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Specification and Assessment of Outcomes-based Engineering Curricula for Program Accreditation

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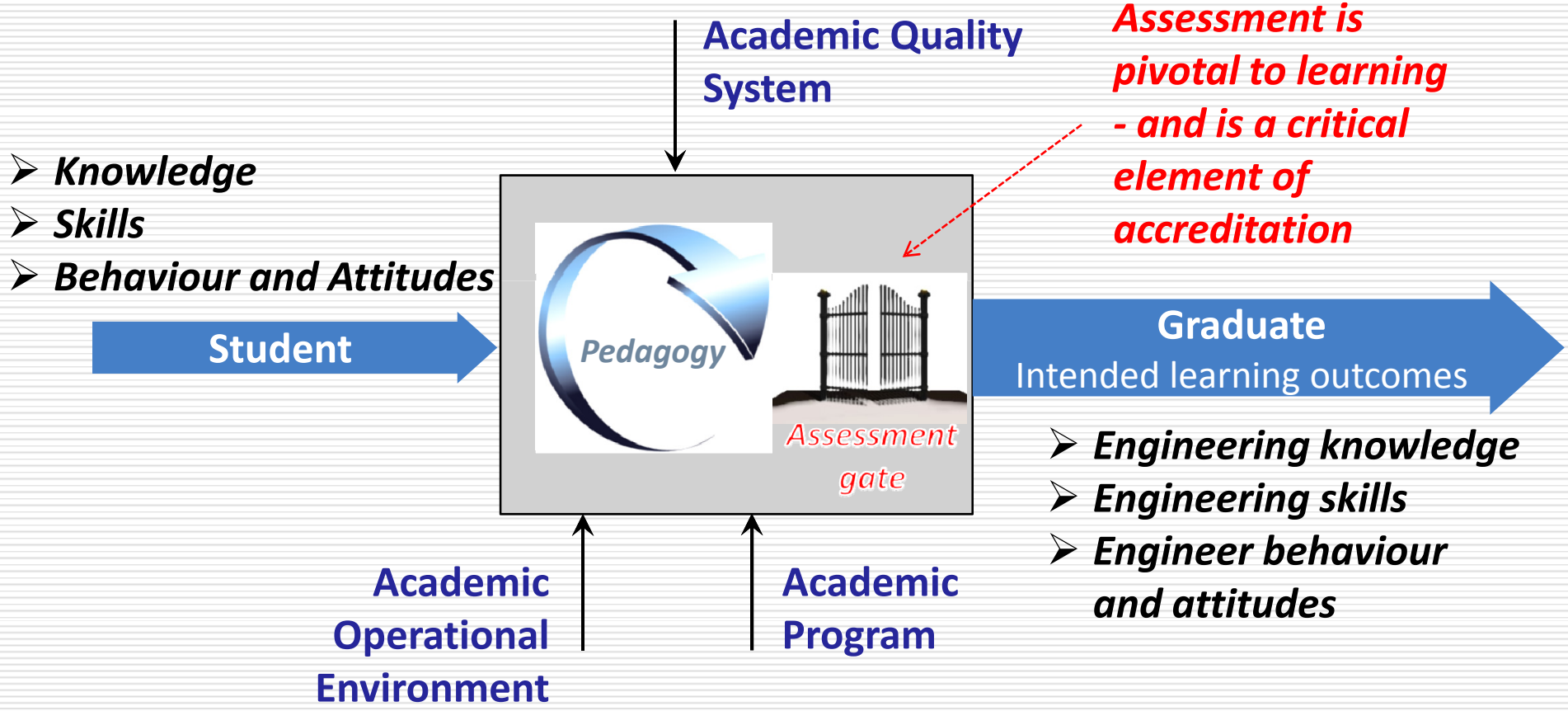
Overview

- **outcomes-based engineering education**
  - constructive alignment for program and unit design
  - international frameworks and benchmarking
  - tools for program specification and mapping

- **challenges of outcomes assessment**
  - improving examinations
  - assessing authentic /simulated projects
  - projecting beyond graduation horizon

- **improving practice**
  - education and training for academics
  - sharing best practice

model of engineering education (+ accreditation)



outcomes-based education

- is the "spirit of [good] education"
- is the "emerging reformation model"
- is learner-centric and holistic
- focusses on competence of the individual
- but encourages cooperative learning
- is consistent with Bloom's taxonomy
- is "constructivist" (with [educator-driven] alignment of objectives, pedagogy and assessment)

