BLOOM'S TAXONOMY IN ENGINEERING EDUCATION AND OBE CURRICULA

A WORKSHOP FOR PROGRAMME EVALUATORS OF OUTCOME-BASED ENGINEERING ACCREDITATION

BY

ENGINEERING ACCREDITATION COMMITTEE

COUNCIL FOR THE REGULATION OF ENGINEERING IN NIGERIA (COREN)

ON 26th NOVEMBER, 2024

OUTCOMES OF THE WORKSHOP

At the end of this workshop, participants are expected to:

1. understand Bloom's taxonomy and its importance.
2. analyse and evaluate the present Engineering education curriculum.
3. apply Bloom's taxonomy to develop a better Engineering education in Nigerian Universities.

OUTLINE OF THE WORKSHOP

1. What is Bloom’s taxonomy and its importance
2. Evaluating the present Engineering education curriculum
3. Applying Bloom’s taxonomy to develop a better Engineering education in Nigerian Universities

SECTION A
BLOOM'S TAXONOMY

BLOOM'S TAXONOMY

- Bloom's taxonomy was created in 1956 under the leadership of Dr. Benjamin Bloom in order to promote higher forms of thinking in education.

- They identified levels of actions that describe and classify observable knowledge, skills, attitudes, behaviours and abilities which became taxonomy with three overlapping domains:
  - ✓ The Cognitive domain deals with the intellectual development
  - ✓ The Affective domain deals with the development of feelings and attitudes
  - ✓ The Psychomotor domain deals with motor skills development .

- Bloom's taxonomy is one of the most recognized and used educational tools that attempts to move students beyond simple memorization.

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BLOOM'S TAXONOMY …

- Bloom's taxonomy can be used as a potential model for framing educational objectives within a course and as a guide to structure activities and assessment based on learning goals.

- Bloom's taxonomy help us not only in **designing curriculum and teaching**, but also to **design appropriate examination questions** belonging to various **cognitive levels**

- In 2001, Anderson and Krathwohl modified Bloom's taxonomy to make it relevant to the present-day requirements

BLOOM'S TAXONOMY …

- **Action Verbs for Assessment:**

- Educators have come up with taxonomy of measurable verbs corresponding to each of the Bloom's cognitive levels.

- Action verbs in preparing assessment questions are most important.

- Action verbs are indicators of the complexity (level) of question.

BLOOM'S TAXONOMY

1. Knowledge (Remembering)

- **Lower Order**

These types of questions test the students' ability to memorize and to recall terms, facts and details without necessarily understanding the concept.

Key Words: Memorize, Define, Identify, Repeat, Recall, State, Write, List & Name

Examples of questions:

•"What is...?"
•"How would you describe...?"
•"Why did...?
•"How would your show...?"

BLOOM'S TAXONOMY …

2. Comprehension (Understanding)

These questions test the students' ability to summarize and describe in their own words without necessarily relating it to anything.

Key Words: Describe, Distinguish, Explain, Interpret, Predict, Recognize & Summarize

Examples of questions:

- "What facts or ideas show...?"
- "How would you compare...?"
- "How would your classify...?
- "Can you explain what is happening...?"

BLOOM'S TAXONOMY …

- **Higher Order**

3. Application (Transferring)

Application questions encourage students to apply or transfer learning to their own life or to a context different than one in which it was learned.

Key Words: Apply, Compare, Contrast, Demonstrate, Examine, Relate, Solve & Use

Examples of questions:
•"What would result if...?"
•"What facts would you select to show...?"
•"What approach would you use to...?"
•"How would you use...?"

BLOOM'S TAXONOMY …

4. Analysis (Relating)

These questions encourage students to break material into parts, describe patterns and relationships among parts, to subdivide information and to show how it is put together.

Key Words: Analyze, Differentiate, Distinguish, Explain, Infer, Relate, Research & Separate

Examples of questions:

- "What inference can you make...?"
- "What is the relationship between...?"
- "What evidence can you find...?"
- "What things justify...?"

