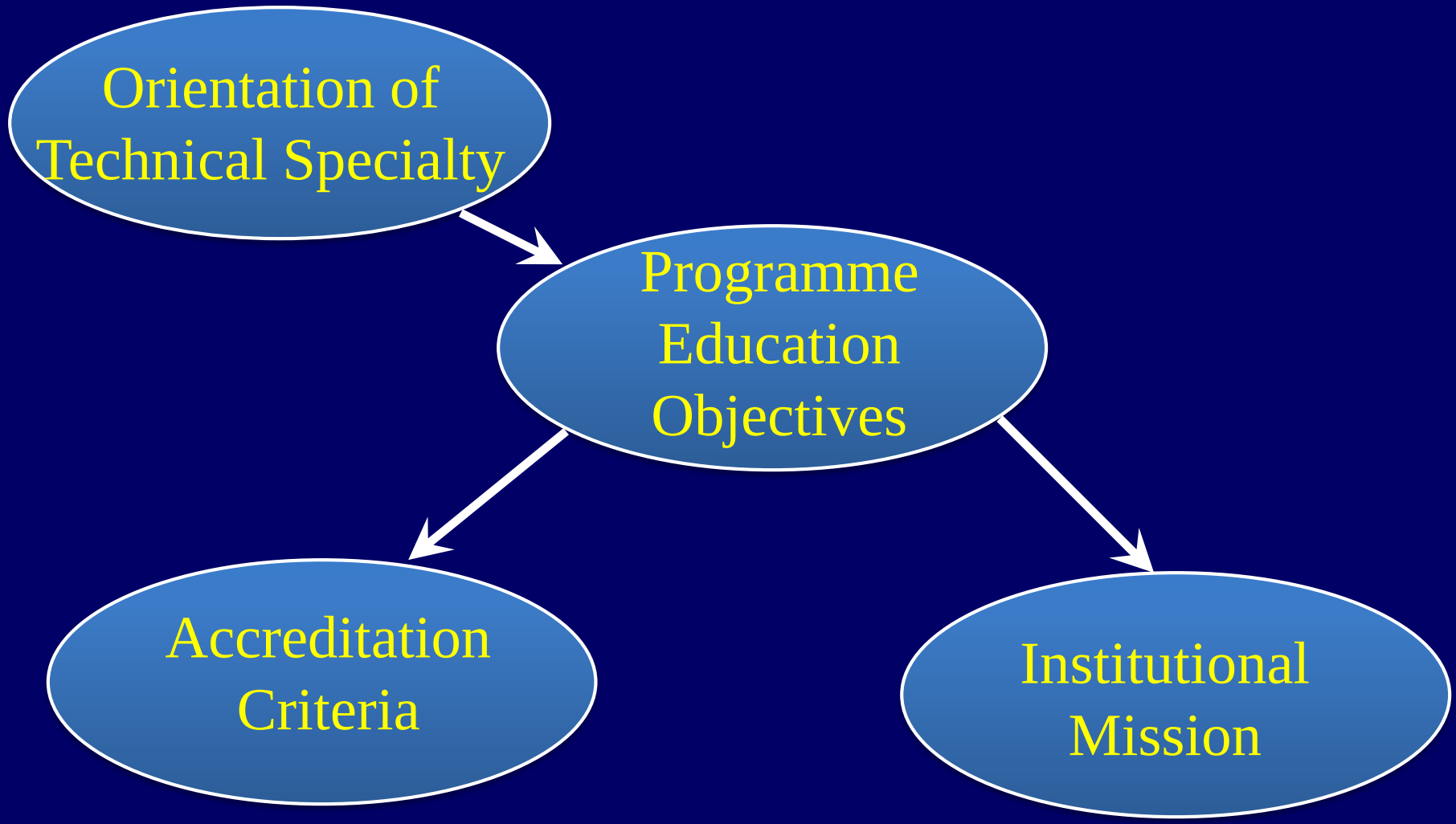
Characteristics of Good Programme Education Objectives (PEO) Statements

- Each addresses one or more needs of one or more stakeholders
- Consistent with the mission & vision of the institution
- Expectation by stakeholder addressed
- Number of statements should be limited and manageable
- Should not be simply restatement of outcomes
- Forward looking and challenging

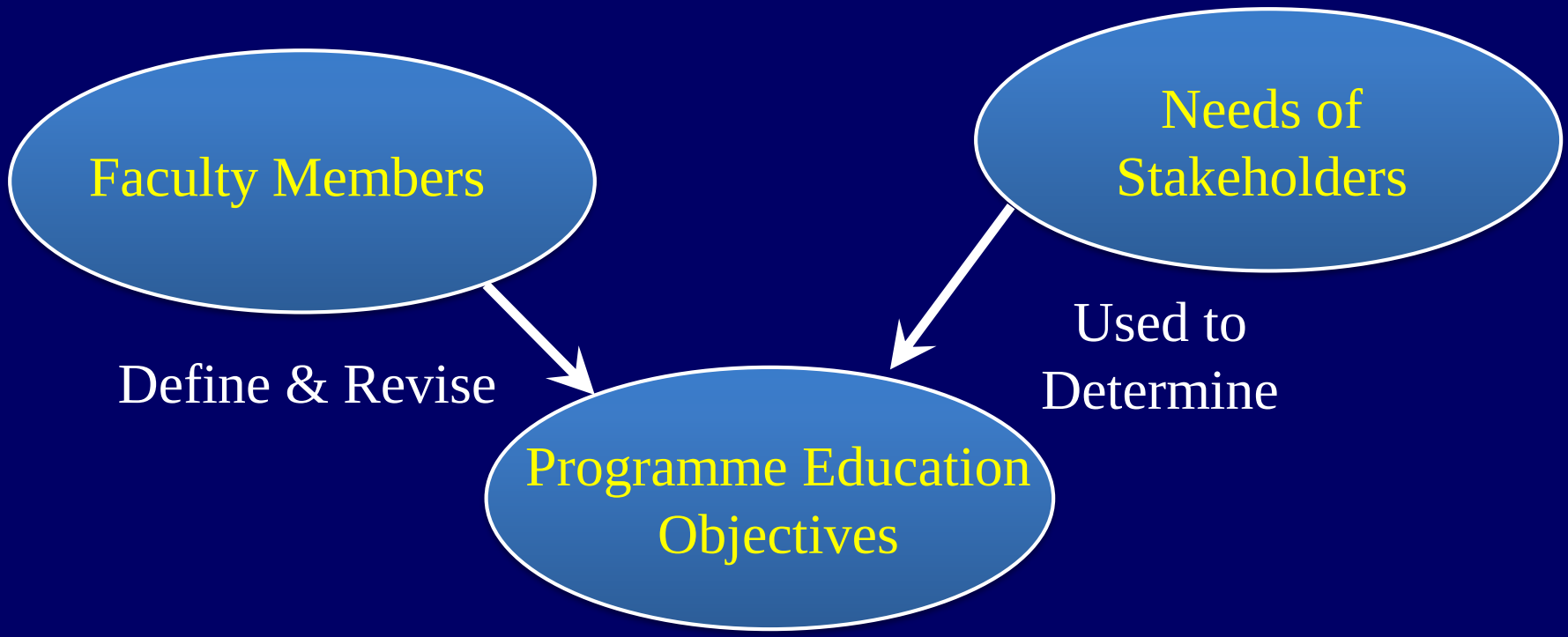
CHARACTERISTICS OF GOOD PEO STATEMENTS (Cont'd)