- is consistent with Indian traditions of education

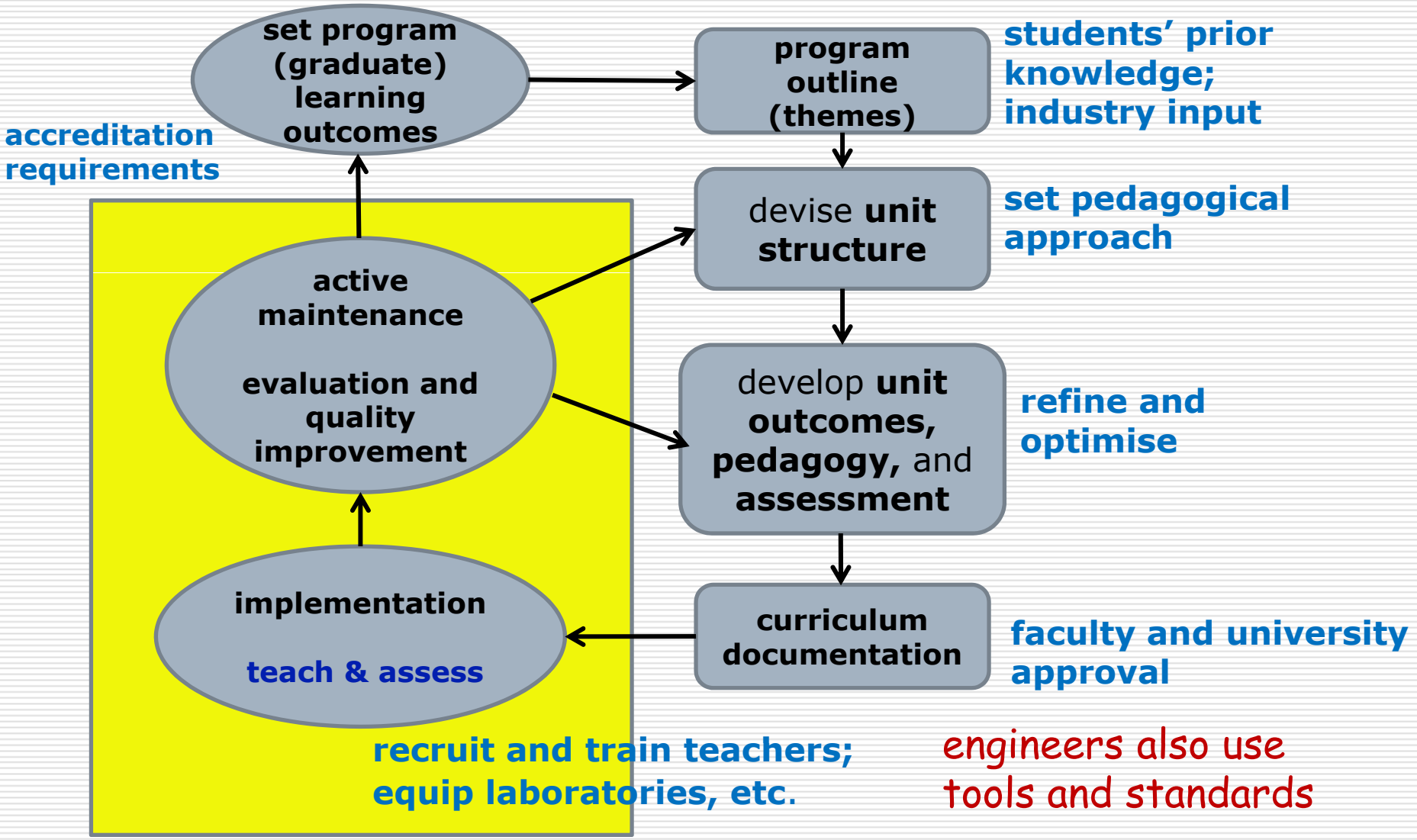
Dr Ketan Kotecha, Dr Richa Mishra,
Institute of Technology, Nirma University Newsletter

OBE is implemented by "constructive alignment"

after Biggs and Tang, Teaching for Quality Learning at University (4th ed. 2011)