BLOOM'S TAXONOMY …

5. Synthesis (Creating)

These questions encourage students create something new by using a combination of ideas from different sources to form a new whole.

Key Words: Arrange, Combine, Create, Design, Develop Formulate, Integrate & Organize

Examples of questions:

- "What could be changed to improve...?"
- "How would you test...?"
- "What way would you design...?"
- "What outcome would you predict for...?"

BLOOM'S TAXONOMY …

6. Evaluation (Judging)

Evaluation questions encourage students to develop opinions and make value decisions about issues based on specific criteria.

Key Words: Assess, Critique, Determine, Evaluate, Judge, Justify, Measure & Recommend

Examples of questions:

- "How could you select...?"
- "How could you prove...?"
- "How would you prioritize...?"
- "What information would you use to support...?"

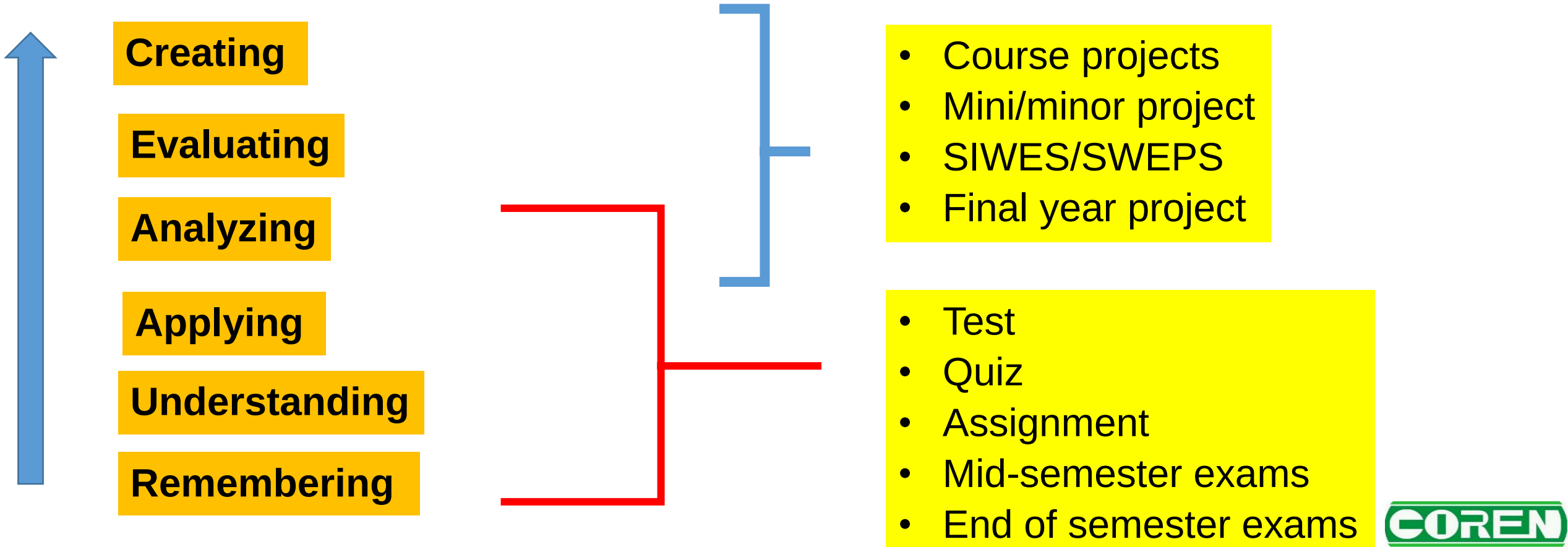
BLOOM'S TAXONOMY …

- The **Analyze, Evaluate and Create** levels are considered to represent **higher-level cognitive activities**

- They require and develop **mental faculties of creativity, critical thinking and innovative problem solving.**

BLOOM'S TAXONOMY …

Assessment methods for different Bloom's cognitive levels:



