Workshop for Program Evaluators

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19 April 2014

Program Evaluators

UTM UNIVERSITI TEKNOLOGI MALAYSIA | MJIIT MALAYSIA-JAPAN INTERNATIONAL INSTITUTE OF TECHNOLOGY | UPM UNIVERSITI PUTRA MALAYSIA | MySET

19th April 2014

Time	Duration	Day 1: Program Evaluators
9.00 – 10.30	1.5 hr	Megat/Azlan
10.30 – 11.00	0.5 hr	Tea Break
11.00 – 12.30	1.5 hr	Megat/Azlan
12.30 – 14.00	1.5 hr	Lunch
14.00 – 15.30	1.5 hr	Megat/Azlan
15.30 – 16.00	0.5 hr	Tea Break
16.00 – 17.30	1.5 hr	Megat/Azlan

Outlines

- Introduction
- Pre-Accreditation Visit Meetings (Preparation)
- Evaluation day
- Report writing
- Decision

ACCULTURALISATION

QUALITY EDUCATION

- Knowledge
- Behaviour
- Attitude

Washington Accord is a long arduous journey

WASHINGTON ACCORD FULL SIGNATORY

- Australia - Engineers Australia (*1989*)
- New Zealand - Institution of Professional Engineers NZ (*1989*)
- Canada - Engineers Canada (*1989*)
- United States - Accreditation Board for Engineering and Technology (*1989*)
- United Kingdom - Engineering Council UK (*1989*)
- Ireland - Engineers Ireland (*1989*)
- Hong Kong China - The Hong Kong Institution of Engineers (*1995*)
- South Africa - Engineering Council of South Africa (*1999*)
- Japan - Japan Accreditation Board for Engineering Education (*2005*)
- Singapore - Institution of Engineers Singapore (*2006*)
- Chinese Taipei - Institute of Engineering Education Taiwan (*2007*)
- Korea - Accreditation Board for Engineering Education of Korea (*2007*)
- Malaysia - Board of Engineers Malaysia (2009)
- Turkey - MUDEK (2011)
- Russia - Association for Engineering Education of Russia (2012)

Provisional Status

- India
- Sri Lanka
- Bangladesh
- Pakistan
- China
- Phillipines

New Applicants

- Thailand
- Indonesia

Pre-Accreditation Visit Meeting

- Meet at least **once** (in addition to the meeting on Day -1) **before** the **Accreditation Visit**, to study and discuss documents, and systematically identify shortcomings.
- Strategically plan and/or request supplementary input from the University to fill the gaps. (**Prepare interim report, checklist, schedule and assignment**)
- Further information required, communicate through PEC.

Day -1 Meeting

- Findings (interim report)
- Strategy (schedule & assignment)
- Update checklist

EVALUATION DAY

- **Opening meeting**
- Meeting with
  - staff members,
  - students,
  - external stakeholders such as alumni, employers, and industry advisor
- Visiting facilities.
- Checking relevant documents.
- **Exit meeting**

OPENING MEETING

- **Introduce** evaluation **team** members
- Mention the **objective** of the visit (programmes)
- Mention that it is **not fault finding** exercise but to identify the programme conformance to the Accreditation criteria
- Explain the **methods** of conducting the evaluation
- **Review** the plan and **schedule**
- **Confirm** the time of the **closing meeting**
- Invite the Programme owner to fill up **the latest** (within a specified timeframe) if any

EVALUATION TOOLS

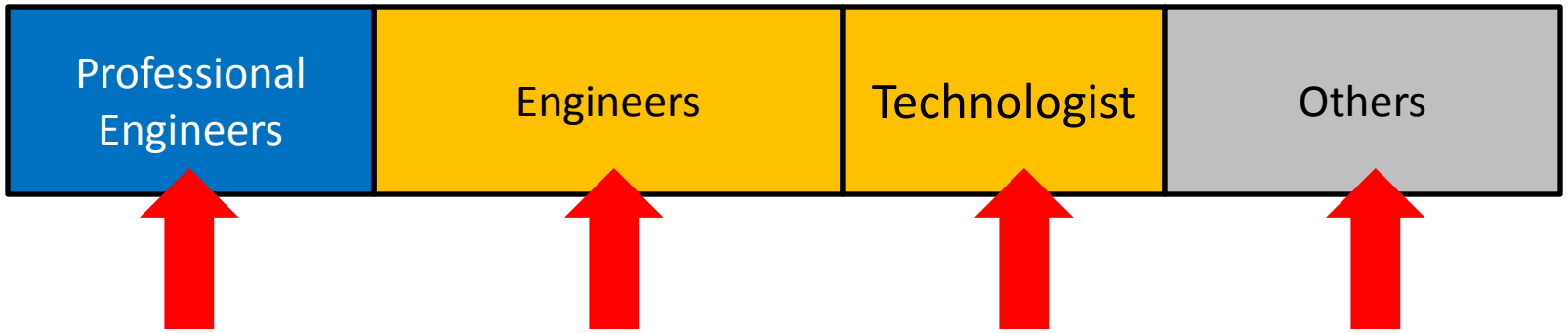
- Sensible questioning
- Check records
- Observing processes
- Analyse inputs and outputs
- Table, matrices, flowcharts and checklists

APPROACH

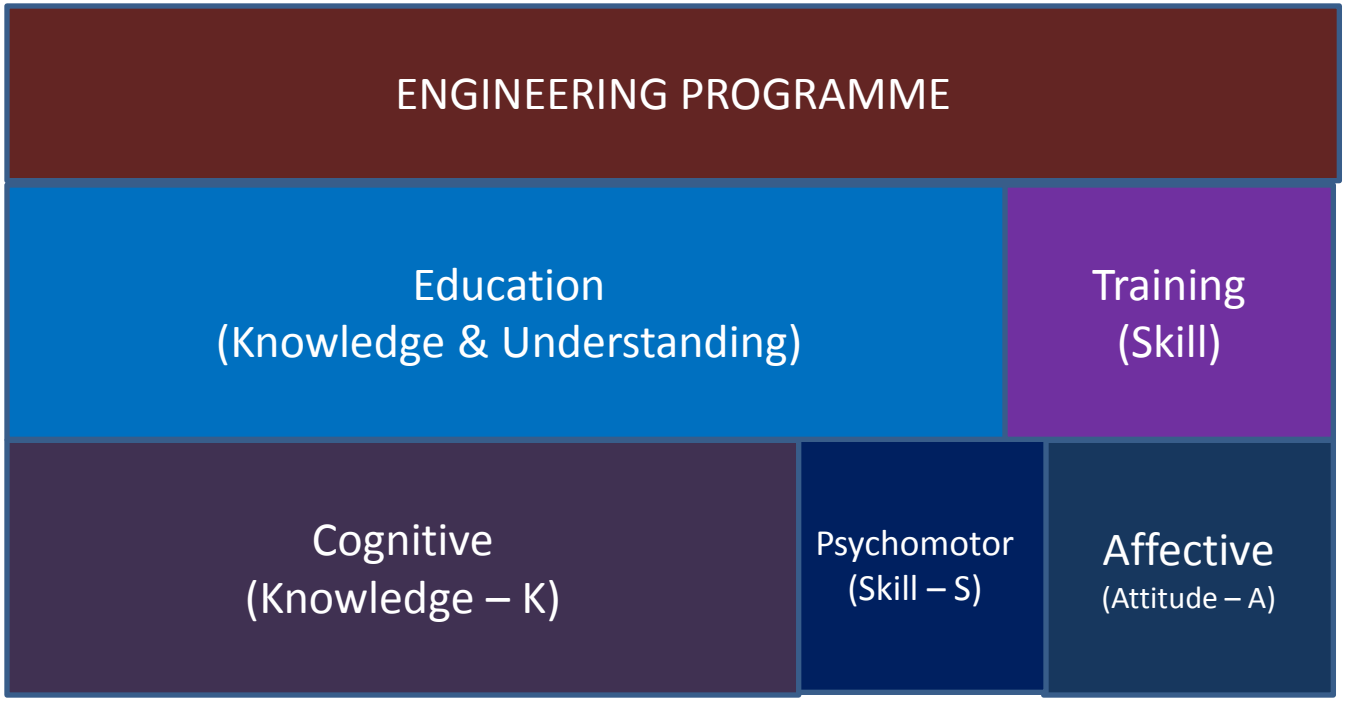
- Curriculum development (specification/input)
- Curriculum implementation (process)
- Demonstrated outcomes (output)

Engineering Curricula

- Emphasising on grades
- No enthusiasm on the part of students
- Unrealistic idea of engineering practice
- Cramming too much in 4 years
- Non-uniform workload among courses



ENGINEERING GRADUATES OUTCOMES


ENGINEERING PROGRAMME
Education
(Knowledge & Understanding)
Training
(Skill)
Cognitive
(Knowledge – K)
Psychomotor
(Skill – S)
Affective
(Attitude – A)

Engineering & Technology Domain

Engineering Education

- Solving complex problems
- Prepared for future
- Theoretical
- High mathematical knowledge
- Strong foundation on Engineering Sciences
- Strong engineering fundamentals
- Knowledge requirements towards professional engineer

Technology Education

- Solving broadly defined problems
- Prepared for present
- Practical / Applied / Hands-on
- Adequate mathematical knowledge
- Adequate foundation on Engineering Sciences
- Adequate engineering fundamentals
- Knowledge requirements towards technologist

Objective Evidence

Evidence is the facts or information used to prove or disprove a proposition. It should be collected through:-

- Interviewing
- Observation of environment
- Observation of implementation
- Checking of records of document

Objective Evidence

- Evidence that exists
- Not influenced by emotion or prejudice
- Can be documented
- Is about quality
- Can be quantitative or qualitative
- Can be verified

Objective Evidence cont…

The facts or information used:

- to come to a conclusion
- on the objective evidence of whether programmes have or have not undertaken appropriate activities effectively to the attainment of the necessary outcomes

Obtaining Objective Evidence

Among the methods used will be:-

a) Document Review (against the Manual)
b) Questioning
c) Check Records

Questioning

6 friends – What, When, Why, Who, Where, How

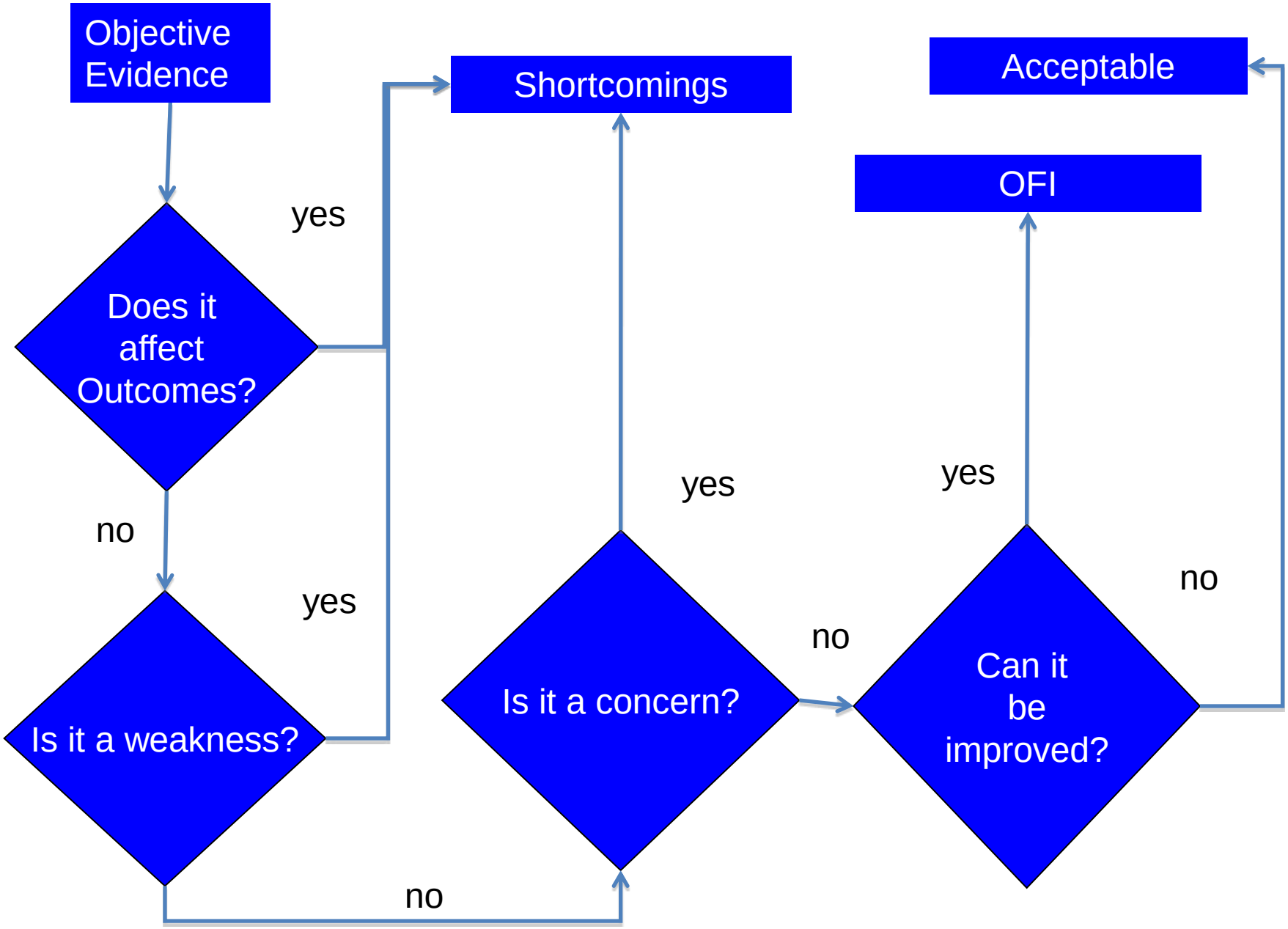
Best friend – Show Me

Additional skills of LISTENING and OBSERVING

Typical questions

- How were the programme objectives determined?
- How are they consistent with the institution missions?
- How does the institution accomplish the objectives?
- How is the review and update done?
- How does the institution knows that the objectives are met?
- How are your stakeholders involved?

EVALUATION FLOW CHART



POINTS TO CONSIDER IN DERIVING FINDINGS/CONCLUSION

- ✓ Establish requirement
- ✓ Probe process
- ✓ Whom do you speak to?
- ✓ What to look for?
- ✓ Sampling
- ✓ How long to persist?
- ✓ Is there any shortcomings?
- ✓ Is it significant?
- ✓ Consult team members

EFFECTIVE COMMUNICATION

Occurs when the right person, says the right things, to the right people, at the right place at the right time and in the right way to be heard and understood and to produce the right response.

Important

- Person is at ease in communicating with the Evaluator.
- Evaluator should do all he/she can to make person feel at ease.


Terrace Cafe

EFFECTIVE COMMUNICATION (Cont..)