- define target outcomes
- choose suitable teaching methods (pedagogy) and content that are as active and authentic as possible
- align assessment tasks with target learning outcomes

OBE aligns with engineering design process



graduate outcome areas in the IEA Accords

Knowledge-oriented

1: Using engineering knowledge

Defined Knowledge Profile for all areas

Problem-solving Skill Group

2: Problem analysis

3: Design/development of solutions

4: Investigations

Range Statements for Problem Solving

Skill-oriented Group

5: Modern Tool Usage

9: Individual and teamwork

10: Communication

11: Project/Engineering Management

Attitude-oriented Group

6: The Engineer in Society

7: Environment and Sustainability

8: Ethics

12: Life long learning

- **achievement is defined for each outcome in each Accord**
- **Accord signatories operate accreditation systems that test substantial outcomes equivalence to the Accord "exemplar"**
- **similar frameworks are defined by ENAEE (EUR-ACE) and CDIO**

OBE mapping of target outcomes

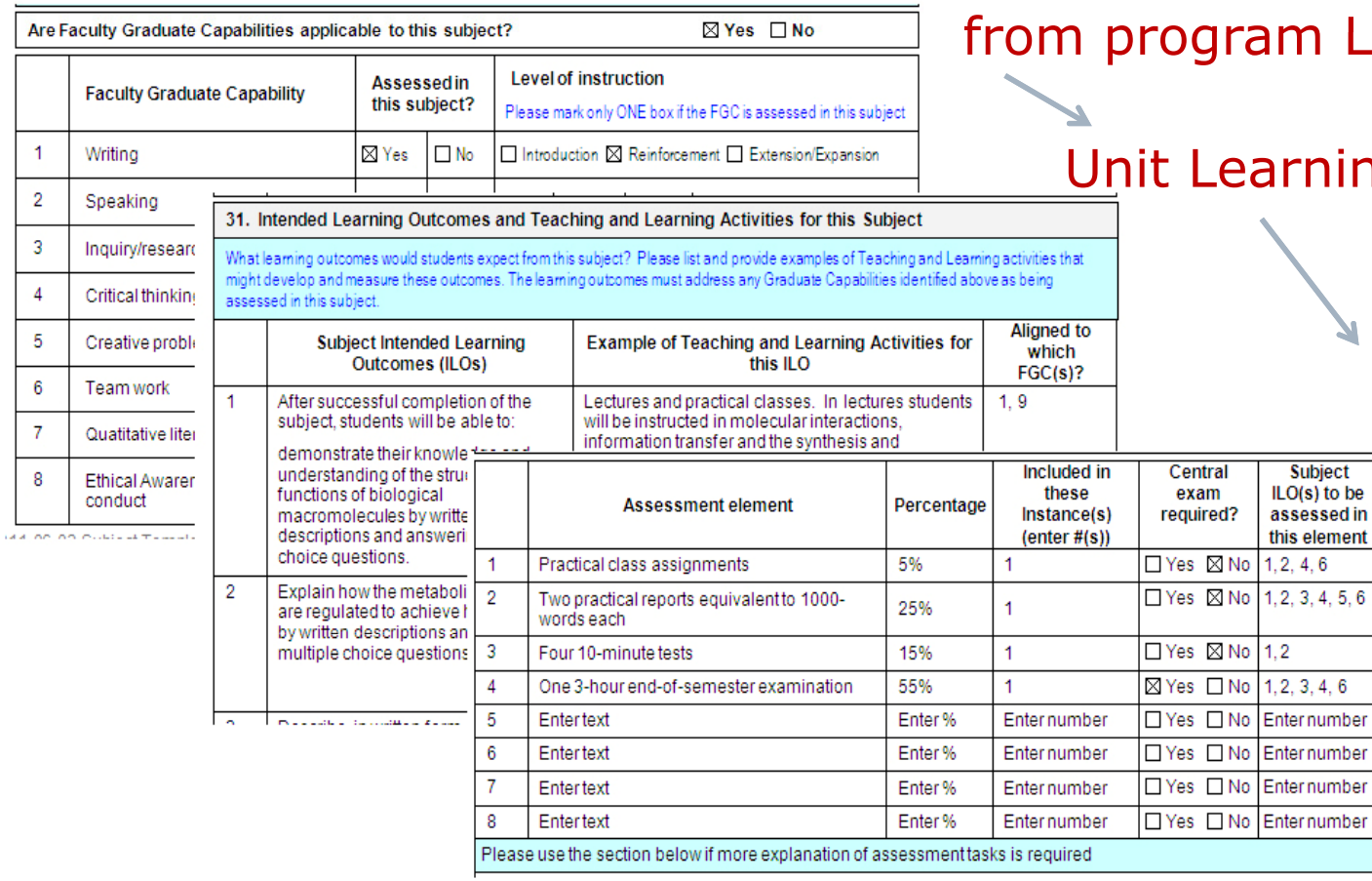
assigning a target level of attainment (e.g. 0 – 5) to each graduate attribute for each program unit provides a good way of developing outcome themes, and choosing pedagogy and aligning assessment tasks