PSYCHOMOTOR DOMAIN

Category Order	Sample Behavioral Verbs
Perception (awareness): The ability to use sensory cues to guide motor activity.	Chooses, describes, detects, differentiates, distinguishes, identifies, isolates, relates, selects,…
Set: Readiness to act. It includes mental, physical, and emotional sets.	Begins, displays, explains, moves, proceeds, reacts, shows, states, volunteers, …
Guided Response: The early stages in learning a complex skill that includes imitation and trial and error.	Copies, traces, follows, react, reproduce, responds,…
Mechanism (basic proficiency): This is the intermediate stage in learning a complex skill.	Assembles, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches, …

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PSYCHOMOTOR DOMAIN…

Complex Overt Response (Expert): The skillful performance of motor acts that involve complex movement patterns.	Assembles, builds, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches,... **Note:** The Key Words are the same as Mechanism, but will have adverbs or adjectives that indicate that the performance is quicker, better, more accurate, etc.
Adaptation: Skills are well developed and the individual can modify movement patterns to fit special requirements.	Adapts, alters, changes, rearranges, reorganizes, revises, varies,…
Origination: Creating new movement patterns to fit a particular situation or specific problem.	Arranges, builds, combines, composes, constructs, creates, designs, initiate, makes, originates,…

AFFECTIVE DOMAIN

Categories Order	Sample Behavioral Verbs
Receiving Phenomena: Awareness, willingness to hear, selected attention.	Asks, chooses, describes, follows, gives, holds, identifies, locates, names, points to, selects, sits, erects, replies, uses, …
Responding to Phenomena: Active participation on the part of the learners.	Answers, assists, aids, complies, conforms, discusses, greets, helps, labels, performs, practices, presents, reads, recites, reports, selects, tells, writes., …
Valuing: The worth or value a person attaches to a particular object, phenomenon, or behaviour.	Completes, demonstrates, differentiates, explains, follows, forms, initiates, invites, joins, justifies, proposes, reads, reports, selects, shares, studies, works,…

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AFFECTIVE DOMAIN…

Categories Order	Sample Behavioral Verbs
Organization: Organizes values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system.	Adheres, alters, arranges, combines, compares, completes, defends, explains, formulates, generalizes, identifies, integrates, modifies, orders, organizes, prepares, relates, synthesizes,…
Internalizing values (characterization): Has a value system that controls their behavior.	Acts, discriminates, displays, influences, listens, modifies, performs, practices, proposes, qualifies, questions, revises, serves, solves, verifies, …

SECTION B
ENGINEERING EDUCATION

WHAT DO ENGINEERING STUDENTS NEED?

1. Professional engineers want the students to be engaged in learning processes that promote creativity.
2. The students also experience much higher learning when engaged in learning processes that promote creativity.
3. Creativity includes an interrelated set of intellectual skills of:

creative thinking ***critical thinking*** ***innovative problem solving***

personal characteristics of versatility ***tolerance for ambiguity***

willingness to take risks ***open-mindedness*** ***confidence, and curiosity***

values of discipline ***perseverance and responsibility*** ***(Arney, 1999).***

WHAT DO ENGINEERING STUDENTS NEED? …

- According to a survey reported by Goel (2004), an overwhelming majority of responding students and academic staff members felt that:

1. Creativity is very important for engineering profession.
2. Creativity can be fostered through instruction and training.
3. Current engineering education, in general, does not enhance creativity.
4. Design assignments, real-life like assignments and discussions play a very important role, while written exams do not contribute much in fostering creativity.

- Reasons of **this weakness** need to be isolated and creativity fostering aspects of teaching-learning-evaluation process **identified, promoted and used more frequently.**
- Hence, engineering curriculum needs to be crafted to promote the reasoning process and creativity rather than carefully visiting a set of topics.

ENGINEERING EDUCATION

- A good Engineering education should provide opportunities for:
  - transforming a problem statement into a model
  - conjecturing solutions : CLOs, POs and PEOs
  - selecting or developing the appropriate mathematics
  - examining the analysis
  - continuing to transform the conjecture into a solution (Gary, 1999).