Tips

- **Gain attention** from the person before starting.
- Explain clearly the **purpose** of the session/visit.
- Include **friendly remarks** or express your interest in what he/she is doing.
- **Politeness** all the way never antagonise or belittle the person.
- Establish **eye contact** all the times.
- Communicate in the **language** he/she is **comfortable**.
- Use of **body language** to promote the dialogue. (Spoken message is 7%, verbal and vocal 38% and 55% facial).
- Listen, listen, listen, an Evaluator need to train himself to be an active **listener**.


Interviewer
Interviewee

TIPS ON GOOD LISTENING

Tip # 1

Be open! Switch off all **negative thoughts** about the person. Respective to what is being said. Drop those emotional barriers that filter out what is being said or **cause you to hear only what you want to hear**.

Tip # 2

Start listening to the first sentence! Self-centered people can't actively listen. They tend to be preoccupied with their own daydreams. Put aside what you are doing and **concentrate on what the person is saying**.

Tip # 3

Concentrate on what is being said! Actively try to hear every words as if it were the most important thing you could hear at that moment. **Avoid the temptation to think faster than the person is talking**.

Tip # 4

Look for the meaning of what is being said. Don't try to read your own meanings into what the person is saying. Rather, **help the person convey his or her own meanings by showing genuine interest**.

Tip # 5

Avoid the temptation to interrupt! Dr. David Schwart, in his *book The Magic of Thinking Big*, says "Big people monopolize the listening. Small people monopolize the talking'.

Tip # 6

Ask questions that **stimulate the person to talk and clarify your understanding of what is being said**. Use trail questions, like "**Do I understand correctly that**…," to test your understanding.

Tip # 7

Record important point being made. If appropriate, take notes.

Tip # 8

Screen out interruptions and **ignore distractions**.

Tip # 9

Use facial expressions and **body language** to express interest and comprehension.

Tip # 10

Don't over-react to highly charged or emotional words; look for the meanings behind those words. **Avoid jumping to conclusions**. Hear the person out.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EVALUATOR'S CHARACTERISTICS

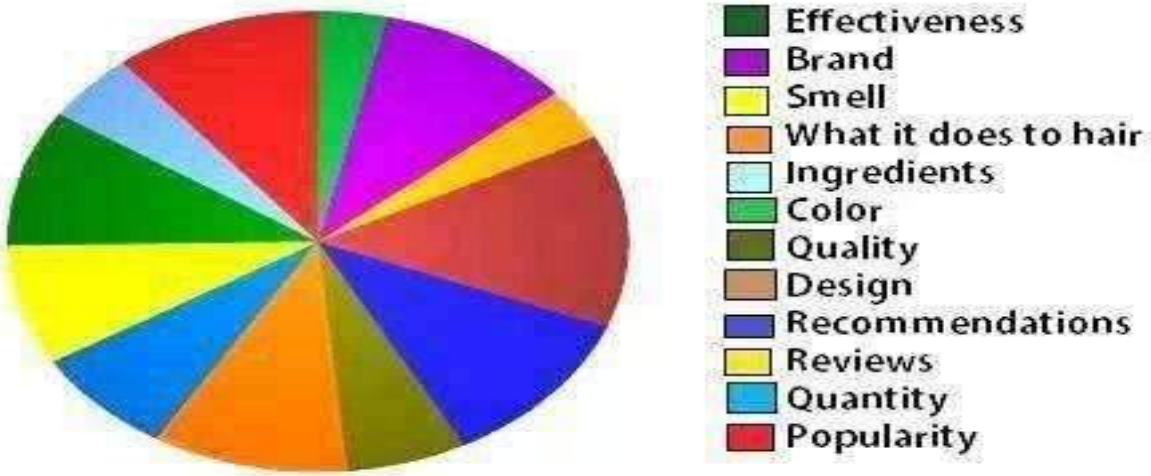
YES

- Punctual
- Objective
- Analytical
- Open minded
- Inquisitive
- Polite
- Good communicator
- Honest
- Impartial
- Industrious/good judgment
- Patient

NO

- Cynical
- A nit picker
- A quitter
- Argumentative
- Anxious to please
- opinionated

HOW WOMEN CHOOSE SHAMPOO:



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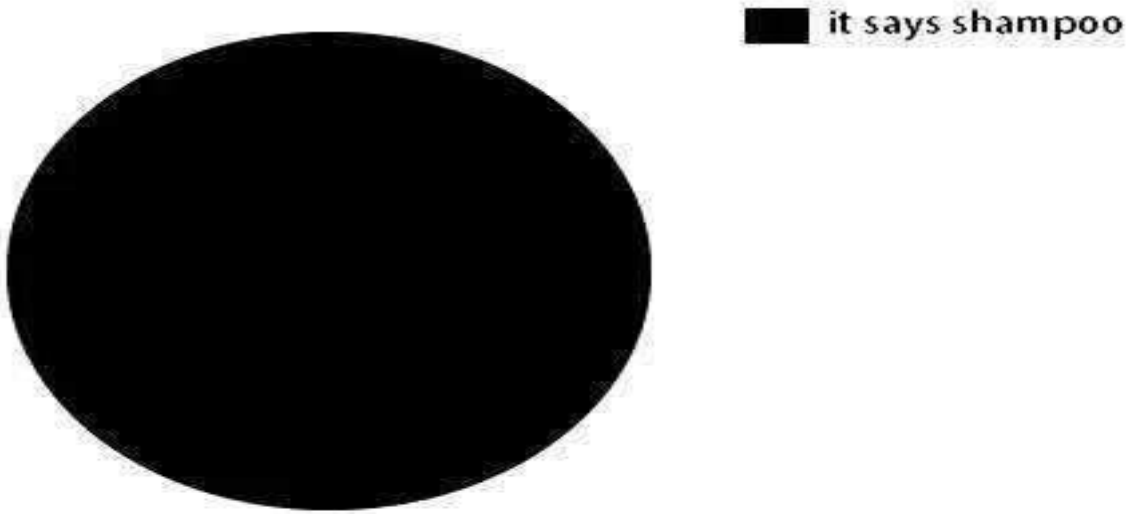


COMPETENCY OF EVALUATORS

- Organizing skills
- Knowledge of the manual
- Questioning skills
- Comprehensiveness of the evaluation
- Listening to persons
- Overall appearances
- Reporting
- Overall judgment
- Overall rapport with persons
- Aplomb (self-confidence) and decorum (etiquette)

PRACTICAL TIPS ON EVALUATION

Tip 1

Evaluators are adequately **trained**. The blind can only led the blind.

Tip 2

Evaluators know the area they are entering. Do some research prior to the evaluation. Read manual, procedures , previous evaluation reports and other records. Take time to prepare your **checklist**.

Tip 3

Department Head, supervisor and other personnel should be clear of the **purpose** of the evaluation.

Tip 4

Record findings immediately

Reporting

- Qualitative
- Strength
- Shortcomings (weaknesses)
- Concerns
- Opportunities for Improvement (OFI)

Evaluation Panel Report - Issues

- Detailed / Skimpy
- Nitpicking
- Usage of words (weakness, inadequate etc)
- Interpretation of the Clauses of Manual / Guidelines (& Appendices)
- What is Engineering? Prescriptive Clauses
- Breadth & Depth (taxonomy)
- “don’t want to be bad boys/girls” attitude
- Summary (forest) from triangulation

What constitutes strength?

- **Exceeds** the minimum standard set by the EAC Engineering Accreditation Manual.
- **Extensive benchmarking** (not only via the external examiners path) with more established programmes/institutions.
- The **curriculum** is built on **strong fundamentals** (engineering sciences) and appropriate engineering knowledge according to the discipline, which transcend national boundaries.
- **Generic attributes** (professional and/or interpersonal skills) should also be **evident** to prepare graduates for the advanced part of their career.

What constitutes strength? Cont…

- A curriculum with **clear (measurable) objective(s) and outcomes** (that satisfies the ten (10) EAC stipulated outcomes)
- Involved stakeholders, both internal and external, **extensively**
- An **appropriate working load for students** determined through **extensive consultation** with the academics (Usually a 15 – 16 credit per semester loading)
- Blend of **delivery methods**

What constitutes strength? Cont…

- Programme **challenges students** to achieve greater heights than just satisfying the minimum standard
- Attain competency in the **open-ended** project based and problem oriented courses
- Majority of the staff has **PhD** qualification and the number available indicates a **low staff-student ratio** (that enables greater contact with students)
- The academic staffs also conduct **research that permeates**/contributes to teaching and learning.

What constitutes strength? Cont…

- Over and above Industrial Training **(extensive & distributed professional exposure)** that does not compromise on the cognitive domain
- **Ergonomics** is taken seriously by the institution to reduce occupational hazard
- **Safety** culture
- Show that they have the **plan** and the completion of the **quality cycles is widespread**
- **Monitoring of the QMS** also indicates strength.

What constitutes strength? Cont…

- Students' ability to give opinion and **articulate with substance**
- Students are clear of their goals upon graduation and **highly motivated** during their course of study ("constructive criticisms")
- **Widespread involvement** of students in **co-curricular activities** (not forced as part of curriculum nor limited to small group of students).

What constitutes strength? Cont…

- Academic staff with **Professional Engineer status**
- Academic staff are **actively participating in professional activities** (not merely members)
- **Design courses** are taught by **experienced academics** (with consultancy experience or professional engineers).

Classifying Concern

- Usually a “concern” is that the programme has **not failed** the criteria set under the EAC Manual, but if left unchecked may lead to **failure at a later date**
- Where there are **lapses** in observing the criteria of the EAC Manual, it would appropriately be classified under “concern”.
- “Concern” can be **minor** (eg. soft skills extensiveness /depth /assessment) or **major** (eg. depth of assessment for cognitive domain)

Classifying Concern (Cont…)

- There is **not enough depth/insight** on the content for a few courses based on the teaching materials provided and course outline/plan written.
- The **semester load** is on the **higher side**.
- Not enough of **discipline examples** for “exotic” programmes

Classifying Concern (Cont…)

- Students are **unaware of the importance of sustainability, safety, and professional involvement** etc, which reflect the lack in generic attributes expected of them.
- Staff and Students lacked the **understanding on the outcome approach.**
- Available **academic staff** are confined to a **specific sub-discipline** only instead of covering all the relevant sub-disciplines of the programme.

Classifying Concern (Cont…)

- Many of the staff are **not involved in research** or **research does not permeate** to student's learning.
- Availability of **time to conduct research and involvement in professional activities** for the academic staff.
- **No evidence** of practices taking place **despite a written policy.**
- Lack of grants obtained by the academic staff should not be used solely to conclude that research has not taken place – look at final year projects.

Classifying Concern (Cont…)

- **Inadequate monitoring** despite having a system
- Mapping and linking of programme objectives/outcomes to the course outcomes are just **on paper**
- **Moderation** of examination questions/ assessment **does not capture** lack of depth.
- **Feedbacks** to students/staff from assessment/complaints/comments/queries made are **not responded/late**.

Opportunity for Improvement

- OFI, an institution could consider **despite already having the necessary strength** or having already satisfied the minimum requirements of the EAC Manual.
- Institutions would **not be penalised** for not taking the necessary action to address the issue. **May raise as a concern at the next visit**
- It would be **against the spirit of continual improvement** that has been set by the EAC Manual.

What constitutes weakness?

- The word "**weakness**" **used freely** denoting any part of the policy, plan, activity, resources or system that does not quite satisfy the expected effectiveness
- Try using other words, such as, **"shortcomings", "improper", "undesirable" and "dissatisfactory"** to denote lapses in adhering to the criteria
- Otherwise the outcome decision would be "decline accreditation", as "weakness" refers to **non-compliance** to the EAC Manual.
- A **number of major concerns**.

Team Chair: Presentation to Board

- University Programmes evaluated
- Strength, weakness, concern, OFI
- Recommendation(s)

Accreditation Decision

- **Five years**
- **Five years with interim or Less than five years**, for Minor & Major shortcoming(s). A further visit will be scheduled to verify the results of the remedial action(s), unless deemed unnecessary
- **Decline**, a further application will normally not be considered within the next one year.
- **Defer**, to allow the IHL to fulfil condition(s) that may be imposed

Decisions

Concerns	No	Yes	No
Weakness	No	No	Yes
Accreditation	Yes = 5 yrs	Yes = Less than 5 yrs	No or defer

Random Observations

- Bullet points & Aggregation
- Ambiguous
- Poor time management
- Guidelines supersede Manual
- Keywords as sole determination
- Interrogative

Expectations on Evaluators

- Commitment
- Not Auditors
- Reference Material: EAC Manual
- Pre-Visit planning & discussion
- Day-1 meeting (seen doing)
- Visit Day Aplomb & Decorum
- Reporting
- Response to factual inaccuracies

Aplomb & Decorum - Evaluators

- Objective
- Official
- Understand the situation
- Understand the Manual
- Be prepared
- Collegial
- Good time keeping
- Right body language
- No surprises

- No nitpicking
- Pursue issues (Inquisitive)
- Non-prescriptive/non-directive
- Triangulate
- No promises
- Identify strength, concern, OFI and weakness

Aplomb & Decorum - Evaluators

- Stop giving solutions
- Seek objective evidence
- Impartial
- Not interrogative
- Good listener
- No favours
- Confidence
- Authoritative
- Firm

- Not sidetracked
- Punctual
- Analytical
- Open minded
- Polite
- Good communicator
- Honest
- Industrious
- Good judgment
- Patient