Prgram Unit (examples)	science & maths	engin'g science	engin' applic'n	problem anaysis	design	comm-unication	team-work	…
Maths 1	2	1	1	1	0	0	0	
Mechanics 1	2	2	1	1	0	1	1	
Systems 1	2	2	2	2	1	0	0	
Design 2	0	0	1	3	3	2	3	…
Project Man'g	0	0	0	3	3	3	3	…
…								
…								
program target	**3**	**4**	**4**	**4**	**4**	**4**	**4**	**…**

example levels: 0 – none, 1 – basic, 2 – developed, 3 - competent / fluent
4 – professional / complex, 5 – advanced (postgraduate)

OBE program and unit mapping tool

used for peer review, refinement, approval



Are Faculty Graduate Capabilities applicable to this subject? ☒ Yes ☐ No

	Faculty Graduate Capability	Assessed in this subject?		Level of instruction (Please mark only ONE box if the FGC is assessed in this subject)
1	Writing	☒ Yes	☐ No	☐ Introduction ☒ Reinforcement ☐ Extension/Expansion
2	Speaking			
3	Inquiry/researc			
4	Critical thinkin			
5	Creative probl			
6	Team work			
7	Quatitative lite			
8	Ethical Awarer conduct			

31. Intended Learning Outcomes and Teaching and Learning Activities for this Subject

What learning outcomes would students expect from this subject? Please list and provide examples of Teaching and Learning activities that might develop and measure these outcomes. The learning outcomes must address any Graduate Capabilities identified above as being assessed in this subject.

	Subject Intended Learning Outcomes (ILOs)	Example of Teaching and Learning Activities for this ILO	Aligned to which FGC(s)?
1	After successful completion of the subject, students will be able to: demonstrate their knowle understanding of the stru functions of biological macromolecules by writte descriptions and answeri choice questions.	Lectures and practical classes. In lectures students will be instructed in molecular interactions, information transfer and the synthesis and	1, 9
2	Explain how the metaboli are regulated to achieve h by written descriptions an multiple choice questions		

	Assessment element	Percentage	Included in these Instance(s) (enter #(s))	Central exam required?	Subject ILO(s) to be assessed in this element
1	Practical class assignments	5%	1	☐ Yes ☒ No	1, 2, 4, 6
2	Two practical reports equivalent to 1000-words each	25%	1	☐ Yes ☒ No	1, 2, 3, 4, 5, 6
3	Four 10-minute tests	15%	1	☐ Yes ☒ No	1, 2
4	One 3-hour end-of-semester examination	55%	1	☒ Yes ☐ No	1, 2, 3, 4, 6
5	Enter text	Enter %	Enter number	☐ Yes ☐ No	Enter number
6	Enter text	Enter %	Enter number	☐ Yes ☐ No	Enter number
7	Enter text	Enter %	Enter number	☐ Yes ☐ No	Enter number
8	Enter text	Enter %	Enter number	☐ Yes ☐ No	Enter number

Please use the section below if more explanation of assessment tasks is required

from program LOs

Unit Learning Outcomes

Teaching and Learning Activities

Assessment

courtesy: Australian Council of Deans of Science

in general, engineering educators are good at outcomes specification and mapping, are quite innovative with pedagogy (with more project work), but need to improve assessment practices and share their expertise

in-program assessment drives students' focus and learning behaviours – basic questions