CREATING A BETTER ENGINEERING EDUCATION

1. Engineering students report more effective learning when they are engaged in higher order cognitive activities through active learning.
2. Academic staff need to bring a strategic transformation and flexibility in the curriculum in order to engage students in higher level cognitive activities.
3. Engineering staff should limit number of assignments and activities that engage students in lower level cognitive activities like calculate, explain, prove (studied theorem, studied method), define (studied definitions) and so on.
4. In order to foster creativity, critical thinking and innovative problem solving amongst engineering students should be encouraged.
5. Make engineering education to be more in alignment with the suggestions of professional engineers and other stakeholders.

APPLICATION OF BLOOM'S TAXONOMY TO ENGINEERING EDUCATION

Engaging students in higher-order thinking is essential in today's Engineering Programmes. Use Bloom's Taxonomy Question Stems to make it happen.

APPLICATION OF BLOOM'S TAXONOMY TO ENGINEERING EDUCATION

1. Use the action verbs to state learning intentions.
2. Use **Bloom**-style questions to prompt deeper thinking.
3. Use **Bloom's Taxonomy** to differentiate your lessons.
4. Course Content Development
   : is the process of originating (creating), editing, manipulating and maintaining the contents in order to provide knowledgeable fillings to the users.

This covers:

- Content – typical topics in the subject matters
- Subject Topics – teaching plan
- Course Learning Outcomes – group of learning (topic) outcomes
- CLO-PO matrix – is it satisfactory?

APPLICATION OF BLOOM'S TAXONOMY TO ENGINEERING EDUCATION …

Considerations of:

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

5. Select and implement appropriate teaching and learning methods for delivering the specified content and facilitate student achievement of the outcomes.

6. Select and implement appropriate assessment and evaluation methods to determine how well the outcomes have been achieved (Abdul Aziz & Mohd Noor, 2014).

OBE CURRICULA

Developing OBE Curricula

Under OBE, curriculum design includes:

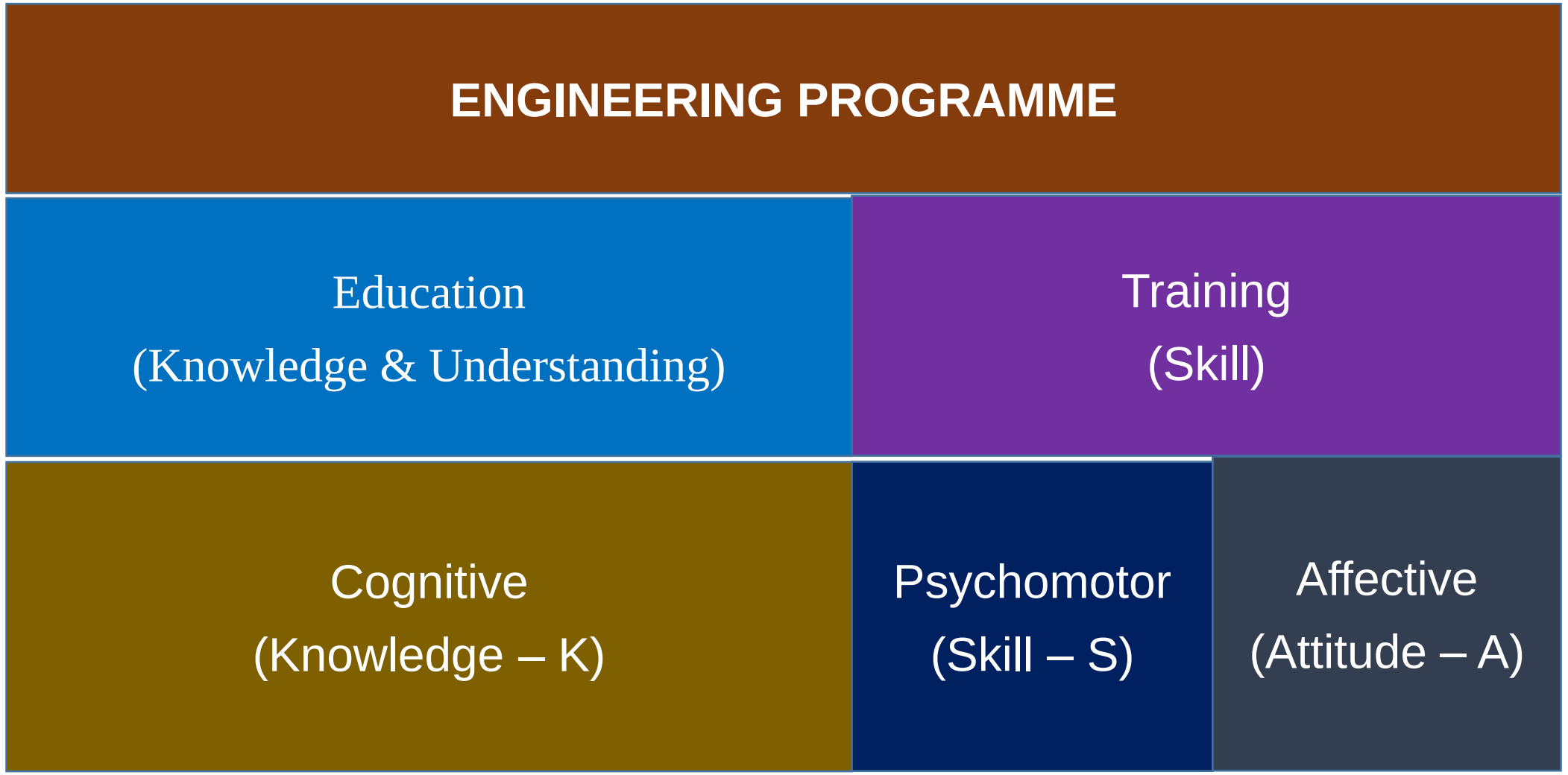
1. Determining future conditions
2. Deriving exit outcomes
3. Developing performance indicators
4. Determining instructional strategies
5. Delivering instruction
6. Documenting results
7. Determining advancement