- Should be stated such that a graduate can demonstrate in their career or professional life after graduation (long term in nature)
- Distinctive/unique features/having own niche
- Specific, Measurable, Achievable, Realistic, and having a Time frame (SMART)
- Clear, concise, consistent and reachable
- Has clear link to the programme outcomes & curriculum design
- Reviewed, revised & updated continually
- Publicised & published

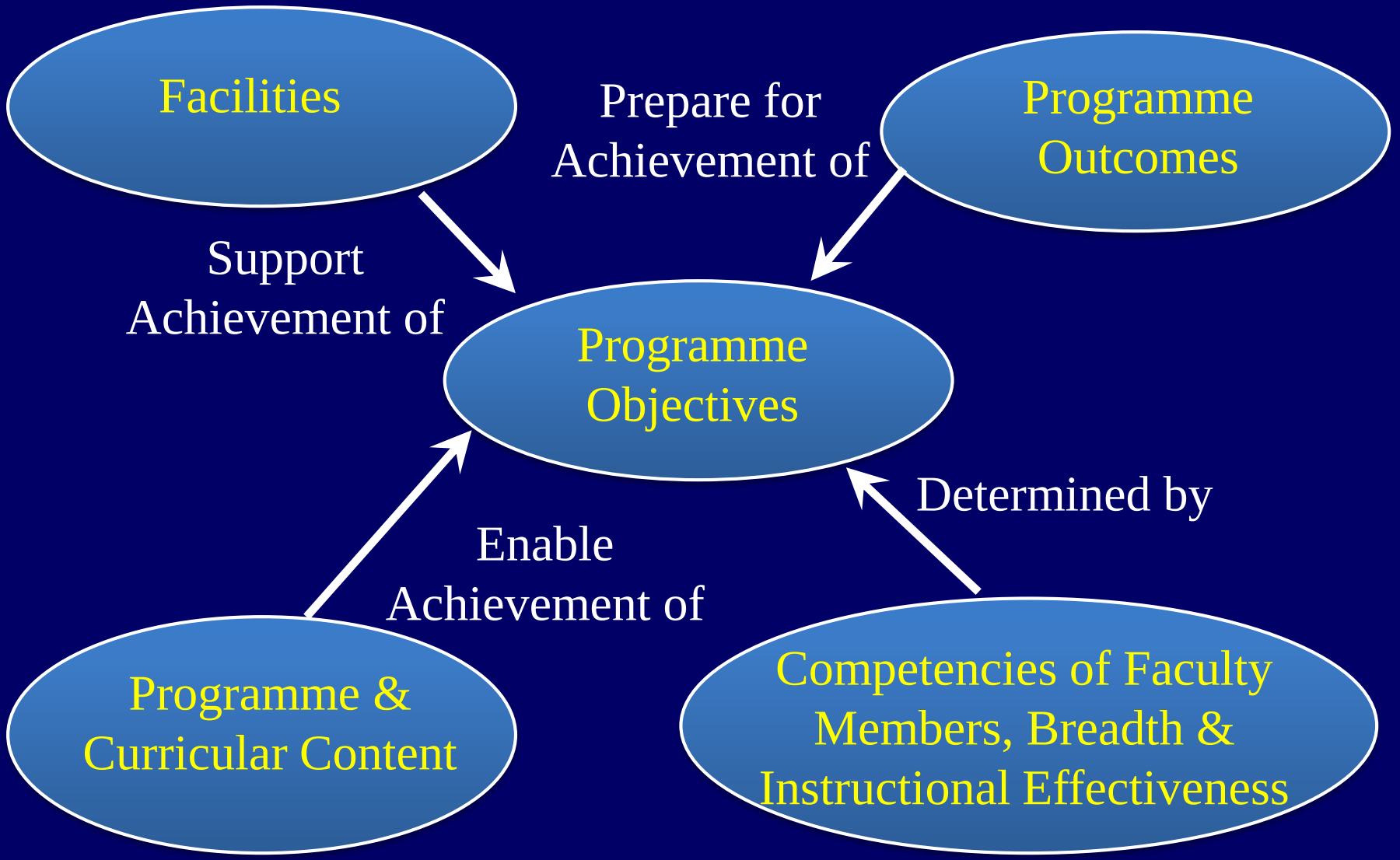
Characteristics of Programme Education Objectives



Development of Programme Education Objectives



Programme Education Objectives



Example of Programme Education Objectives

BEng (Hons) Electrical and Electronic Engineering is to produce:

PEO 1: Graduates competent in practising fundamental scientific and engineering principles in **E&E** engineering in a creative and innovative manner

PEO 2: Graduates capable of communicating and managing effectively in diverse areas of **E&E**

PEO 3: Graduates practising professional ethics, life-long learning, and sustainable development for the betterment of the profession and society

Programme Outcomes

- What the graduates are expected to know and able to perform or attain by the time of graduation (knowledge, skills or psychomotor, and effective or interpersonal or attitude)

- There must be a clear linkage between Objectives and Outcomes

Need to distribute the outcomes throughout the programme, and not one/two courses only addressing a particular outcome