- **Does (unit) assessment align with learning outcomes ?**
- **Does the combination of unit assessments match the overall outcomes targets ?**
- **Is the assessment (over the whole unit and program) inclusive of the range of students' learning styles ?**
- **Are assessment tasks authentic with respect to engineering practice, especially in group tasks and project work ?**
- **Are the threshold and higher levels of assessed attainment defined for students ?**
  - What does "50% pass" mean in terms of "competency" in a task or behaviour?
- **Can all assessment tasks be formative and encourage greater self-reflection – especially in major project work ?**

broader questions and issues

- **Despite assessment covering all target outcome areas, employers may question typical engineering graduates' demonstrated ability in:**
  - communications, teamwork and project management
  - understanding of business practice
- **So rarely do they question abilities in technical knowledge and skills, should we assume these are broadly satisfactory?**
- **Can (some) target program outcomes be assessed directly ?**
  - What further insights to the education process do registration and licencing examinations provide ?
  - Are generic or discipline specific graduate assessment instruments useful ?
- **External Examiners and Accreditation processes provide some inter-institutional benchmarking of assessment – how can this be exploited to increase reliability and standards ?**

approaches and tools for improved assessment

- **Bloom's (revised) taxonomy provides action verbs for cognition at progressively higher levels**
  - within each level, further verbs guide learning activities within the contexts of experience and prior knowledge

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyse	5. Evaluate	6. Create
A) Factual Knowledge						
B) Conceptual Knowledge						
C) Procedural Knowledge						
D) Metacognitive Knowledge						

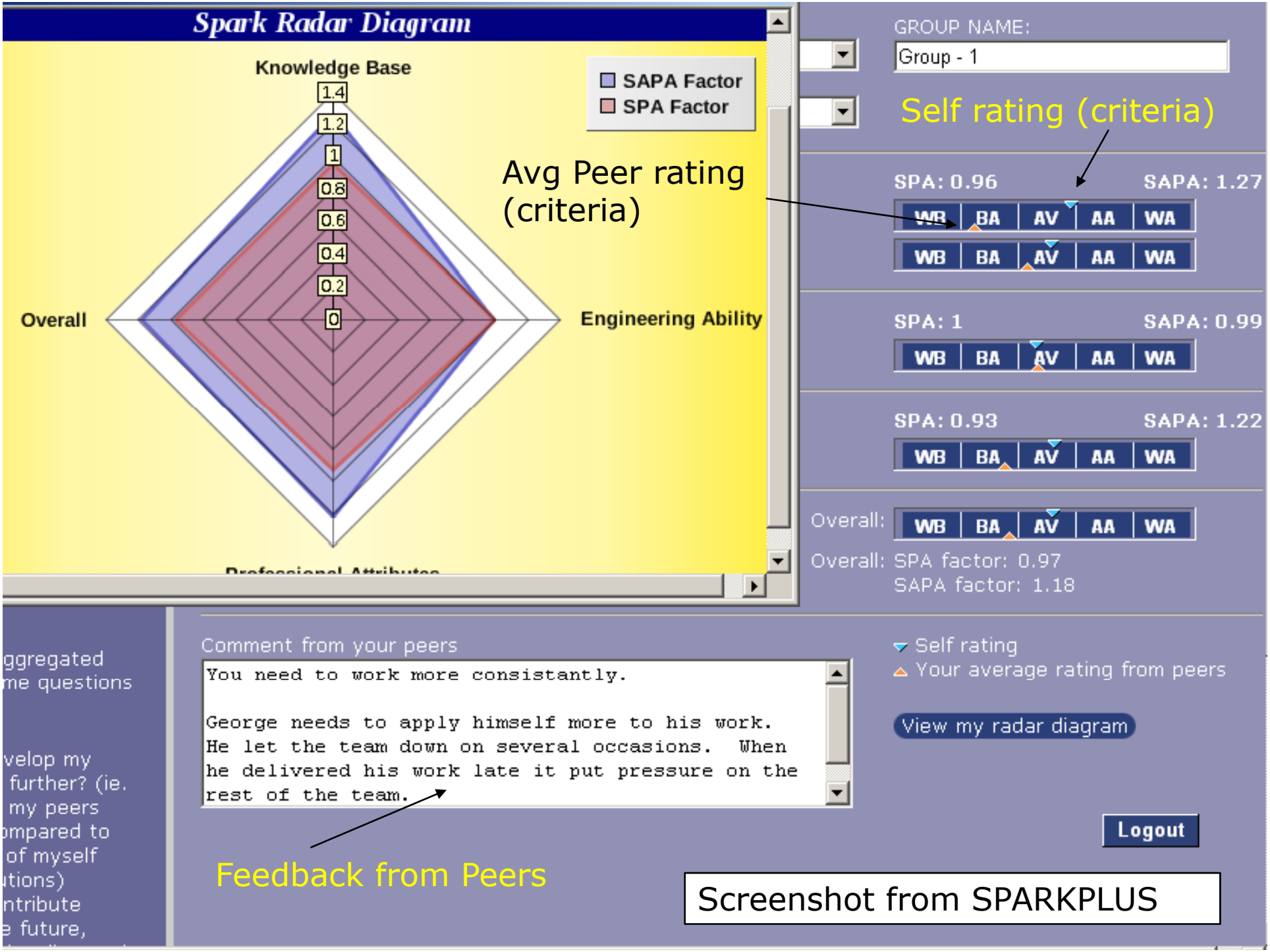
tests and examinations
dominate early year units