Characteristics of OBE Curricula

The following are characteristics of the OBE Curricula:

1. It has programme educational objectives, programme outcomes, course learning outcomes, performance indicators and target for student achievements.
2. It is objective and outcome-driven, where every stated objective and outcomes can be assessed and evaluated.
3. It is centred on the needs of the students and the stakeholders.
4. Every learning outcome is intentional and therefore the outcomes must be assessed using suitable performance indicators.
5. Every learning outcome is intentional and therefore the outcomes must be assessed using suitable performance indicators.

6. Programme objectives address the graduates' attainment within 3-5 years after their graduation.
7. Programme outcomes, which consist of abilities to be attained by students before they graduate, are formulated based on the programme objectives.
8. Programme outcomes address Knowledge, Skills and Attitudes to be attained by students. Education programme are based on two categories (education and training). Education addresses cognitive, while the training addresses the psychomotor and affective domains.
9. Course learning outcomes must satisfy the stated programme outcomes. There is no need for ANY (individual) CLOs to address all programme outcomes.
10. Learning methods have to be integrated to include different delivery methods.


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

Models of Curricula Content

Distribution of Knowledge, Skills & Attitude elements throughout the 5 years

What do you want the students to have or able to do and at what level

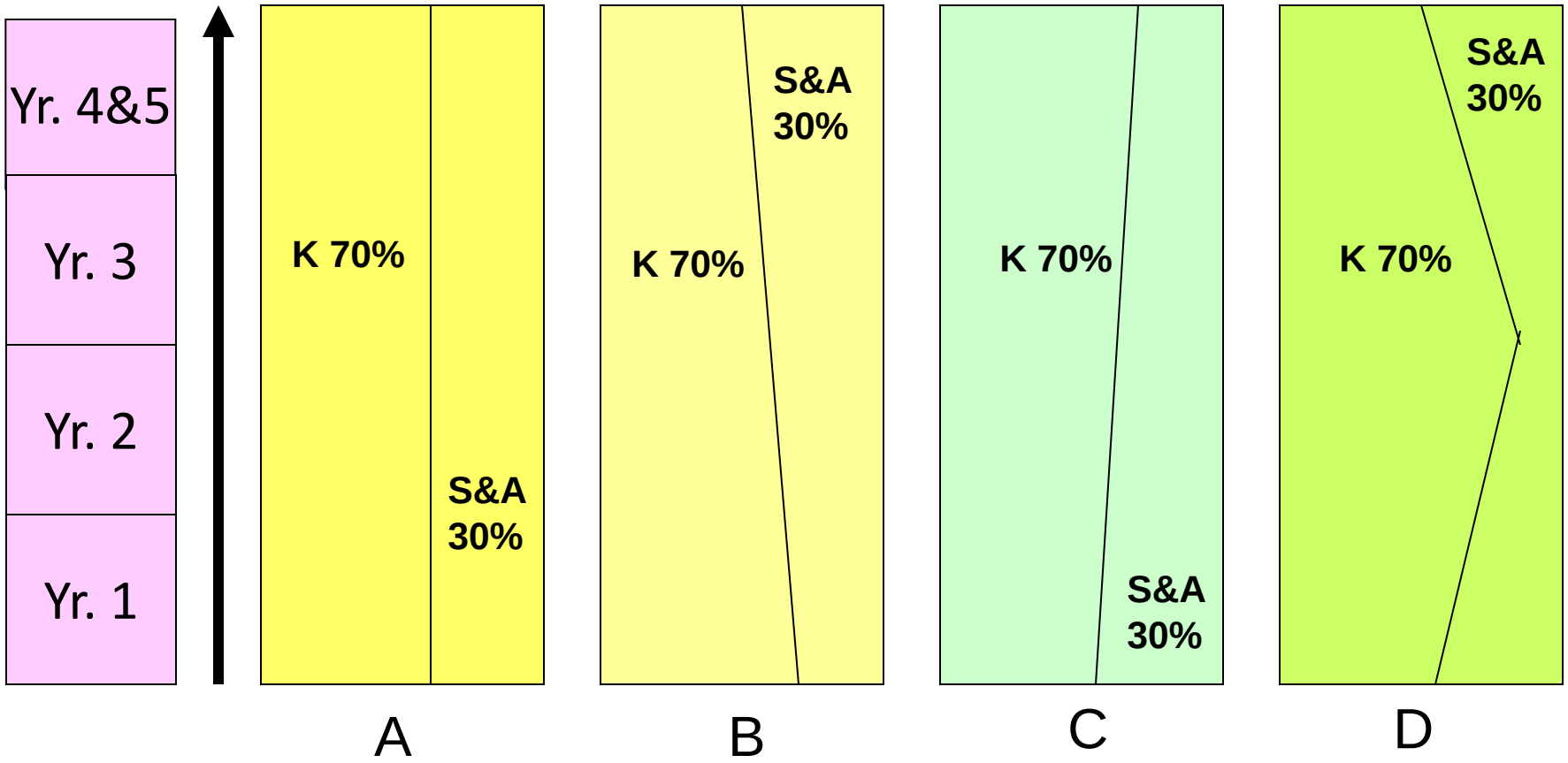
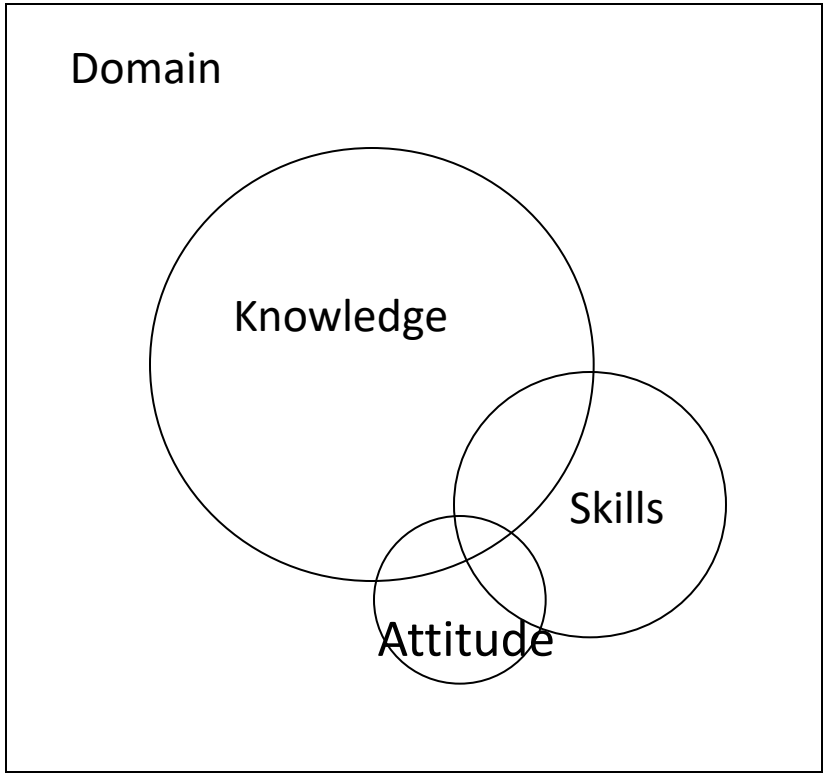