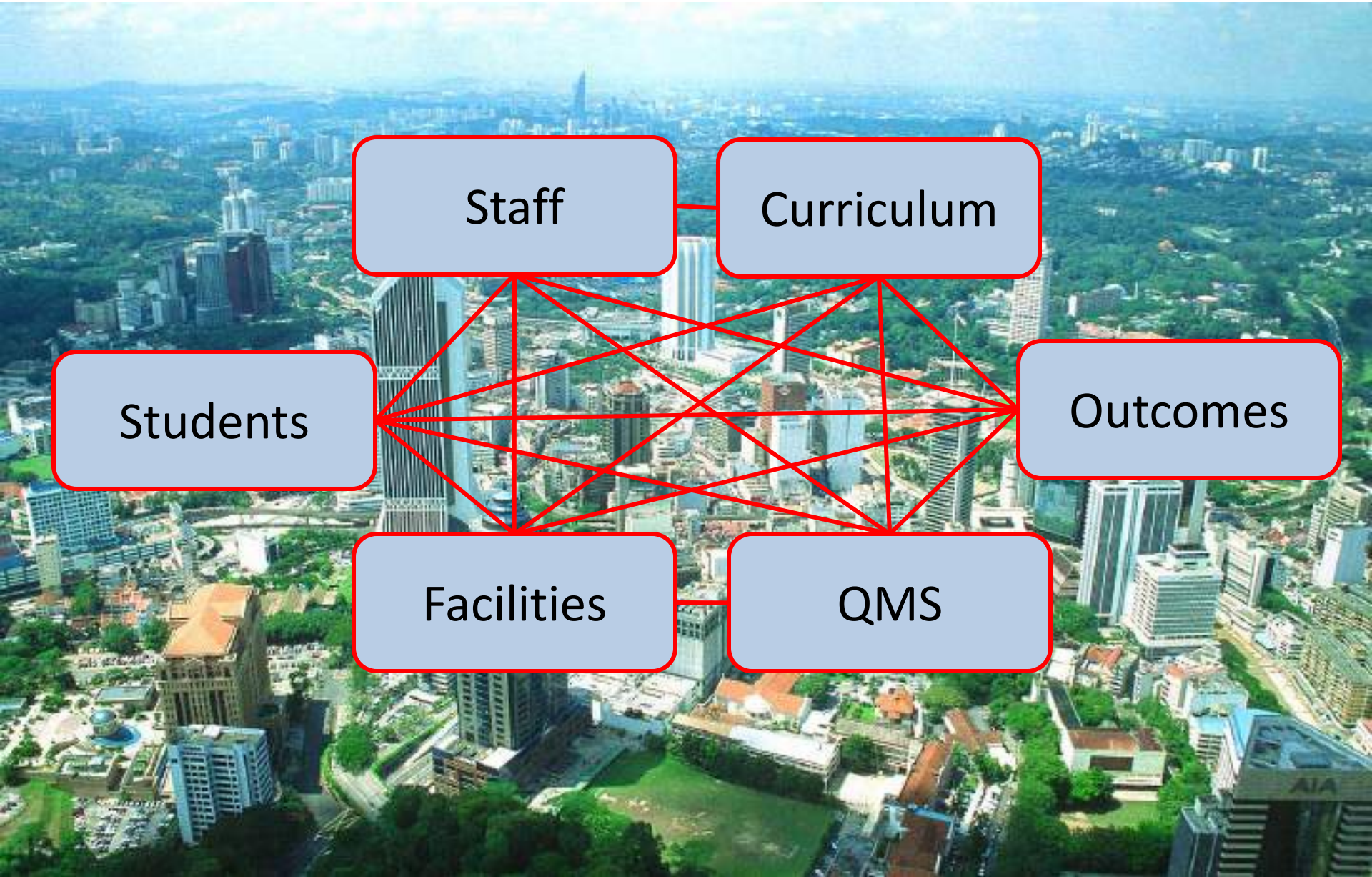
Notes and Statements

- Make notes on all findings (including compliances and strength)
- Ensure consistency between notes and exit statements
- Exit statements support recommendation made

Facts & Compliance

- Facts
- Compliance
  - Strength
  - Concern
  - OFI
  - Weakness (Deficiency)

Results Triangulated by Evaluators



Evaluators @ *Day-1 & Visit Day*

- Preparation
- Confidence
- Formal
- Organised
- Collegial
- Listening
- Probing
- Triangulating
- Time management
- No surprises
- No excess baggage

- Observe
- Interview
- Document/Records

- Depth of Assessment
- Programme Outcomes
- Quality improvement
- QMS

Minimum mastery of engineering knowledge

What WA will be observing?

- Adherence to PEC/EAB document
- EAB evaluator's aplomb and decorum
- Probing questions (not interrogative)
- Discussion level
- Clarity of reports
- Graduate outcomes
- Health & safety at IHL
- Equivalency of practice

Malaysia's WA Review Checklist

EAD

- Prepare "WA Review Plan"
- Review EAD/EAC Accreditation Process & Document
- Prepare the 2014 Accreditation list
- Identify IHLs for the Review visit
- Confirm & Request for the IEA-WA Reviewers (US, SA, Taiwan)
- Reflect on the 2009 WA Review report
- Arrange the Review visits of the selected IHLs
- Prepare selected IHLs to receive the visit

EAC Evaluator

- Plan & Conduct the Accreditation (Review) Visits
- Write Accreditation report & respond to factual inaccuracies/corrective actions
- Participate in Pre-ADM (Decision meeting)

EAC

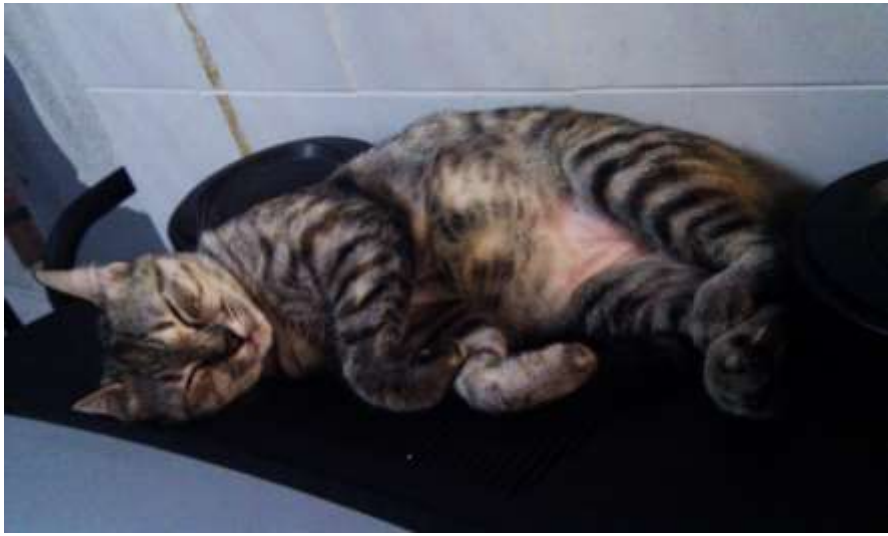
- Conduct ADM (Decision meeting; Apr, Aug, Dec) in the "presence" of the IEA-WA Reviewer
- Respond to IEA-WA Review report

WA

- Submit Review Report to IEA-WA by Jan 2015
- Circulate Review Report to all signatories by March 2015
- Table Review Report at the June 2005 IEA Meeting

Role of PEVs

- What do you think of your job as a PEV?
- TOO MUCH WORK !!!!!



Universities are always caught in between?

University Dilemma

Welcoming the Accreditors

CONCLUSION

- Challenges
  - IHL: OBE Approach ; Improving Standards
  - PEC: Changing Paradigm ; Innovative & Creative Programmes
- Maintaining Standards
- Engineering Education clearly defined
- Trained Panels
- Consistency in decisions

THANK YOU

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Activity 1

- Make overall comments on the self-assessment report
- Note down findings based on the 7 criteria
- Make overall comments on the following:
  - Engineering curriculum
  - Outcome based approach
  - Continual quality improvement

Activity 2

- Prepare a checklist for the evaluation visit

Activity 3

- Prepare the script for the opening meeting
- Prepare the script for the closing meeting

Activity 4

- Prepare a presentation for the EAB Decision Meeting

Workshop for Program Evaluators

Prof. Megat Johari Megat Mohd Noor

Director of Quality & Risk Management Centre,

Universiti Teknologi Malaysia (UTM) Kuala Lumpur Campus

Ir. Azlan Abdul Aziz

Former Director of Engineering Accreditation Department,

Department of Civil Engineering, Universiti Putra Malaysia (UPM)

Lahore & Islamabad, Pakistan

19 April 2014

Outcome-based Education

19th April 2014

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14.00 – 15.30	1.5 hr	Megat/Azlan
15.30 – 16.00	0.5 hr	Tea Break
16.00 – 17.30	1.5 hr	Megat/Azlan

OBE & What to look for in Accreditation

Outline

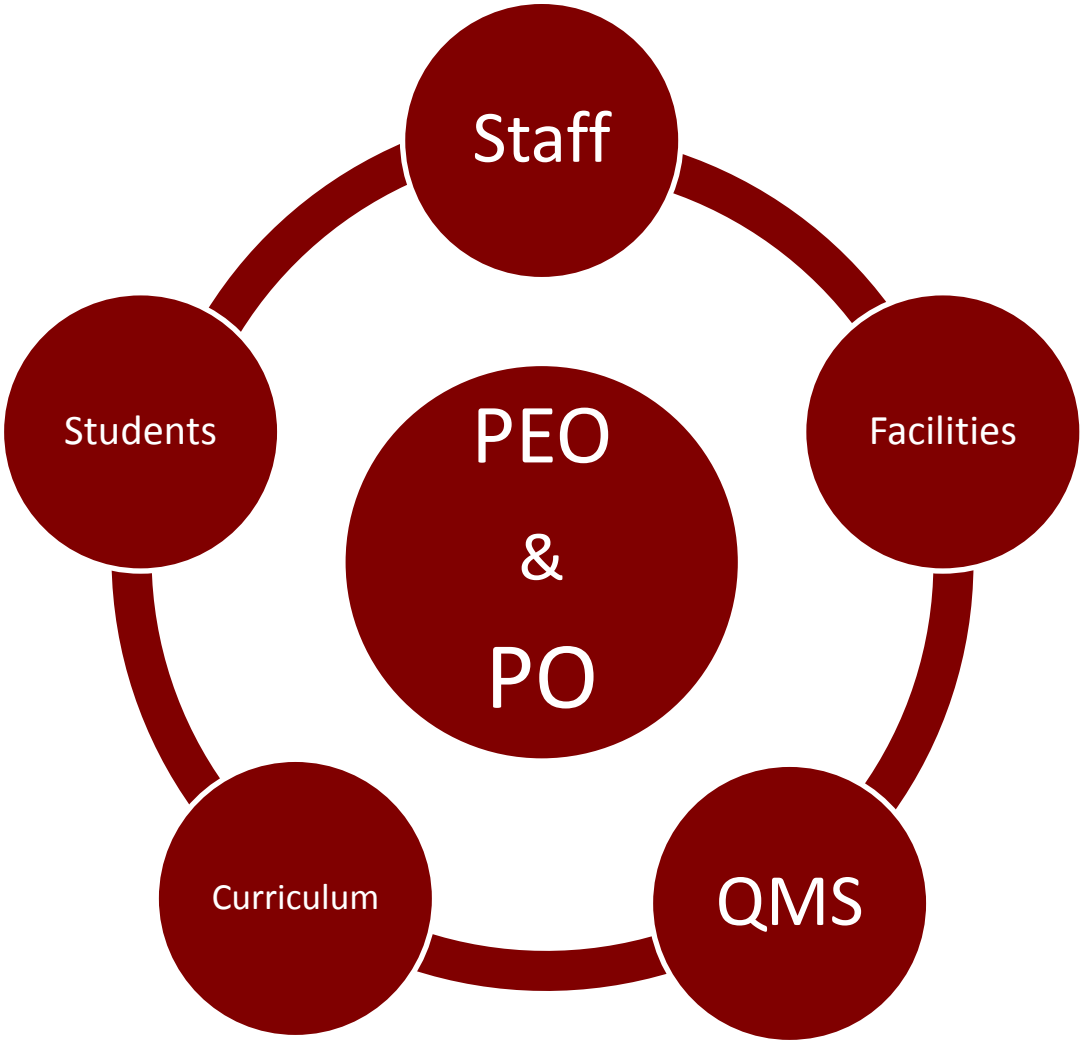
From previous visits, need to emphasise on

- PEO
- PO
- Curriculum/ Depth of knowledge
- Complex Problem Solving/ Taxonomy
- Assessment & Evaluation, CQI, safety
- Probing and Triangulation

Accreditation Objective

- Ensuring the expected engineering education level is maintained (breadth and depth)
- Outcome-based engineering education (OBE) programme is practised
- Continual Quality improvement (CQI) on Programmes applied
- Quality Management System practised

Accreditation Criteria and Qualifying Requirements



Outcome Based Education

- OBE is a process that involves assessment and evaluation practices in education to reflect the attainment of expected learning outcomes and showing mastery in the programme area

- OBE in a Nutshell

What do you want the students to have or able to do?

How can you best help students achieve it?

How will you know what they have achieved?

How do you close the loop

Strategy of OBE

- Top down curricula design
- Appropriate Teaching & Learning Methods
- Appropriate Assessment & Evaluation Methods

Programme Objectives (PEO) and Programme Outcomes (PO)

PEO are specific goals consistent with the vision & mission of IHL

Look for the

- Published statements of PEO
- Clear linkages between PEO and PO
- Involvement of constituents/ stakeholders
- Expected to be achieved/analysed a few years after graduation (usually for about 5 years of employment) except for new programmes. Look for measurable indicators for each goals.

PEO – Typical Questions

- How were the PEO determined?
- How are they consistent with the institution missions?
- How is the review and update done?
- How does the institution know the objectives are met?
- Who are the stakeholders?
- How are the stakeholders involved?

Programme Outcomes (PO)

- POs are statements that describe what students are expected to know and be able to perform or attain by the time of graduation
- Knowledge, skills and Behaviour/Attidude (Cognitive, Psychomotor and Affective Domains)
- Outcomes (i) to (xii)

PROGRAMME OUTCOME

(i) Engineering Knowledge
Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems;

PROGRAMME OUTCOME

(ii) Problem Analysis

Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences

PROGRAMME OUTCOME

(iii) Design/Development of Solutions

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

PROGRAMME OUTCOME

(iv) Investigation

Conduct investigation into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions

PROGRAMME OUTCOME

(v) Modern Tool Usage

Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations

PROGRAMME OUTCOME

(vi) The Engineer and Society

Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice

PROGRAMME OUTCOME

(vii) Environment and Sustainability

Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development

PROGRAMME OUTCOME

(viii) Ethics

Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice

PROGRAMME OUTCOME

(ix) Communication

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

PROGRAMME OUTCOME

(x) Individual and Team Work

Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings

PROGRAMME OUTCOME

(xi) Life-long Learning

Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAMME OUTCOME

(xii) Project Management & Finance

Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO – Typical Questions/ Probe

- How are the POs published?
- How are the POs considered in the curriculum design?
- How is the process of measuring, assessing and evaluating the attainment of PO is established?
- How are the results from the assessment (measuring, assessing and evaluating) are applied towards CQI?