assignments and projects
dominate later year course units

Metacognitive knowledge: awareness of learning and learning strategies, techniques to improve learning, knowledge of one's own abilities and weaknesses, ability to recognise higher and lower level thinking – not much covereage in engineering

tools for improved assessment

- **unambiguous specifications of what is expected**
  - clear course (program unit) guides are essential
  - examples of assessed work inform students of standards
  - clear rubrics provide students and markers with guidance
  - *see Spurlin et al. for examples*
- **improving group work**
  - effective group work has to be learned – and is a key skill for engineers
  - use schema for formulating groups for clear purpose
  - use self- and peer- assessment tools to enhance assessment accuracy and students' self awareness (eg SPARKPLUS)
  - *see Kavanagh et al., Willey & Gardner*
- **ensure capstone project assessment covers all its intended outcomes**


Spark Radar Diagram
Knowledge Base
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Overall
Engineering Ability
SAPA Factor
SPA Factor
GROUP NAME:
Group - 1
Self rating (criteria)
Avg Peer rating (criteria)
SPA: 0.96
SAPA: 1.27
WB BA AV AA WA
WB BA AV AA WA
SPA: 1
SAPA: 0.99
WB BA AV AA WA
SPA: 0.93
SAPA: 1.22
WB BA AV AA WA
Overall:
WB BA AV AA WA
Overall: SPA factor: 0.97
SAPA factor: 1.18
ggregated
me questions
velop my
further? (ie.
my peers
mpared to
of myself
tions)
ntribute
e future,
Comment from your peers
You need to work more consistantly.
George needs to apply himself more to his work. He let the team down on several occasions. When he delivered his work late it put pressure on the rest of the team.
Self rating
Your average rating from peers
View my radar diagram
Logout
Feedback from Peers
Screenshot from SPARKPLUS

capstone projects and their assessment

- **are increasingly important to students (self-identity and efficacy as beginning engineers)**
- **contribute to (all) outcomes in the WA profile**
  - advanced knowledge, (complex) problem-solving, investigation (research), design, tools, communications (multiple forms), attitudes, life-long learning
- **but these are rarely (all) rigorously and reliably assessed**
- **a national project in Australia has developed Guidelines for best-practice in BEng(Hons) capstone projects:**
  - curriculum – clear outcome and process specifications
  - supervision – focus on mentoring to the student outcomes , with formative feedback
  - assessment – clear rubrics and examples
  - collaborative benchmarking between other supervisors

adopting improved assessment practices

- **reflect on own and faculty/department assessment practice (e.g. answer questions on slides 11, 12)**
  - share practice, and benchmark against best-practice
- **adopt systematic development activity for individual academics and faculty/department**
  - familiarity with educational principles and assessment literature (as appended)
  - short courses for all and formal higher education qualifications for some
  - engage in and disseminate engineering education conferences

Conclusions

- outcomes-based education should underpin improved graduate attainment
- the engineering profession has agreed international outcomes standards and accreditation systems
- educators have created evidence-based literature and resources for curriculum specification, pedagogy and assessment, including for engineering
- accreditation indicates that best-practice assessment lags program and unit specification and mapping
- individuals and faculties/departments need to reflect on their assessment practices, and take steps to improve
- this presentation has provided some insights into improving the coverage and reliability of student assessment

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