Figure 2: Distribution of Knowledge, Skills And Attitude Elements Throughout the 5 Years Programme (Chong, 2

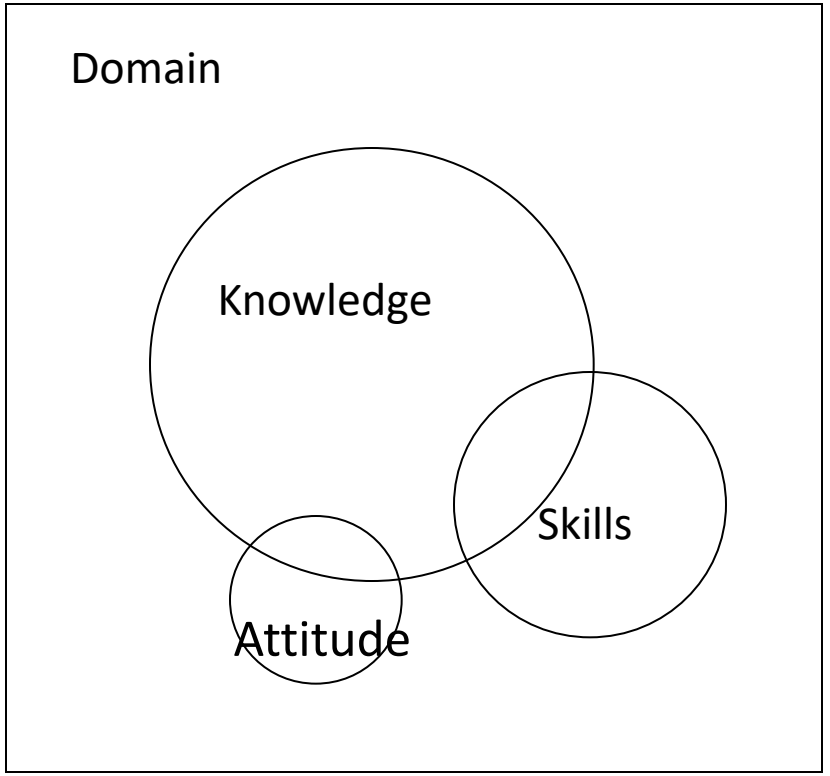
Course Coverage & Assessment

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

Model A



Model B



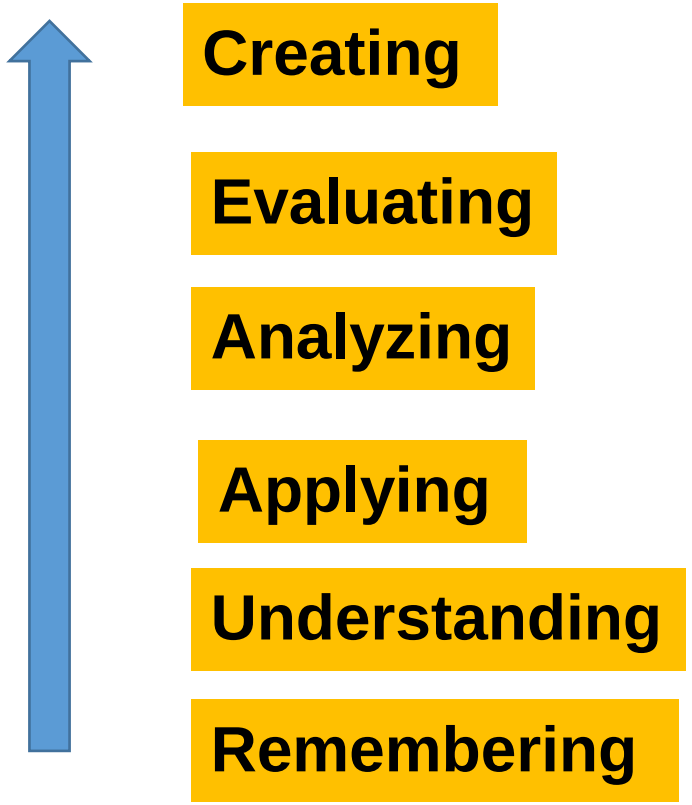
Curriculum Review

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

1. Sustainability and Environmental Friendliness
2. Ethnics and Professionalism
3. Soft-skills (Communications/Languages/ Emotional Intelligence/ Cultural)
4. Life- Long Learning
5. Project Management
6. Finance, Economics and Accountancy
7. Related Laws (Land Law/Contract Law/ By-Laws)

ASSESSMENT PLANNING

Learning Levels



Pattern of assessment in each of the course for the Programme:

1. Alignment of assessment questions with Course Learning Outcomes

2. Check whether all the learning outcomes are tested; sometimes some learning outcomes are over tested at the expense of others which may not be tested at all

3. Overall weightage in the assessment to each of the Bloom's learning levels.

Suggestions for Effective Questioning Techniques

1. **Ask Thought Provoking Questions**
   Promote higher order, critical thinking skills and get the students to question their own views. Ask different types of questions to get students to demonstrate their knowledge and comprehension as well as their ability to apply, analyze, synthesize and evaluate material.

2. Build in Sufficient Wait Time

Wait 10 to 12 seconds before calling on a student by name to answer. If the students still don’t understand the question, perhaps it needs to be rephrased.

Suggestions for Effective Questioning Techniques…

3. Pose a Question / Call on Students by Name

Make learning personal by calling on different students in every class. This also encourages student to come to class prepared and ready to contribute.