CHARACTERISTICS OF GOOD OUTCOME STATEMENTS

- Each describes an area of knowledge and/or skills that a person can possess
- Should be stated such that a student can demonstrate before or by the time of graduation
- Should be supportive/responsive of/to one or more programme education objectives (must be linked to the programme education objectives)
- Do not have to include measures or performance expectations

CHARACTERISTICS OF GOOD OUTCOME STATEMENTS (Cont'd)

- Responsive to objectives
- Take advantage of the "unique" character of the Institution
- Should meet the specific programme criteria
- Package: knowledge, skills, attitude, etc
- Cover the domains in the national qualifications framework or accreditation requirements for programmes

Examples of Programme Outcomes

Students of an engineering programme are expected to have the following outcomes by the time of graduation:

1. Acquire and apply fundamental knowledge of science, engineering and mathematics, with an engineering focus in solving complex engineering problems
2. Apply first principles of mathematics, natural and engineering sciences to identify, study, formulate and evaluate complex engineering problems based on systematic approach and leading to authenticated conclusions
3. Devise solutions for complex engineering problems and design systems, components or processes by taking into consideration cost-effectiveness and specific concerns for public health, safety and environment

Examples of Programme Outcomes

4. Make use of research based knowledge and methodology through critical thinking to interpret, analyse, and study complex engineering problems, designs and operational performances to reach convincing conclusions
5. Apply original engineering techniques and state of the art engineering and IT resources to model, simulate and analyse complex engineering problems within the relevant constraints and range of validity
6. Apply appropriate knowledge in the evaluation and assessment of subject matters pertinent to the professional engineering practice with considerations of public health and safety, community welfare and cultural perspectives as well as legal, moral and ethical responsibilities

Examples of Programme Outcomes

7. Recognise the significance of sustainable development when devising professional solutions to engineering problems with a clear understanding and pro-active considerations of environmental concerns as well as needs for eco-friendly continual growth for local and global community

8. Apply professional virtues and principles with strong commitment to moral and ethical responsibilities during the course of engineering practice

9. Demonstrate the ability to convey ideas and information effectively within the engineering profession and the general community when addressing complex engineering issues and activities, including unambiguous interpretation of data and instructions, enlightening oral presentations and writing skills evident in accurate documentation of designs and solutions

Examples of Programme Outcomes

10. Display capability to work competently in the context of a diverse team within multidisciplinary environment, as an individual member with teamwork fortitude or as an inspiring leader with effective management skills

11. Recognize the need to take on independent life-long learning and continuous self improvement in the context of scientific and engineering advancement and professional development

12. Show capability to comprehend and apply engineering and management philosophy to manage projects of in cross disciplinary content, as a member or a leader in a team realising the importance of cost-effective design and solution for sustainable development

Course Development

This covers

- Content - typical topics in the subject matters
- Subject Topics - teaching plan
- Course Outcomes - group of learning (topic) outcomes
- Course Outcomes to Programme Outcomes linkage

Considerations of:

- **Depth – e.g. Bloom's taxonomy**
- **Delivery and assessment**
- **Students' time and competencies covered**

Creating a Course

Planning

- Identifying course content and defining measureable learning outcomes

Instruction

- Select and implement methods – deliver the specified content and facilitate student achievement of the outcomes

Assessment and Evaluation

- Select and implement methods – determine how well the outcomes have been achieved

Course Outcomes are essential as they:

- define the breadth and depth of learning that students are expected to achieve
- provide a benchmark for formative and summative, assessment
- clearly inform expectations to students
- clearly communicate graduates' skills to the stakeholders
- define coherent units of learning that can be further subdivided for classroom or other delivery modes
- guide and organize the lecturer and the student

Reasons for careful specification of outcomes:

1. They enable better planning of instruction and since they are end points they ensure lecturers know where they are going
2. If the student knows where the lecturer is going they can direct their attention and effort to this goal a point
3. They can improve performance assessment through between test construction
4. They provide clearly defined parameters for evaluation

John Heywood (1997)

3 Essential Components of a Course Outcome:

1. Action verb (V): Describe behavioural action

2. Condition (C): Context under the behaviour is to happen

3. Standard (S) : Criteria of acceptable level of performance

3 Essential Components of a Course Outcome:

1. Action verb (V)

- Well-written verbs must be (SMART), i.e. observable: Specific, Measurable, Achievable, Realistic, Time Frame

- Try to avoid using these (not observable): appreciate, aware, familiar, know, learn, understand

Example 1:

• describe the principles used in designing Z (V)

Example 2:

• design a column (V)

3 Essential Components of a Course Outcome:

2. Condition (C)

Example 1:

- describe the principles used in designing Z (V)
- orally describe the principles used in designing Z. (V&C)

Example 2:

- design a column (V)
- design a column using Microsoft X design template (V&C)

3 Essential Components of a Course Outcome:

3. Standard (S)

Example 1:

- describe the principles used in designing Z (V)
- orally describe the principles used in designing Z (V&C)
- orally describe the four principles used in designing Z (V & C & S)

Example 2:

- design a column (V)
- design a column using Microsoft X design template (V&C)
- design a column using Microsoft X design template based on BS 5950:Part 2 (V & C & S)

3 Essential Components of a Course Outcome:

Another example of Course Outcome:

Poor

- Students should be able to design research (V)

Better

- Students should be able to independently design and carry out experimental and correlational research (V&C)

Best

- Students should be able to independently design and carry out experimental and correlational research that yields valid results (V & C & S)