PO (Cont)

- Assessment process and documented evidence:

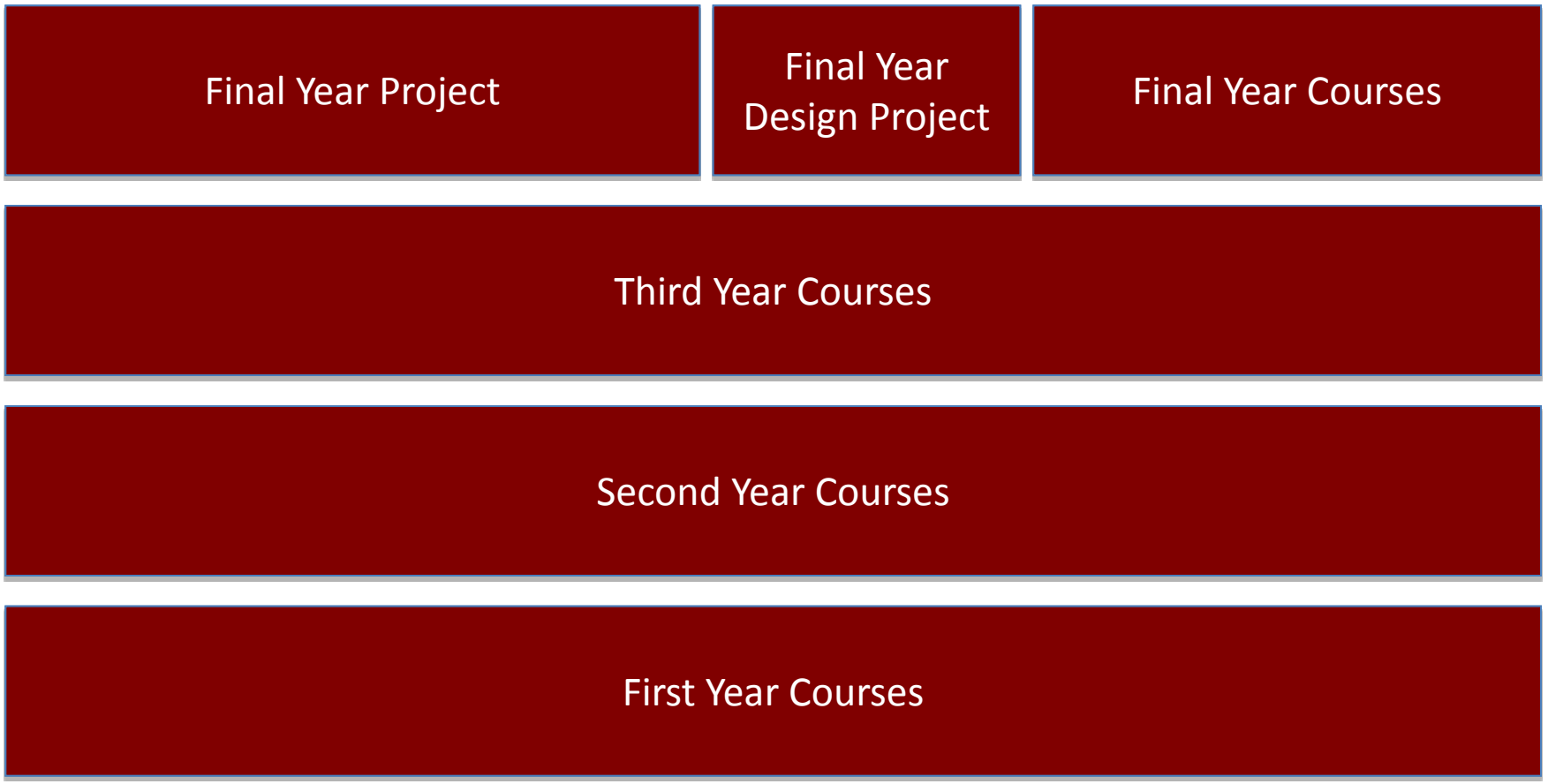
  - anecdotal vs measured results (data are sometimes embedded and reused)

  - reliance on course grades only

  - over reliance on indirect assesment (survey)

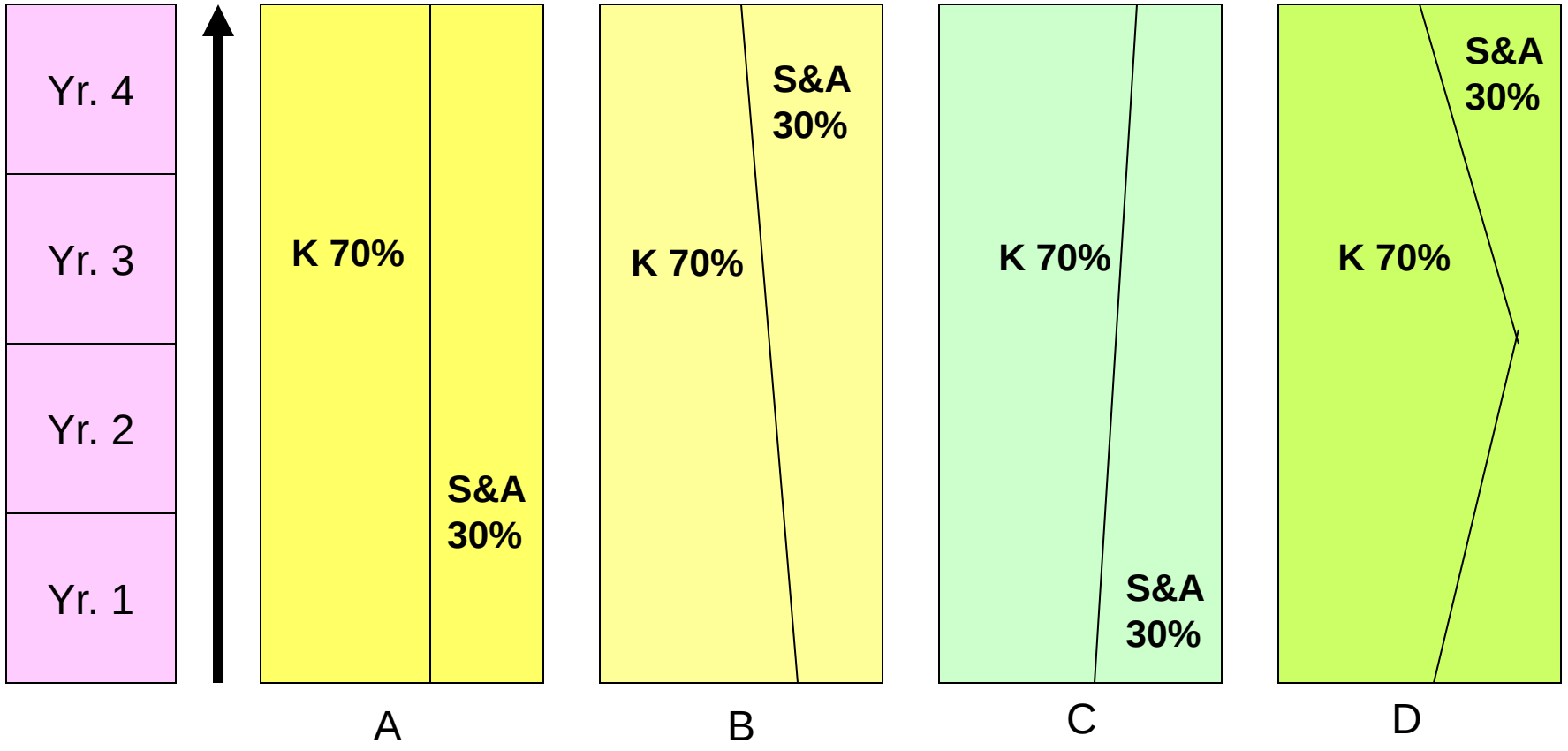
  - plan available but not implemented (looks nice on paper!)

PO Attainment



Operation Models for OBE

Distribution of K,S,A elements throughout the 4 years



WA's Knowledge Profile (Curriculum)

The curriculum shall encompass the **knowledge profile** as summarised in the table below:

Knowledge Profile
A systematic, theory-based understanding of the natural sciences applicable to the discipline (e.g. calculus-based physics)
Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline
A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
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
Knowledge that supports engineering design in a practice area

Knowledge Profile (Curriculum)

Knowledge Profile
Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
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
Engagement with selected knowledge in the research literature of the discipline

Characteristics of OBE curricula

- It has programme objectives, programme outcomes, course learning outcomes and performance indicators. It is centered around the needs of the students and the **stakeholders**.
- It is objective and outcome driven, where stated objective and outcomes can be **assessed and evaluated**.
- Suitable tools and methods are used to measure and evaluate attainment of the outcomes
- Results from evaluation are used for CQI

Depth of Knowledge Required

Complex Problems (Engineer)	Broadly Defined Problems (Technologist)	Well defined Problems (Technician)
Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach	Requires knowledge of principles and applied procedures or methodologies	Can be solved using limited theoretical knowledge, but normally requires extensive practical knowledge

Definition of Complex Problem Solving (IEA WA)

The range of **complex problem solving** as required by the Programme Outcomes in Section 4.0 is defined as follows:

	Attributes	Complex Problems
1.	Preamble	Engineering problems which cannot be resolved without in-depth engineering knowledge, much of which is at, or informed by, the forefront of the professional discipline, and have some or all of the following characteristics listed below:
2.	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.
3.	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.

Definition of Complex Problem Solving

	Attributes	Complex Problems
4.	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.
5.	Familiarity of issues	Involve infrequently encountered issues
6.	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.
7.	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.

Definition of Complex Problem Solving

	Attributes	Complex Problems
8.	Consequences	Have significant consequences in a range of contexts.
9.	Interdependence	Are high level problems including many component parts or sub-problems.

Strategy of OBE

- Top down curricula design
- Appropriate Teaching & Learning Methods
- Appropriate Assessment & Evaluation Methods

Adequacy of Academic Curriculum

Some things to look for :

- course structure and sequence
- appropriate breadth and depth
- adequate time for contents
- mechanisms used for identifying topics
- Matrix linking PO to courses, courses linked to assessment with stated PO

Adequacy of Academic Curriculum

Some things to look for:

- Environment & Sustainability, Project Management & Finance, Engineer & Society (ethics, legal issues, etc). Some Eng. Prog. lack these courses/ topics
- Integrated exposure to PE practice, incl mgmt and ethics
- Exposure to engineering practice – use of guest lecturers; use of staff with industrial experience; industry-based final year/design project

Learning outcomes by adding a condition and standard

Poor

- **Students should be able to design research.**

Better

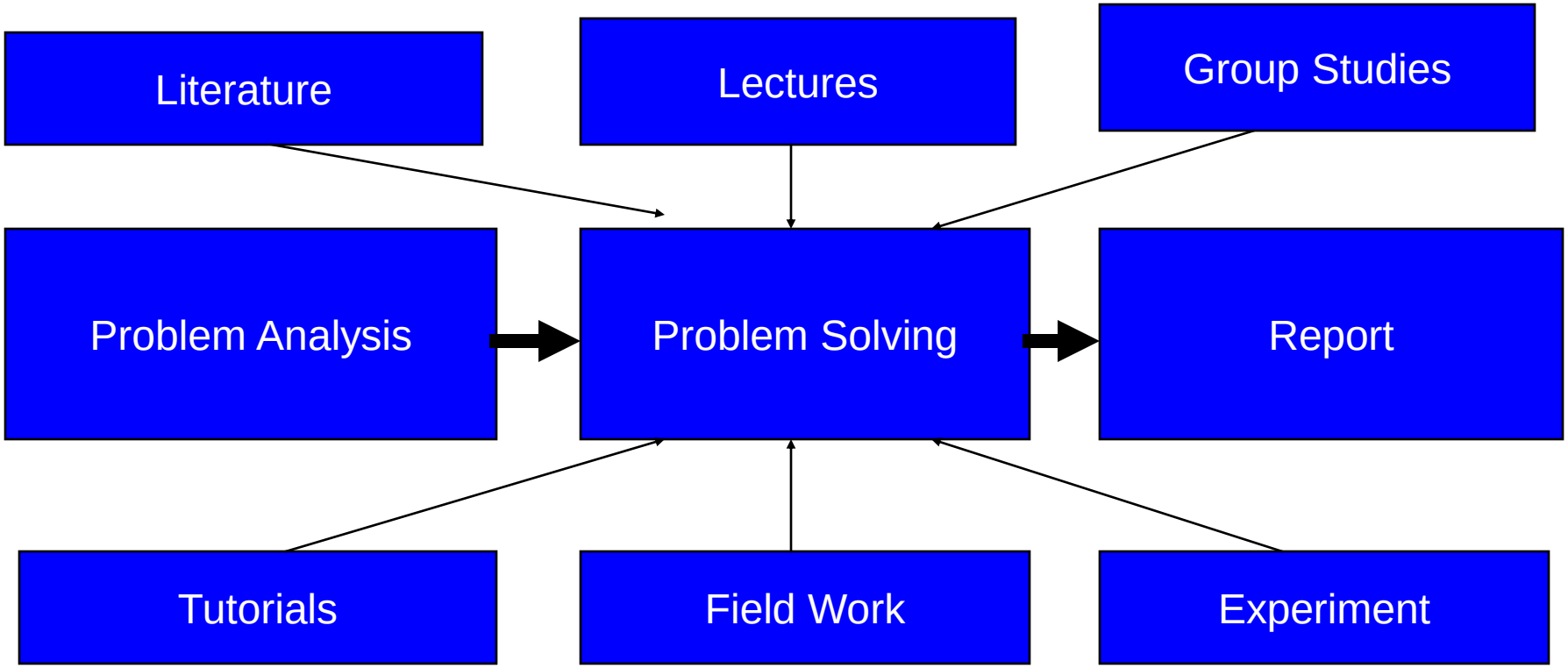
- **Students should be able to independently design and carry out experimental and correlational research.**

Best

- **Students should be able to independently design and carry out experimental and correlational research that yields valid results.**

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

Problem organised project work



ASSESSMENT:

Processes that identify, collect, use and prepare data for evaluation of achievement of programme outcomes or educational objectives.