4. Redirect Student Questions

Redirecting student questions is beneficial because it shows students they can be sources of information for one another, it encourages positive dialogue in the classroom, it increases student participation, and allows the instructor to formulate a synthesized response.

Suggestions for Effective Questioning Techniques…

5. Paraphrase Student Questions

An instructor can increase participation by paraphrasing questions. The question can also be raised to a higher order status, which increases the interest level for all students, especially the one who originally asked the question.

6. Understand Why Students Repeat the Same Questions

Remember that understanding may not always occur at the time of delivery. It is not until the new material has been digested and has become meaningful that students can ask questions.

Suggestions for Effective Questioning Techniques…

7. Script-out Key Questions

Key points you want to cover in your demonstration, discussion, lecture or workshop should be thought about in advance. How can you elicit these points from the students? Key questions should be planned and well thought out before going to class.

8. Invite More Than One Response to a Question

Call on several students to get varying ideas and opinions before offering your own.

9. Answer Student Questions with Another Question

Encourage students to think for themselves and to demonstrate their understanding of new material.

SUMMARY

1. …
2. ….
3. …..
4. …..

EXERCISE

1. How will you demonstrate that learning has taken place during a classroom activity?

2. How are you going to facilitate learning in teaching of your course (remember you must be able to demonstrate that learning has taken place)?

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Thank you