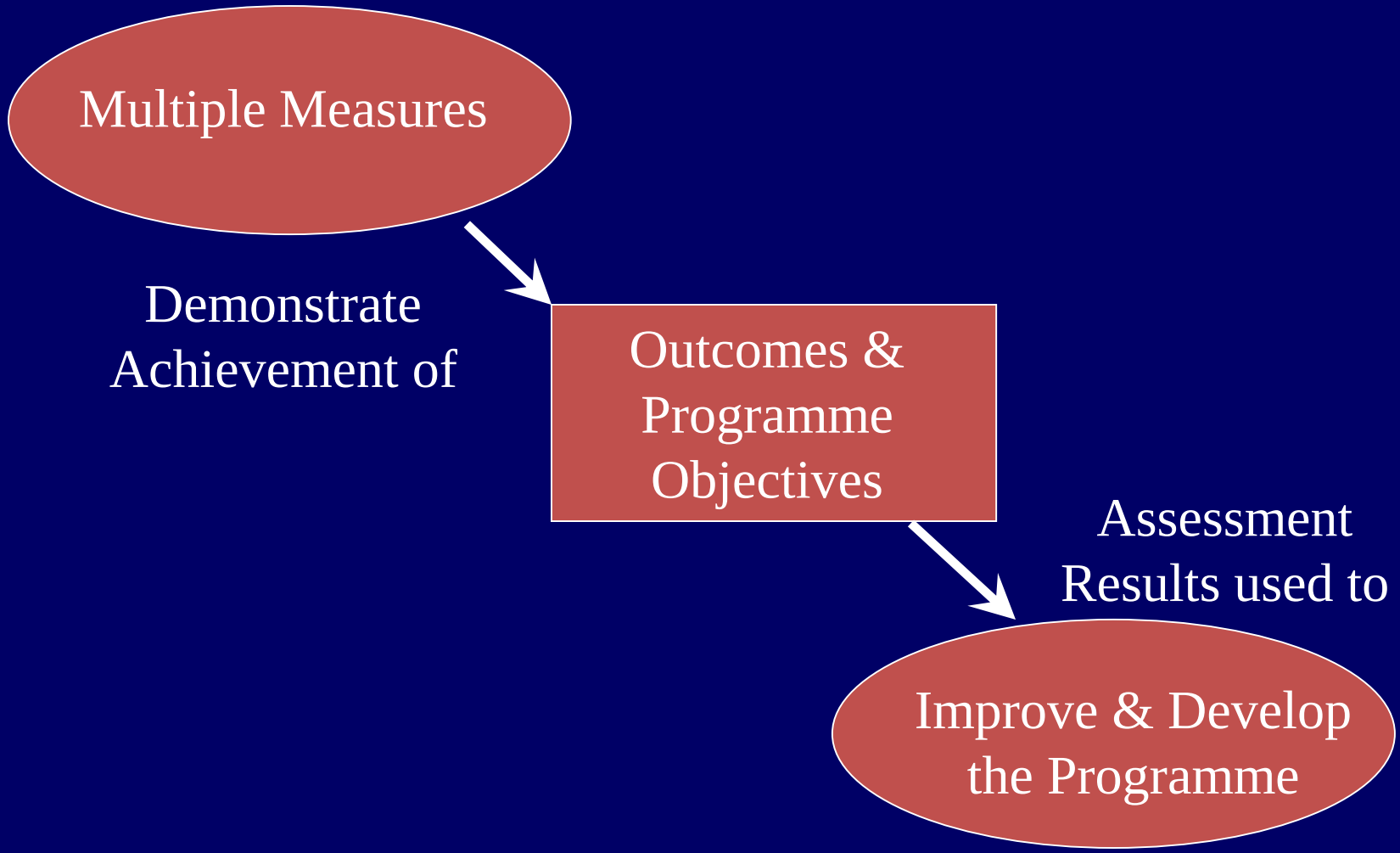
Source: Bergen, R. 2000. A Program Guideline for Outcomes Assessment at Geneva College

Course Outcomes (COs)

- ✓ Uses action verbs that specify definite, observable behaviors
- ✓ Uses simple language
- ✓ Describes student rather than teacher behaviors
- ✓ Describes an outcome rather than a learning process
- ✓ Focuses on end-of-instruction behavior rather than subject matter coverage
- ✓Can be assessed by one or more indicators (methods)
- ✓ Is clearly link to a goal
- ✓ Is realistic and attainable
- ✓ Is not simple when complexity is needed
- ✓ Is clear to people outside the discipline
- ✓ Is validated by departmental colleagues

Assessment and Evaluation Methods

Assessment & Evaluation



What is Assessment?

In education, assessment is the process of gathering, interpreting, recording and using information about pupils' responses to an educational task

(Harlen, Gipps, Broadfoot, Nuttal, 1992).

In other words, Assessment is :

- the formative or/and summative determination for a specific purpose of the student's competence in demonstrating a specific outcome
- the processes that identify, collect, use and prepare data that can be used to evaluate achievement

Rightfully, Assessment is done because it :

- Helps to distinguish between ***Teaching*** and ***Learning***
- Informs what students know or not know
- Provides feedback to ***improve*** teaching/learning process

Formative Assessment

- Believe all students are *teachable*
- Assessment is carried out frequently and is planned at the same time as teaching
- Collecting information according to preset criteria to supply feedback on how learning can be improved
- Teaching/learning materials are structured in manageable components and assessed
- Feedback to students on their learning achievements for students to improve their learning; allows lecturer/student to recognise the "gap" in learning
- Adjust teaching/learning activities taking into account of feedback

Summative Assessment

- Judging the worth according to preset criteria of the student's demonstration of outcome attainment competence
- Used to assess a person's achievement under exam conditions, using tests and exams only and report only the marks
- The test and exam is a final measure of the students' ability/competency
- Tests are comprehensive and thorough
- Reliability is essential as they are used numerically to classify students and compare them to each other

Formative Assessment and Summative Assessment: Analogy

- When the cook tastes the soup, that's *formative assessment*

- When the customer tastes the soup, that's *summative assessment*

Paul Black

Formative Assessment and Summative Assessment

- Formative assessment takes place during the course of teaching and is used essentially to feed back into the teaching and learning process.

  In other words, "***The soup can still be improved!***"

- Summative assessment is the "sum" of teaching/learning assuming a finality status and happens at the end of a course.

  By analogy, **the student is *past help, just like the soup*!**

Functions of Formative and Summative Assessment Techniques

Formative assessment (***To improve for***)	**Summative assessment** (***To prove for***)
• Lecturers to ensure that learning has taken place • Lecturers to improve methods of instruction • Students to gain an idea of their success • Monitors progress in learning by students	• Employers for job selection • Curriculum developers for curriculum reviews • Validation /accreditation bodies for award of grades and diplomas • Students for selecting courses of higher study

The Fundamentals of Effective Assessment

- Assessment should help students to learn
- Assessment must be consistent with the objectives of the course and what is taught and learnt
- Variety in types of assessment allows a range of different outcomes to be assessed. It also keeps students interested
- Students need to understand clearly what is expected of them in assessed tasks

The Fundamentals of Effective Assessment (Cont'd)

- Criteria for assessment should be detailed, transparent and justifiable
- Students need specific and timely feedback on their work - not just be informed of a grade/mark
- Too much assessment is unnecessary and may be counter-productive
- Assessment should be undertaken with an awareness that an assessor may be called upon to justify a student's result