EVALUATION:

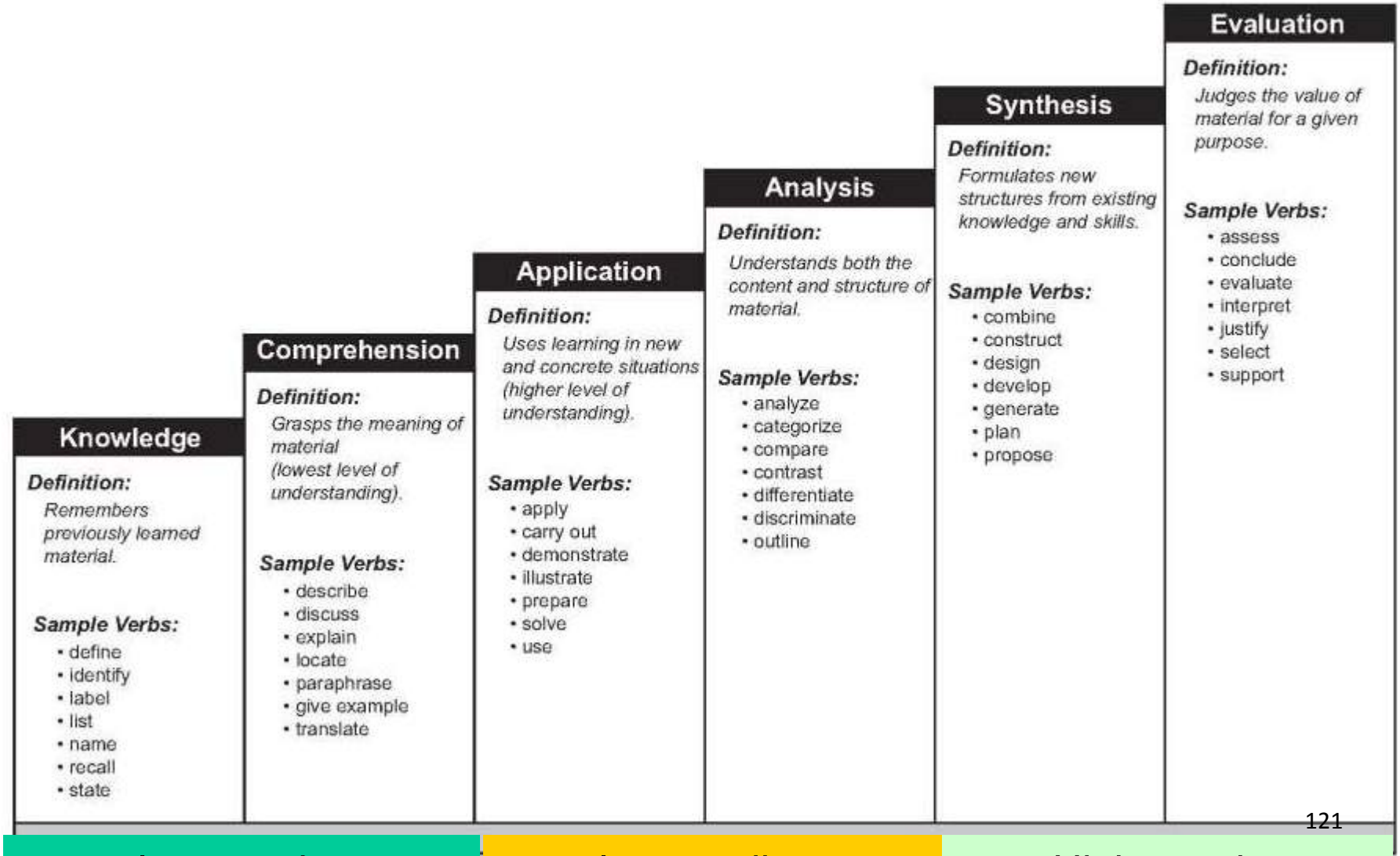
Processes for interpretation of data and evidence from assessment practices that determine the program outcomes are achieved or result in actions to improve programme.

Depth of Assessment: Bloom's Taxonomy (Cognitive)

- Knowledge (list)
- Comprehension (explain)
- Application (calculate, solve, determine)
- Analysis (classify, predict, model, derived)
- Synthesis (design, improve)
- Evaluation (judge, select, critique)

Cognitive Domain

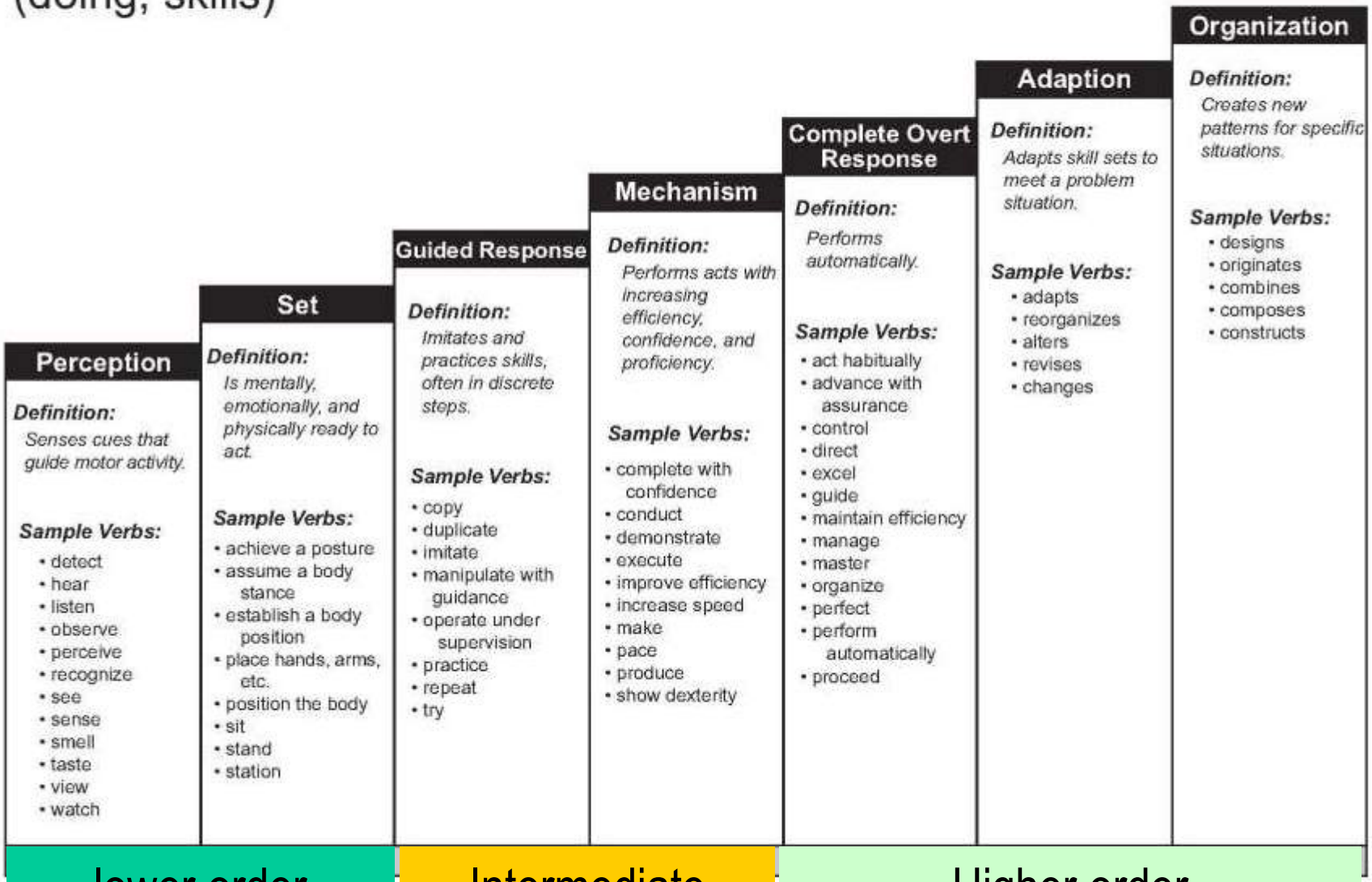
(thinking, knowledge)



lower order | Intermediate | Higher order

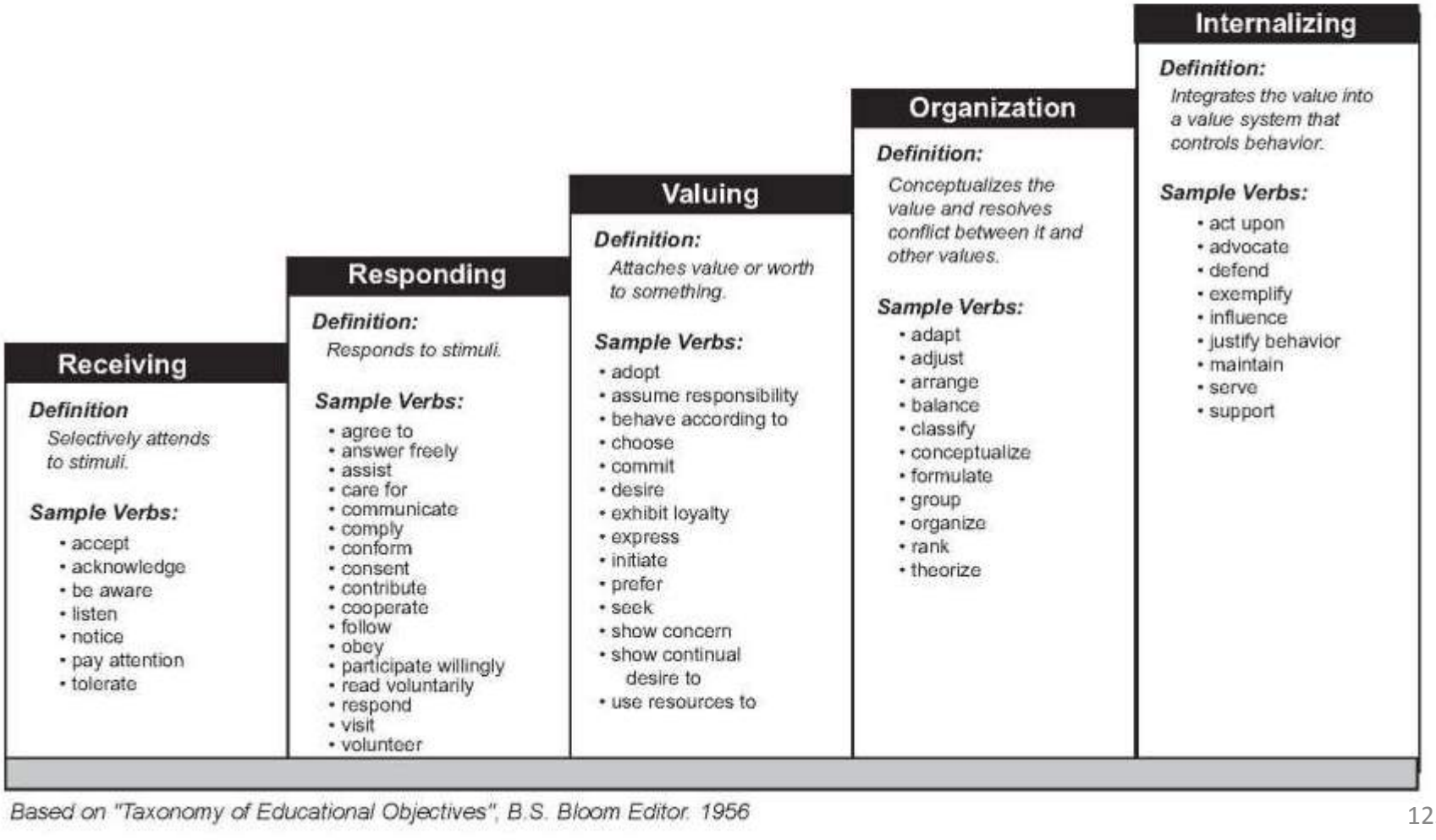
Psychomotor Domain

(doing, skills)



Affective Domain

(feeling, attitudes)

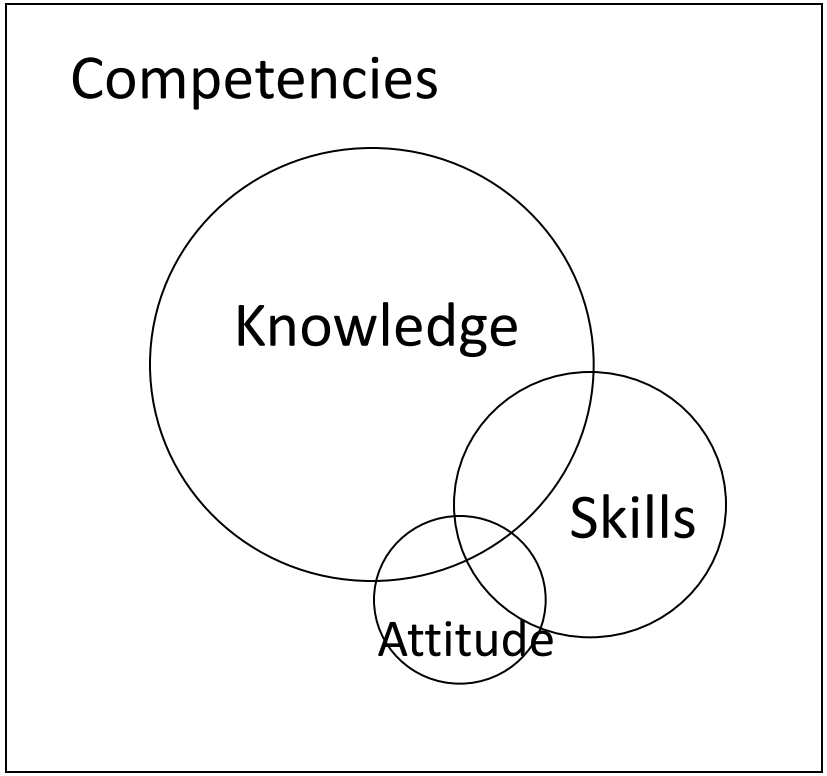


Based on "Taxonomy of Educational Objectives", B.S. Bloom Editor. 1956

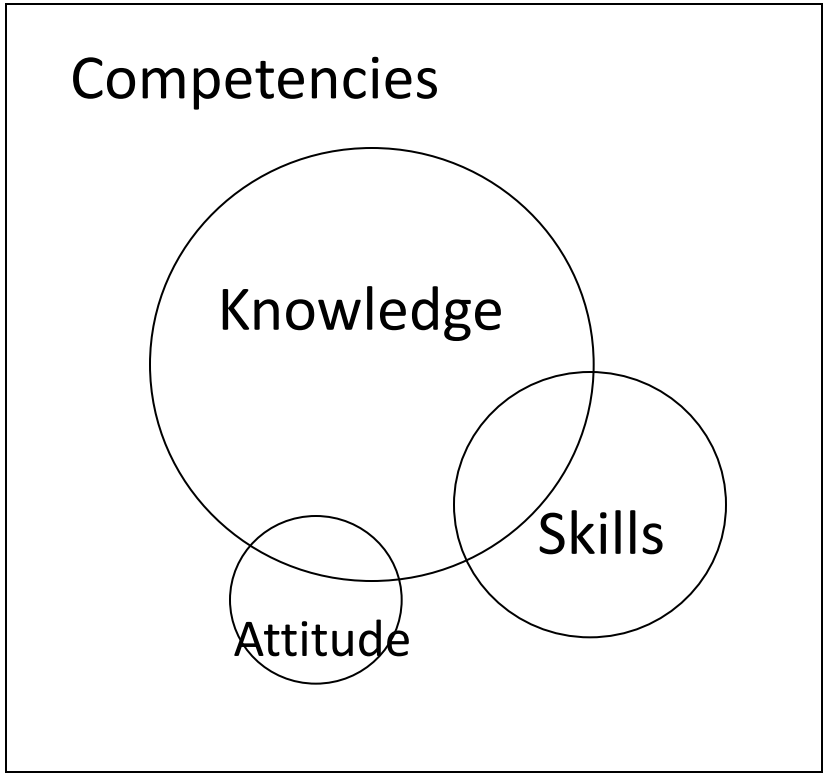
Course Coverage & Assessment

When assessing, an instructor must consciously assess and evaluate the applicable elements (Knowledge, Skills, Attitude aka Cognitive, Psychomotor, Affective Domains). An activity may be used to examine all the three elements related to the PO

Model A



Model B



Uniform Use of Rubrics for Assessment

Oral Communication Assessment Rubric

Scale	1	2	3	4	5
Criteria	**Poor**		**Acceptable**		**Excellent**
1. Content	Topic is poorly developed with supporting details that are absent or vague. Trite ideas and/or unclear wording reflect lack of understanding of topic and audience.		Topic is evident with some supporting details; generally meets requirements of assignments		Topic is well developed, effectively supported and appropriate for the assignment. Effective thinking is clearly and creatively expressed.
2. Organization	Speech is rambling and unfocussed, with main theme and supporting details presented in a disorganized and unrelated way		Speech demonstrates some grasp of organization, with a discernible theme and supporting details.		Speech is clearly organized with effective introduction and conclusion. Each segment relates to the others according to carefully planned framework.
3. Delivery	Speaker appears unpracticed. Unnecessary pauses or filler words. Problems with voice control, eye contact or posture. Incorrect or inappropriate language. Visuals/notes are not used as needed.		Speaker appears proficient with language, vocal and physical expression. Notes and visuals are used as needed.		Speaker uses grammatically correct and appropriate language. Smooth and effective delivery. Good eye contact, voice control and physical demeanour. Notes and visuals used to enhance the presentation.