The Fundamentals of Effective Assessment (Cont'd)

- Group assessment needs to be carefully planned and structured
- When planning and wording assignments or questions, it is vital to mentally check their appropriateness to all students in the class, whatever their cultural differences
- Systematic analysis of students' performance on assessed tasks can help identify areas of the curriculum which need improvement

Assessment Tools for Programme Education Objectives (PEO)

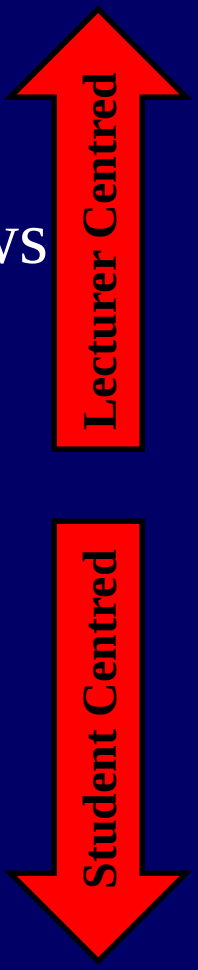
- Employers' Survey on Employment Satisfaction
- Input from Industrial Advisory Committee
- Program Educational Objectives Alumni' s Survey
- Faculty Annual Self-Assessment

Assessment Tools for Programme Outcomes (PO)

- Course-based Embedded Assessment
- Student Course Satisfaction Survey
- Cumulative GPA (CGPA) Index for Each Course
- Senior Design Projects -- Index of Excellence
- Programme Accreditation
- Academic Review – External Examiner
- Graduate Employment Statistics

Assessment Tools for Course Outcomes (CO): Formative

- Written tests linked to course outcomes
- Oral presentation and assessment
- Student surveys, individual and focus group interviews
- Written project reports
- Assignments, and reports in capstone design subject
- Demonstration and simulation
- Student portfolios
- Peer-evaluations and self evaluations
- Behavioral observation



Assessment Tools for Course Outcomes (CO): Summative

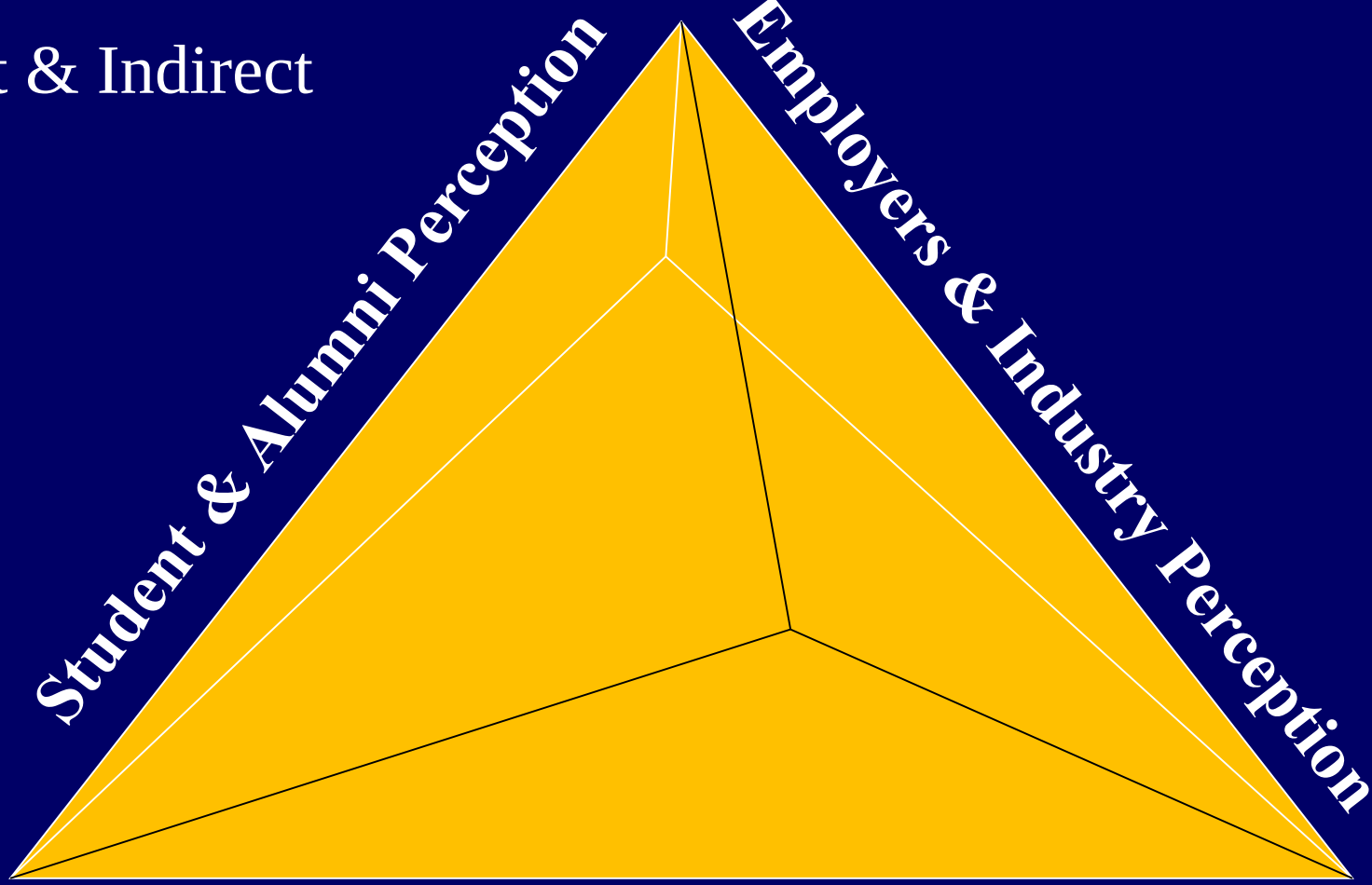
- Written examination and tests linked to course outcomes
- Oral presentation and assessment
- Student surveys, individual and focus group interviews
- Written project reports
- Demonstration
- Employer survey

Some Key Points

- Provide clear guidelines for all work
  - Report writing – nature and structure of the information required
  - Oral presentation – detailed evaluation criteria: clarity, effective use of visual aids, eye contact
- Use of higher order thinking skills
- Team involvement to be defined

Assessment & Evaluation Triangulation

Direct & Indirect



Assessment Process

- Anecdotal vs Measured Result
- Reliance on Course Grades only
- Over-reliance on Indirect Assessment (Survey)

Presenting Assessment Result

- A staff member can represent the data graphically
- How many students meet the expected standard of "meet criterion", the number who exceed standard and the number that are making progress can be determined
- Staff should think through how the data are going to be used before developing a rubric.