Assessment/Evaluation tools

- Exit surveys, Exit interviews (P)
- Alumni surveys and interviews (P)
- Employer surveys and interviews (P)
- Job offers, starting salaries (relative to national benchmark) (P)
- Admission to graduate schools (P)
- Performance in group and internship assignments and in PBL situation (P,C)
- Assignments, report and tests in capstone design course (P,C)
- Standardized tests (P,C)

P: Program C: Course

Assessment tools (cont)

- Student surveys, individual and focus group interviews (P,C)
- Peer-evaluations, self evaluations (P,C)
- Student portfolios (P,C)
- Behavioral observation (P,C)
- Written tests linked to learning objectives (C)
- Written project reports (C)
- Oral presentation, live or videotape (C)
- Research proposals, student-formulated problems (C)
- Classrooms assessment Techniques (C)

Institutional Mission Statement

Stakeholders Interest

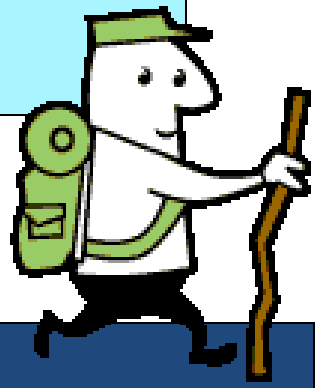
Programme Objectives

Programme Outcomes
(Knowledge, skills, attitudes of graduates)

Outcome-Related Course Learning Objectives
(Ability to: explain, calculate, derive, design)

Assessment of Attainment Level

Continual Improvement, CQI



Facilities

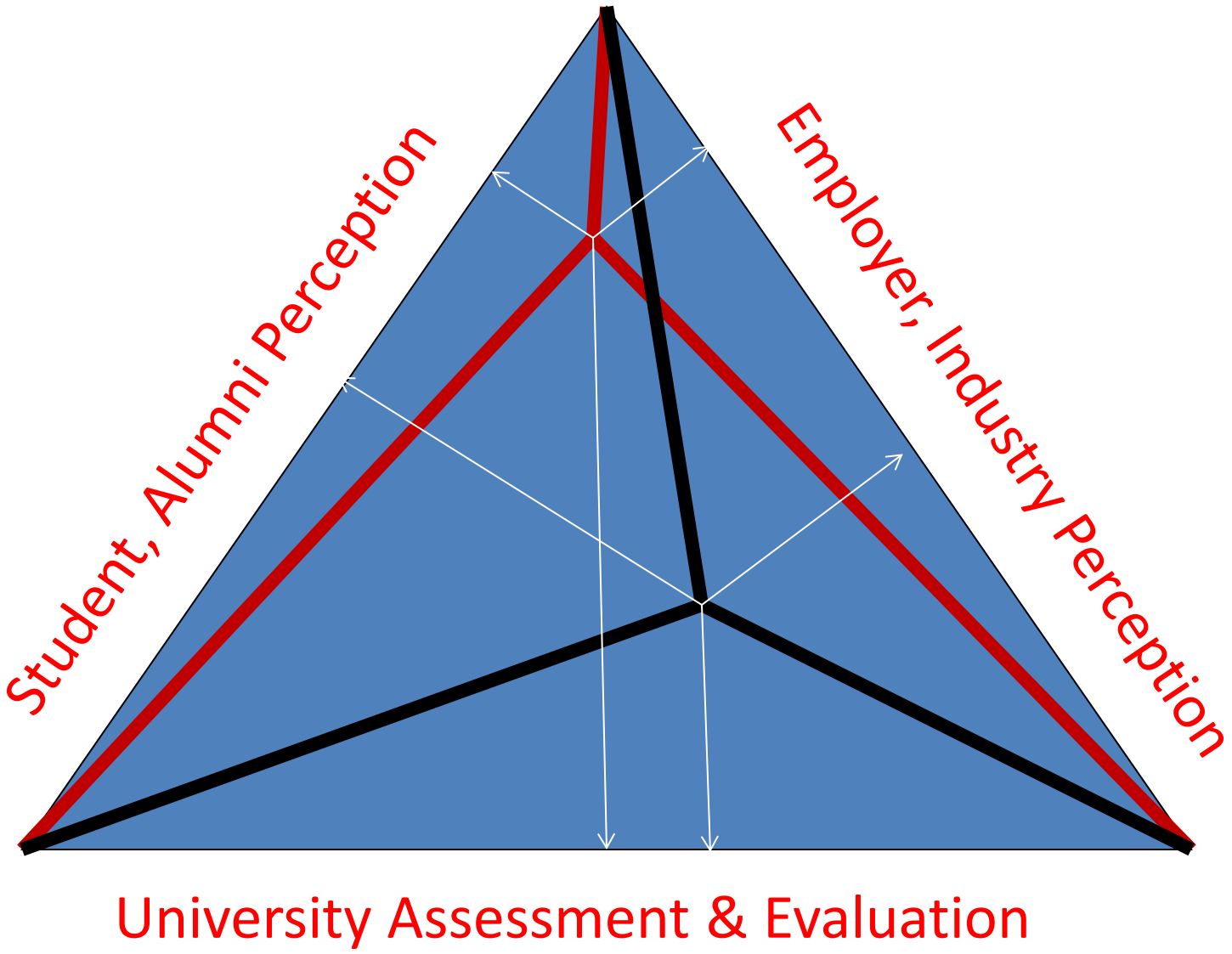
Some things NOT previously probed

- Classrooms, laboratories, equipment

  -Safety issues
- Opportunity to use modern engineering tools
- Computers

  -Ergonomics

TRIANGULATION OF DATA COLLECTED THROUGH PROBES BY PEVs TO GET THE BIG PICTURE



THANK YOU

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Exercise 1

Scenario

- OneMalaysia University decided to start a new “general” engineering programme (Bac of Eng) in addition to the existing two programmes. The existing programmes have only one common programme objective, i.e., “to produce engineers (according to the related field). The team which includes you is responsible to develop the new programme, and had decided to expand the programme objectives to include
  - Global player
  - Leading in advanced design

Questions

- Identify the appropriate POs for the new programme, and link them to the PEOs
- Identify the suitable taxonomy level for the respective POs.
- A course, Strength of Materials has been identified as a fundamental course for the new programme. Develop the course outcomes and identify the appropriate taxonomy level.

Questions

- How would you assess the course's cognitive outcomes?
- If you have to include non-cognitive outcomes, what are the possible assessment techniques to be employed?
- Establish a mechanism to demonstrate attainment of the course outcomes (both formative and summative)
- Show that the course outcomes contribute to the programme outcomes.

Exercise 2

	PO1	PO2	PO9	PO10
CO1	+	+		
CO2		+	+	
CO3	+			+
CO4			+	+

How would you design the assessment for the above matrix?

Exercise 3

Table 1		
Q1	CO1	+
Q2	CO2	-
Q3	CO3	+
Q4	CO4	+

Discuss on the attainment of COs and POs (using Exercise 2)for both Tables, 1&2

Table 2				
Q1	CO1	+	CO2	+
Q2	CO2	+	CO3	-
Q3	CO3	-	CO4	+
Q4	CO4	+	CO1	-

Exercise 4

	PO1	PO2	PO3
C1	3	2	1
C2	2	1	2
C3	3	0	3
C4	2	1	3

Discuss on the potential problems, if any, where 3, 2, 1, and 0 refer to High, Moderate, Low, and No emphasis, respectively. C1..4 refer to the courses, whereas PO1..3 refer to Programme Outcomes.

How would cohort POs attainment be obtained?

Exercise 5

Delivery	Assessment
Lecture	
Laboratory	
PBL	
Case Method	
Project Based	

Identify suitable assessment techniques for the different delivery modes.

Exercise 6

- Write a brief executive summary of how you are going to facilitate learning in your course (remember you must be able to demonstrate that learning has taken place)

Workshop on

Complex Engineering Problem Solving/Activities

Prof. Megat Johari Megat Mohd Noor

Director of Quality & Risk Management Centre,

Universiti Teknologi Malaysia (UTM) Kuala Lumpur Campus

Ir. Azlan Abdul Aziz

Former Director of Engineering Accreditation Department,

Department of Civil Engineering, Universiti Putra Malaysia (UPM)

Pakistan Engineering Council

Islamabad, Pakistan

25 April 2014

UTM UNIVERSITI TEKNOLOGI MALAYSIA | MJIIT MALAYSIA-JAPAN INTERNATIONAL INSTITUTE OF TECHNOLOGY | UPM UNIVERSITI PUTRA MALAYSIA | MySET

25th April 2014

Time	Duration	Day 3: Complex Problem Solving
9.30 – 10.45	1.25 hr	Programme Outcomes & Knowledge Profile - Azlan
10.45 – 11.00	0.25 hr	Tea Break
11.00 – 12.45	1.75 hr	Level of Problem Solving - Megat
12.45 – 14.00	1.25 hr	Lunch
14.00 – 15.30	1.5 hr	Exemplars of Complex Problem - Megat
15.30 – 16.00	0.5 hr	Tea Break
16.00 – 17.30	1.5 hr	Discussion - Azlan

Outlines

- Program Outcomes (WA)
- Knowledge Profile (WK)
- Level of Problem Solving
- Exemplars

Azlan

International Engineering Alliance (IEA) Meeting, July 2012, Sydney

Washington Accord

- Graduate Attributes (Programme Outcomes)
- Knowledge Profile
- Level of Problem Solving

PEC Accreditation Manual 2014

uploaded on
PEC website Feb 2014

Washington Accord Graduate Attributes
PROGRAM OUTCOMES

WA1	Engineering Knowledge	Breadth & depth of knowledge
WA2	Problem Analysis	Complexity of analysis
WA3	Design/Development of Solutions	Breadth & uniqueness of engineering problems i.e. the extent to which problems are original and to which solutions have previously been identified and coded
WA4	Investigation	Breadth & depth of investigation and experimentation
WA5	Modern Tool Usage	Level of understanding of the appropriateness of the tool
WA6	The Engineer and Society	Level of knowledge and responsibility
WA7	Environment and Sustainability	Type of solutions
WA8	Ethics	Understanding and level of practice
WA9	Individual and Team Work	Role in and diversity of team
WA10	Communication	Level of communication according to type of activities performed
WA11	Project Management and Finance	Level of management required for differing types of activity
WA12	Life-long Learning	Preparation for and depth of continuing learning

PROGRAMME OUTCOME

(i) **Engineering Knowledge**

Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of **complex** engineering problems;

PROGRAMME OUTCOME

(ii) **Problem Analysis**

Identify, formulate, research literature and analyse **complex** engineering problems reaching substantiated conclusions using **first principles** of mathematics, natural sciences and engineering sciences

PROGRAMME OUTCOME

(iii) **Design/Development of Solutions**

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**

PROGRAMME OUTCOME

(iv) **Investigation**
Conduct investigation into **complex** problems using **research based knowledge** and **research methods** including **design of experiments, analysis and interpretation of data, and synthesis of information** to provide valid conclusions

PROGRAMME OUTCOME

(v) **Modern Tool Usage**
Create, select and apply **appropriate techniques, resources, and modern engineering and IT tools**, including **prediction** and **modelling**, to **complex** engineering activities, with an understanding of the limitations

PROGRAMME OUTCOME

(vi) **The Engineer and Society**
Apply reasoning informed by contextual knowledge to assess **societal, health, safety, legal and cultural issues** and the consequent responsibilities relevant to professional engineering practice

PROGRAMME OUTCOME

(vii) **Environment and Sustainability**
Understand the **impact of** professional engineering **solutions in societal and environmental** contexts and demonstrate knowledge of and need for **sustainable development**

PROGRAMME OUTCOME

(viii) **Ethics**
Apply ethical principles and **commit** to professional ethics and responsibilities and norms of engineering practice

PROGRAMME OUTCOME

(ix) **Communication**

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**

PROGRAMME OUTCOME

(x) **Individual and Team Work**
Function effectively as an individual, and as a member or leader **in diverse teams and in multi-disciplinary settings**

PROGRAMME OUTCOME

(xi) **Life-long Learning**
Recognise the need for, and have the preparation and ability to **engage in independent** and **life-long learning** in the **broadest context of technological change**

PROGRAMME OUTCOME

(xii) **Project Management & Finance**
Demonstrate knowledge and understanding of engineering and management principles and **apply** these to one's own work, **as a member and leader in a team**, to **manage projects and in multidisciplinary environments**

Knowledge Profile *(Curriculum)*

Theory-based natural **sciences**	WK1
Conceptually-based **mathematics**	WK2
Theory-based **engineering** fundamentals	WK3
Forefront **specialist** knowledge for practice	WK4
Engineering **design**	WK5
Engineering **practice** (technology)	WK6
Engineering in **society**	WK7
Research literature	WK8

Megat Johari

Level of Problem Solving

25th April 2014

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- Level of Problem Solving
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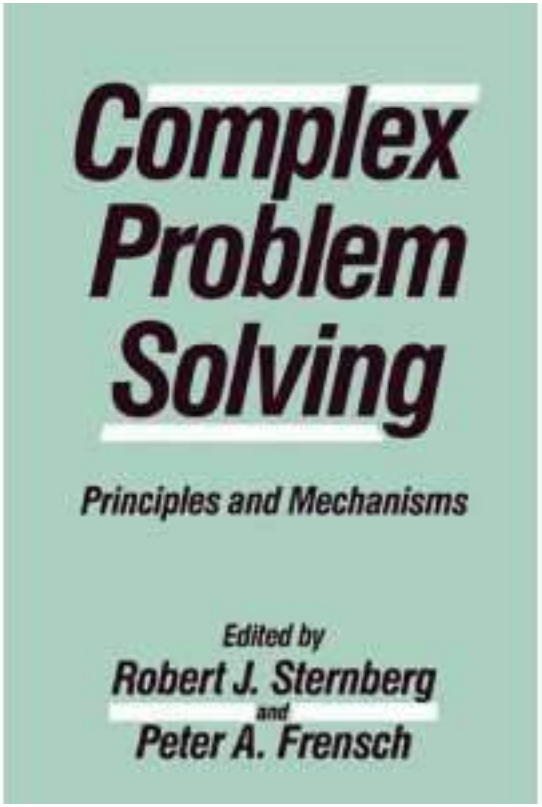
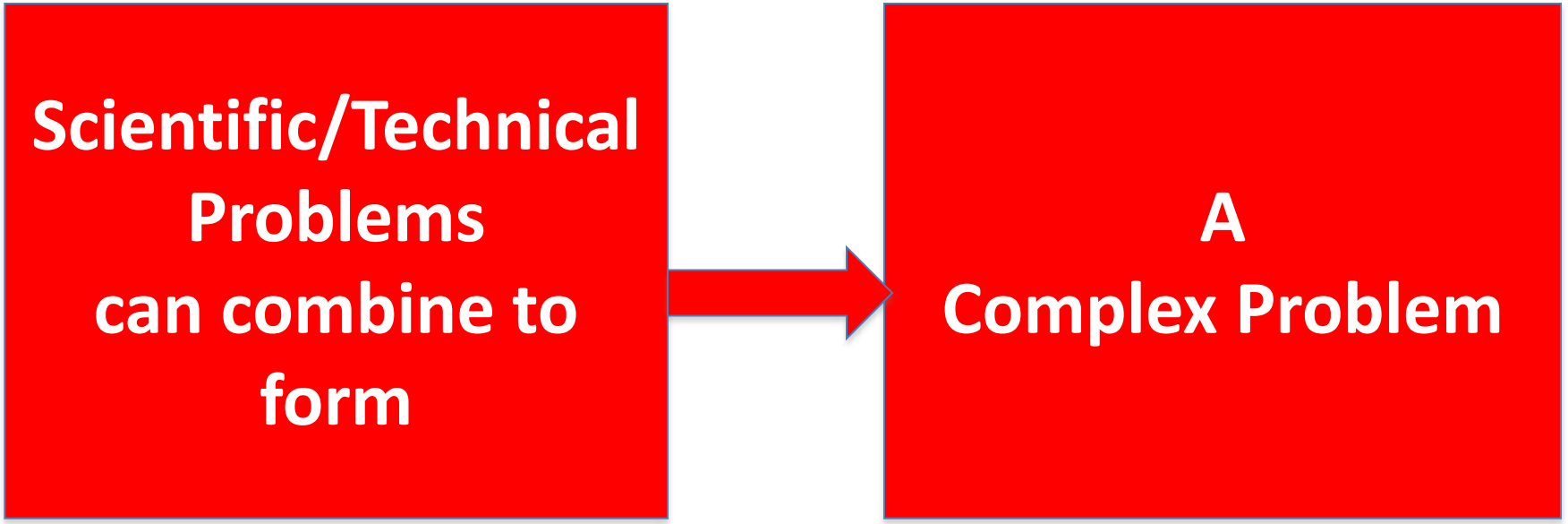
Depth of Knowledge Required

Complex Problems (Engineer)	Broadly Defined Problems (Technologist)	Well defined Problems (Technician)
Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach	Requires knowledge of principles and applied procedures or methodologies	Can be solved using limited theoretical knowledge, but normally requires extensive practical knowledge


Problem
Solving
DEFINE
ANALYZE
LIST
POSSIBLE SOLUTIONS
TAKE ACTION/S


Complex
Problem
Solving
Principles and Mechanisms
Edited by
Robert J. Sternberg
and
Peter A. Frensch


Scientific/Technical Problems can combine to form
A Complex Problem

Complex Problem

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

Complex Problem

Difficult Decision

Uncertain Strategy

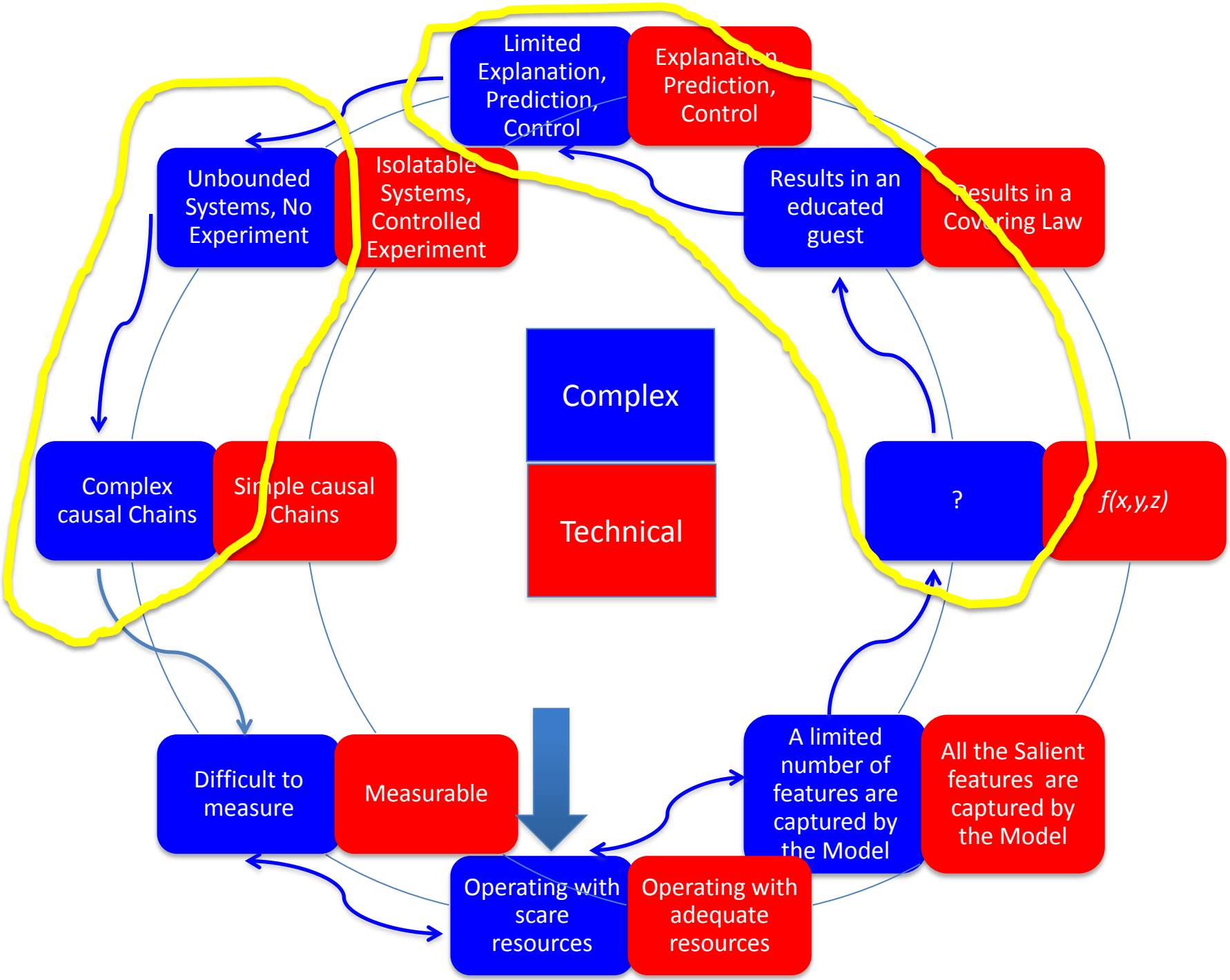
Confusing Idea

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


Limited Explanation, Prediction, Control
Explanation, Prediction, Control
Unbounded Systems, No Experiment
Isolatable Systems, Controlled Experiment
Results in an educated guest
Results in a Covering Law
Complex
Technical
Complex causal Chains
Simple causal Chains
?
f(x,y,z)
Difficult to measure
Measurable
A limited number of features are captured by the Model
All the Salient features are captured by the Model
Operating with scare resources
Operating with adequate resources

Characteristics

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 Problems *(Need High Taxonomy Level)*

Complex Engineering Problems have characteristic WP1 and some or all of WP2 to WP9 that can be resolved with in-depth forefront knowledge

WP1	Knowledge required	Resolved with **forefront in-depth** engineering knowledge
WP2	Range of conflicting requirements	Involve **wide-ranging or conflicting** technical, engineering and other issues.
WP3	Depth of analysis required	Have **no obvious solution** and require abstract thinking, originality in analysis to formulate suitable models.
WP4	Depth of knowledge required	Requires **research-based knowledge** which allows a fundamentals-based, first principles analytical approach.
WP5	Familiarity of issues	Involve **infrequently encountered** issues
WP6	Extent of applicable codes	**Beyond codes** of practice
WP7	Extent of stakeholder involvement and level of conflicting requirements	Involve **diverse groups of stakeholders** with widely **varying needs**.
WP8	Consequences	Have **significant consequences** in a range of contexts.
WP9	Interdependence	Are **high level problems** including **many component** parts or sub-problems.

Bloom's Taxonomy

- Knowledge (list)
- Comprehension (explain)
- Application (calculate, solve, determine)
- Analysis (classify, predict, model,derived)
- Synthesis (design, improve)
- Evaluation (judge, select, critique)

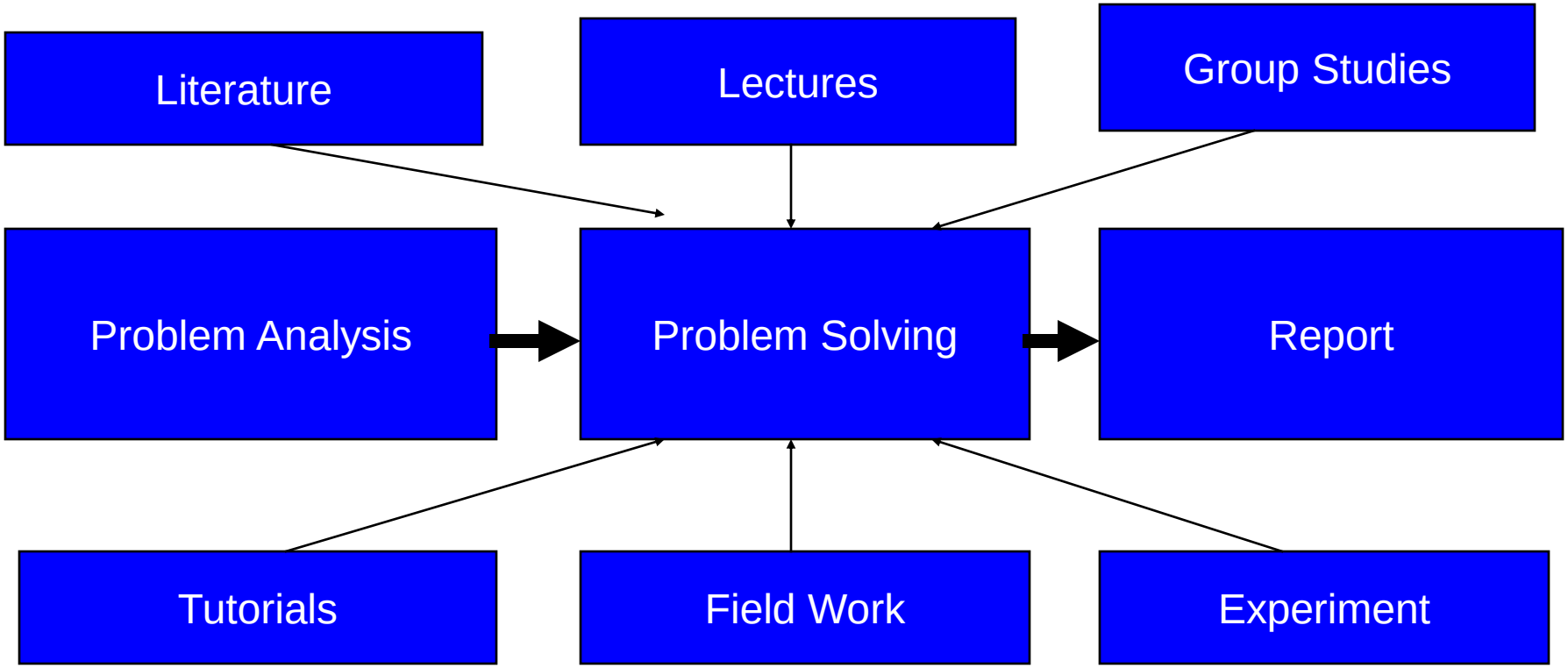
New Bloom's Taxonomy

Remembering: can the student recall or remember the information?	define, duplicate, list, memorize, recall, repeat, reproduce state
Understanding: can the student explain ideas or concepts?	classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
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 parts?	appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
Evaluating: can the student justify a stand or decision?	appraise, argue, defend, judge, select, support, value, evaluate
Creating: can the student create new product or point of view?	assemble, construct, create, design, develop, formulate, write.

Complex Engineering Activities *(Project based)*

Preamble	**Complex activities** means (engineering) activities or projects that have **some or all** of the following characteristics listed below
Range of resources	**Diverse resources** (people, money, equipment, materials, information and technologies).
Level of interaction	Require resolution of significant problems arising from interactions between **wide ranging** or **conflicting** technical, engineering or other issues.
Innovation	Involve creative use of engineering principles and **research-based** knowledge in **novel** ways
Consequences to society and the environment	Have **significant consequences** in a **range of contexts**, characterised by **difficulty** of prediction and mitigation.
Familiarity	Can extend **beyond previous** experiences by applying **principles-based** approaches.

Problem organised project work



Example 1: Complex Problem Solving

- Two villages in Timbuktu are **separated** from each other by a valley, at its **deepest** section about 30 metres.
- The valley is dry all the year around, except for the four months, from October to December each year, where torrential **rainfall** can flood major parts of the valley to a depth of over 12 metres in some site.
- The soil is generally **lateritic** with firm bedrock underneath. A **bridge** connecting the two villages is in a state of disrepair and has to be replaced.
- Write a project brief on how would you approach to design for the replacement bridge.
- You are limited to the use of locally available **building materials**.
- Heavy **equipment** is not available for the construction.