Expectations of Evaluators on Assessment

- ✓ Course assessment links to Course Outcomes /Programme Outcomes
- ✓ Formative Assessment
- ✓ Summative assessment
- ✓ Looking for content breadth & depth from direct assessment
- ✓ Looking for students ability to attain the highest level (depth)

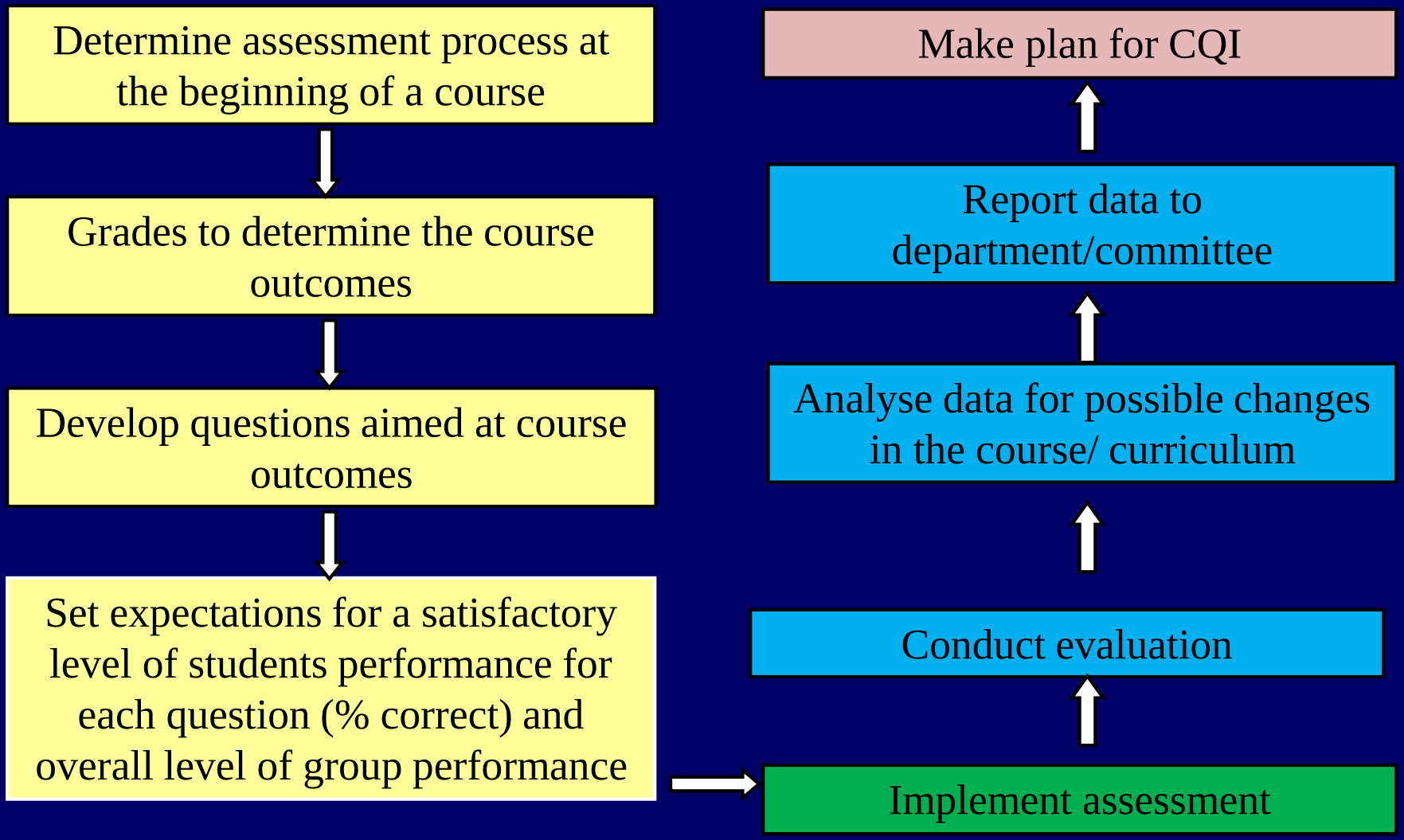
Continual Quality Improvement (CQI)

How do you close the loop ?

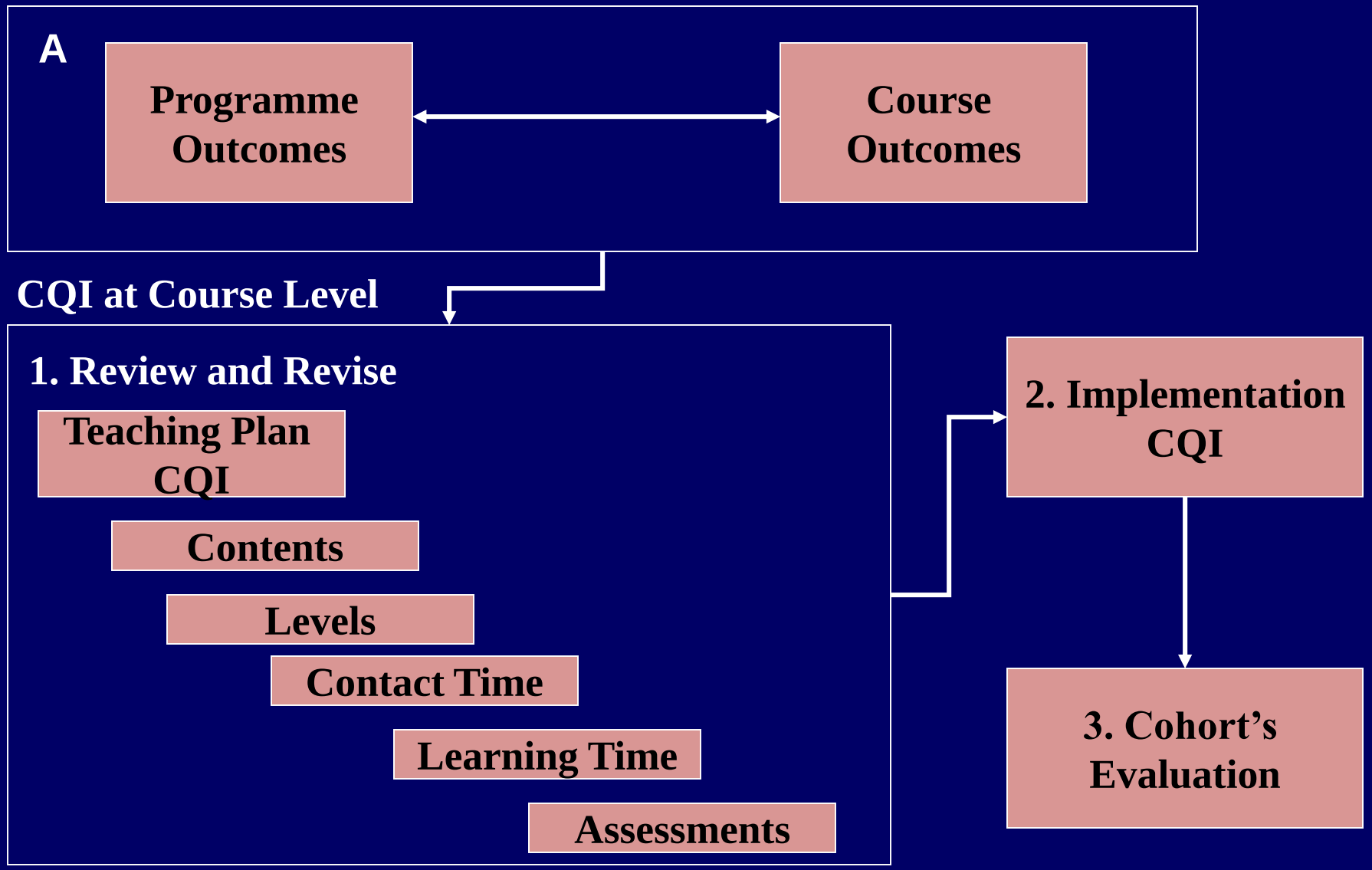
- ✓ Assessment Plan
- ✓ Who is doing what and when
- ✓ Stakeholder participation
- ✓ CQI in place

Outcome-Based Education

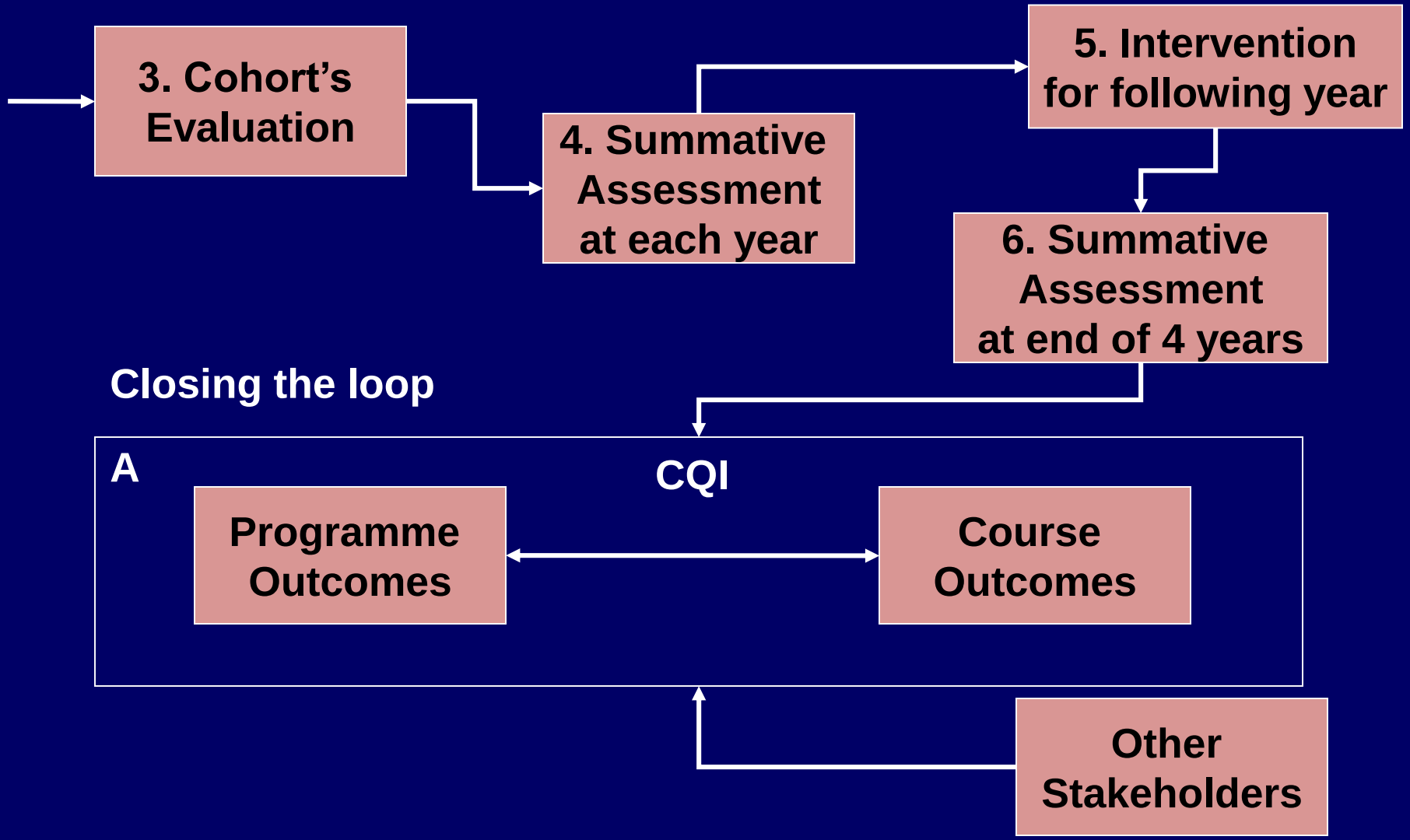
Assessment & Continual Quality Improvement (CQI)