Aspects

- Economics
- Social
- Environment
- Ethics
- Management
- Technology
- Analysis
- Evaluation

Thinking

- Site condition
- Weather
- Available technology
- Building materials
- Design
- Costing
- Scheduling

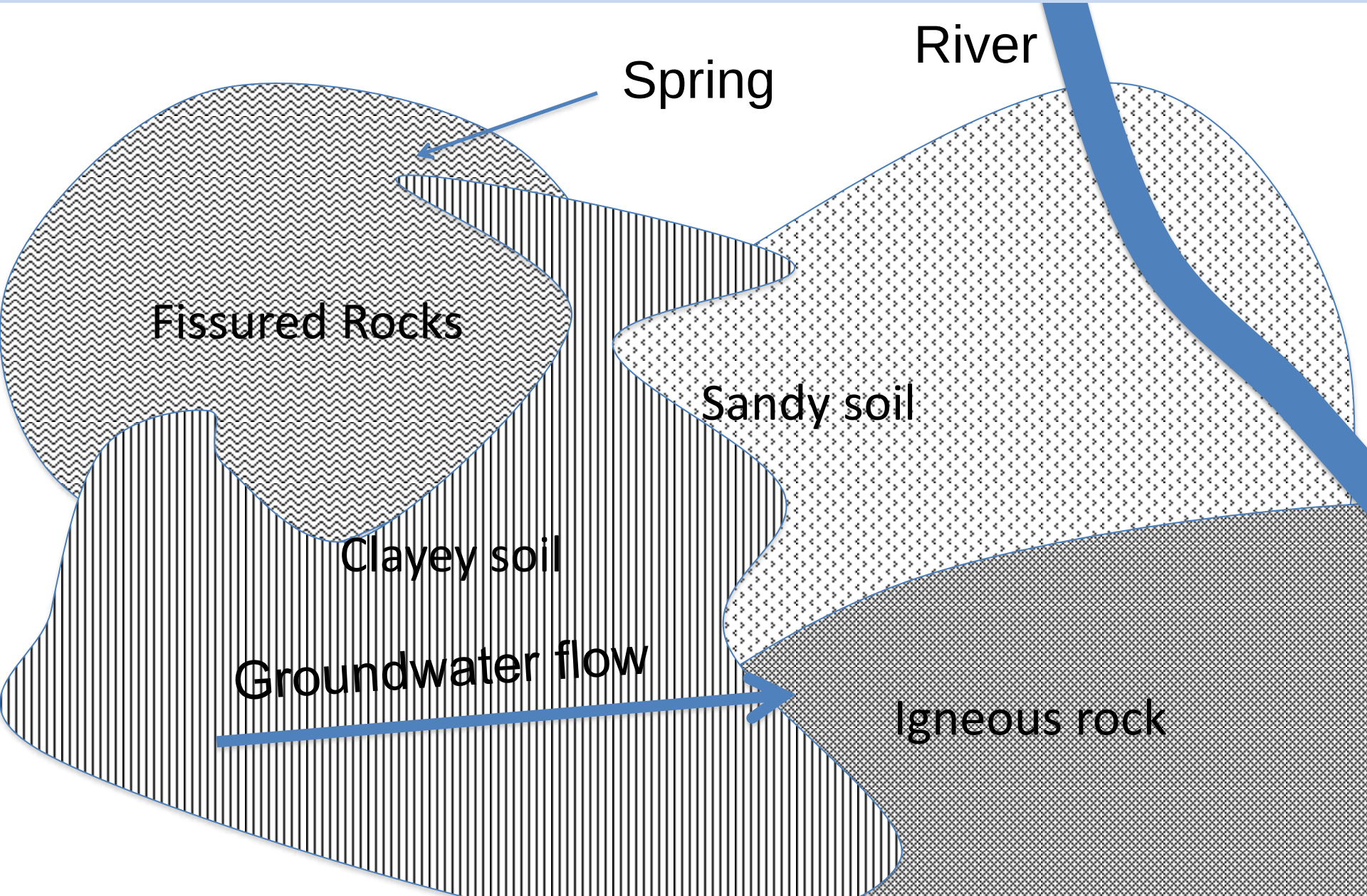
Solutions?

- Problem solving skills
- Formulate the problem
- Literature
- Experiment?

Assessment

- Report – style and content (flow)
- Display – attractive ?
- Viva / Articulation
- Teamwork
- Management – scheduling

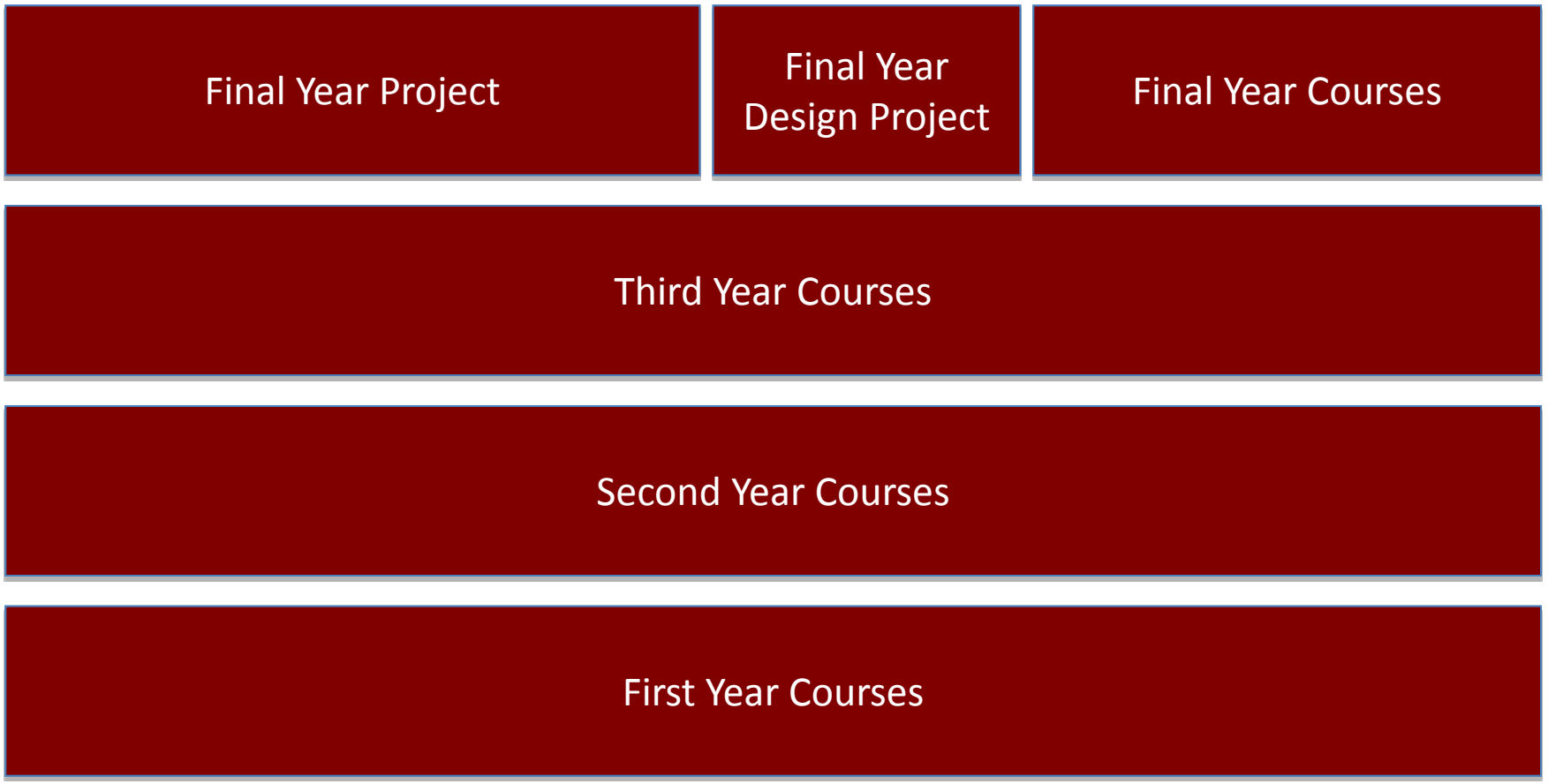
Example 2: Complex Problem Solving



How does complexity relates to curriculum?

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

PO Attainment



THANK YOU

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Appendix

Complex Problem Solving (CPS)

- **Dynamic**, because early actions determine the environment in which subsequent decision must be made, and features of the task environment may change independently of the solver's actions;
- **Time- dependent**, because decisions must be made at the correct moment in relation to environmental demands;
- **Complex**, in the sense that most variables are not related to each other in a one-to-one manner

Microworld CPS Model

- The problem requires **not one decision**, but a long series, in which early decisions condition later ones.
- For a task that is **changing continuously**, the same action can be definitive at moment t1 and useless at moment t2.
- Include novel **solutions to an old dilemma** in general science (external validity vs. experimental control)

Expert-novice CPS Model

- Expert-novice approach most of the time produces conclusions that are **crystal-clear**.
- It almost guarantees statistically significant results, because the groups compared (expert and novices) are very different and tend to **perform very differently** when confronted with similar experimental situations (Sternberg 1995).

Naturalistic decision making (NDM)

- Naturalistic decision making (NDM) (e.g., Zsambok and Klein 1997, Salas and Klein 2001)
- **‘real-world’** task
- Example interviewing firefighters after putting out a fire or a surgeon after she has decided in real time what to do with a patient.

Dynamic decision making DDM

- Dynamic decision making (DDM) (Brehmer 1992, Sterman 1994).
- Discrete dynamic decision **tasks that change** only when the participant introduces a new set of inputs.
- Variables like **time pressure** have been successfully integrated in models like Busemeyer and Townsend's (1993) decision field theory

Implicit learning in system control

- This tradition has used tasks like the sugar factory (Berry and Broadbent 1984) or the transportation task (Broadbent et al. 1986), that are governed by comparatively **simple equations.**
- The theorization and computational modeling in this branch of CPS are extremely rich. Models are based on exemplar learning, rule learning, and both (e.g., Dienes and Fahey 1995, Gibson et al. 1997, Lebiere et al. 1998).

European complex problem solving (CPS)

- Initiated by Dörner (Dörner and Scholkopf 1991, Dörner and Wearing 1995)
- **A large number of tasks** that have been considered complex problem solving are nowadays affordable for theory development and computer modeling (e.g. Putz-Osterloh 1993, Vollmeyer et al. 1996, Burns and Vollmeyer 2002, Schoppek 2002)
- Transport **real-life complexity to the lab** in a way that can be partly controlled

Time related

- Time variant – time invariant (dynamic vs. static systems)
- Continuous time – discrete time.
- Degree of time pressure – decision has to be made quickly

Variable related

- Number and type (discrete/continuous) of variables
- Number and pattern of relationships between variables
- Non-Linear - Linear

System behaviour related

- Opaque - transparent.
- Stochastic - deterministic
- Delayed feedback - immediate feedback.

Delivery

- Knowledge-lean vs. knowledge-intensive
- Skill based vs planning based (reactive vs predictive
- Learning vs. no learning during problem solving
- Understanding-based vs. search-based problems
- Ill-defined vs. well-defined

Conclusion

- Problem solving has been traditionally a task-centered field. VanLehn (1989) think that ‘task’ and ‘problem’ are virtually synonymous.

Idiagram

- Seeing the System
- Filling the Vacuum
- Visual Modeling
- The Problem-Solving System
- Process

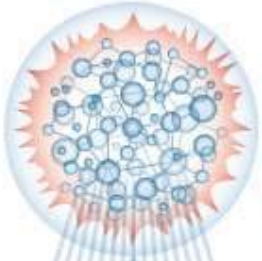
with complex problems requires that we think broadly, systemically, and **see the big-picture** – into which the narrow technical details must fit.

Sources of 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 quantitative data
- **Novelty** - there is a new situation evolving, or an innovative design is needed

The Big-Picture

A Complex Problem

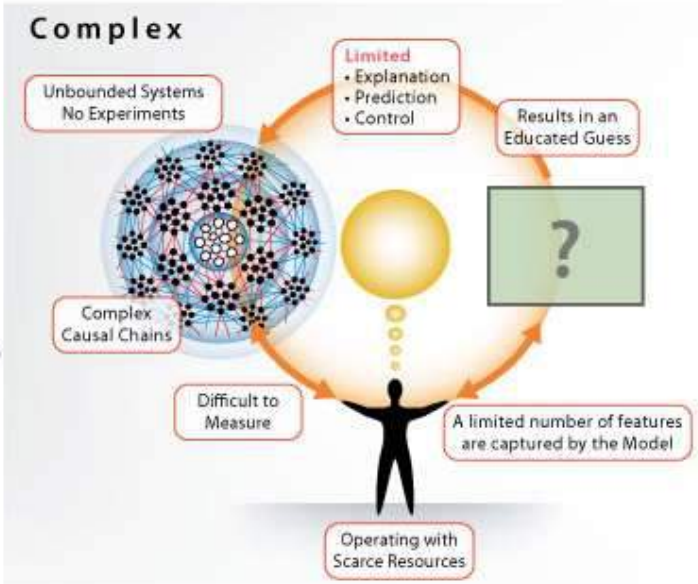


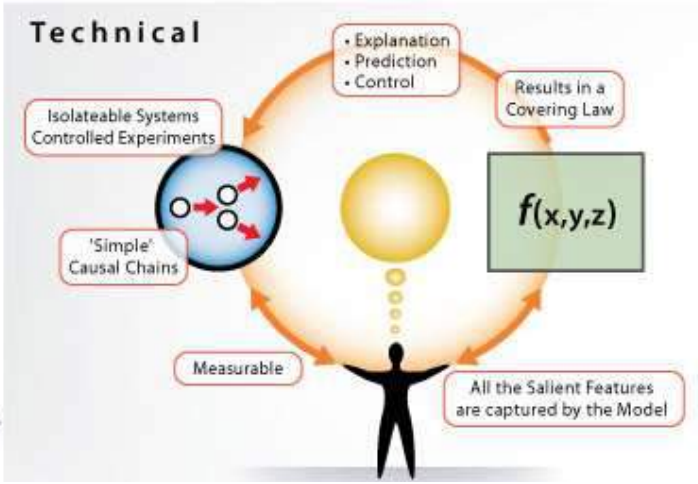
Complex	Problem
Difficult	Decision
Uncertain	Strategy
Confusing	Idea
Contentious	Product
Intractable	Change

can combine to form

Scientific/Technical Problems

The Technical Details





Characteristics of Complex Problems*:

- No definitive problem boundary
- The problem is relatively unique or unprecedented
- Unstable and/or unpredictable problem parameters
- Multiple experiments are not possible
- There is no bounded set of alternative solutions
- Involve multiple stakeholders with different and/or conflicting viewpoints and interests
- No single optimal and/or objectively testable solution
- No clear stopping point

Require Different Approaches

Characteristics of Technical Problems:

- Isolateable, boundable problems
- Problems are of a universally similar type
- Stable and/or predictable problem parameters
- Multiple low-risk experiments are possible
- There is a limited set of alternative solutions
- Involve few or homogeneous stakeholders
- There is a single optimal and testable solution
- The single optimal solution can be clearly recognized

* Adapted from:
Conklin, Jeff; "Wicked Problems and Social Complexity", CogNexus Institute http://cognexus.org, 2001-2003
Rittel, H. and M. Webber: "Dilemmas in a General Theory of

The author would like to thank the contributors of the clip arts used in this presentation