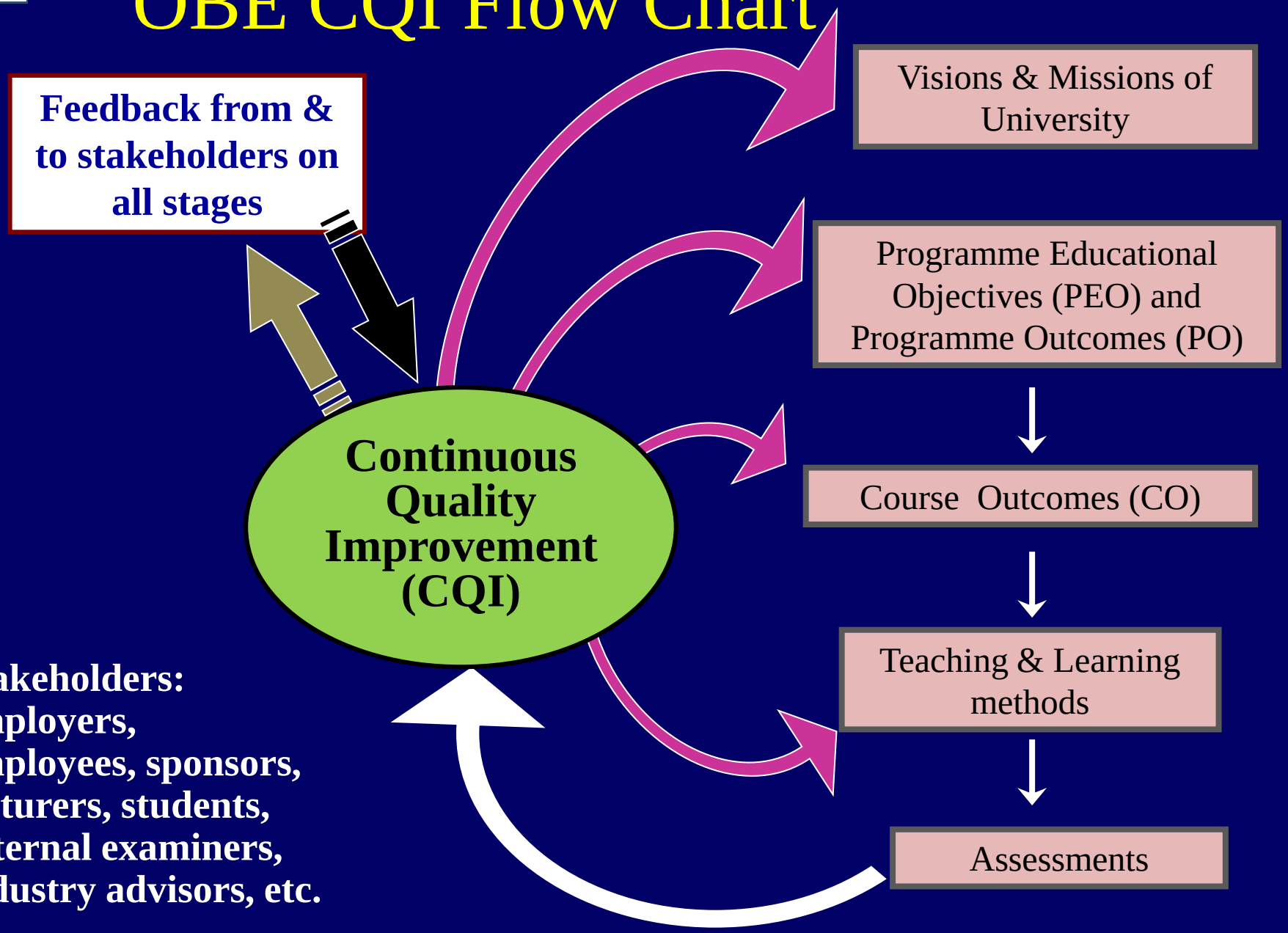
Continual Quality Improvement (CQI)



Continual Quality Improvement (CQI)



OBE CQI Flow Chart



Stakeholders: employers, employees, sponsors, lecturers, students, external examiners, industry advisors, etc.

Continual Quality Improvement (CQI)

Not only

(a) Exam System

(b) Library System

(c) Administration System

(d) HR or Finance Division

But it includes a Feedback System on

(a) Curriculum Review

(b) Facility Improvement

(c) Delivery

(d) Attainment of Outcomes

Some Current Issues for Educators

- OBE concept is quite new to most universities
- The main focus – to impart, assess, and evaluate only technical outcomes – therefore less well-rounded graduates.
- Some non-technical outcomes - assessed and evaluated formally only in design subjects and industrial training and non-engineering subjects.
- Curriculum not designed to prepare students and graduates towards achieving the **outcomes (POs)** and education **objectives (PEOs)** of programme.

Some Current Issues for Educators (cont'd)

- **Students not informed** of the levels of achievement of **non-technical** outcomes

- **Programme** normally **reviewed** based on a five-year cycle
  - **CQI not implemented**

- No **documented evidence** on the processes of measuring, assessing and evaluating the **degree of achievement** of the **graduate outcomes**

Some Current Issues for Educators (cont'd)

Effective quality system tends to be limited to check:

- the quality processes surrounding the setting of examination papers
- the security of the examination process
- the moderation of the assessment process
- the policy, processes, and practices in place for the proposal and approval of new academic programmes.

No quality system to ensure the achievement of the graduate outcomes (CO's/PO's/PEO's)

Some Current Issues & Challenges

Evaluators:

- Shortage
- Difficulty in Selection of Panel Members
- Focus Processes and Inputs
- NOT on Programme/Graduate Outcomes
- Bean Counting and Miss the Bigger Picture
- NOT to penalise, BUT to HELP and ENABLE

Tertiary Education

OR

No Bean Counting:
Focus on the forest, not just the tree
Don’t Miss the Forest

Curriculum Review

There must be a review of engineering curriculum to emphasise on:

1. Sustainability and Environmental Friendliness
2. **Ethics and Professionalism**
3. Soft-skills (Communications/Language/Emotional Intelligence/Cultural Intelligence/Negotiation/Cognitive Flexibility)
4. **Life-Long Learning**
5. Project Management
6. **Finance, Economics and Accountancy**
7. Related Laws (Land Law/Contract Law/By-laws)
8. **Complex Problem**

THANK YOU

FOR LISTENING