CAETS Symposium 2013

Innovative Approaches to Engineering Education:

The Australian Experience

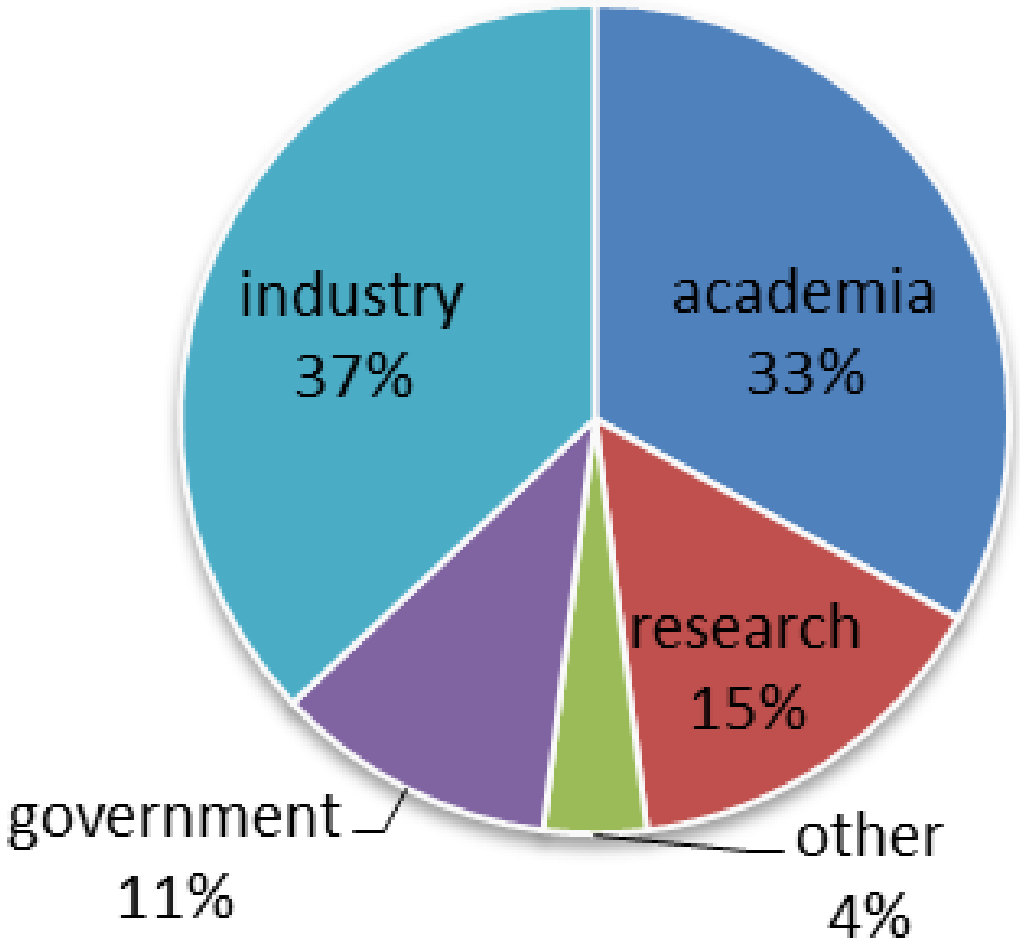
Dr Alan Finkel FTSE

President ATSE

27 June 2013

ATSE

- One of four Learned Academies in Australia, established in 1976 as the applied science academy
- Independent, not-for-profit, evidenced-based advocate of technology for prosperity
- 815 Fellows - outstanding scientists, technologists and engineers in Australia


industry
37%
academia
33%
research
15%
other
4%
government
11%

Vision

A future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing.

ATSE STRATEGY PLAN 2013-17

Sets out renewed focus on linking technological innovation to productivity and prosperity through core activity areas.

Why ATSE cares about education

One of our key strategies:

Provide leadership in STEM education at all levels

- promote secondary school science literacy
- promote STEM careers
- promote tertiary education units on entrepreneurship, project management and business skills for engineering students.

Starting with secondary-school STEM

Science & Technology Education Leveraging Relevance

What is STELR?

- An ***in-curriculum***, secondary school science education initiative, aimed at 14 – 15 year olds
- Between 6 and 10 weeks duration
- Currently in over 340 schools across Australia (15%)
  - with trials in Singapore and New Zealand
- Over 35,000 students participate each year

STELR Aims

1. Increase the numbers of students studying maths and sciences, using technology, in upper secondary school
2. Improve the level of science literacy and understanding in the community
3. Raise awareness of opportunities in technology-related careers
4. Raise awareness that engineering is creative
5. Improve the quality of science classroom teaching practice

STELR Strategies

1. Provide ***relevant*** technology context

   STELR uses ***renewable energy*** for its teaching context

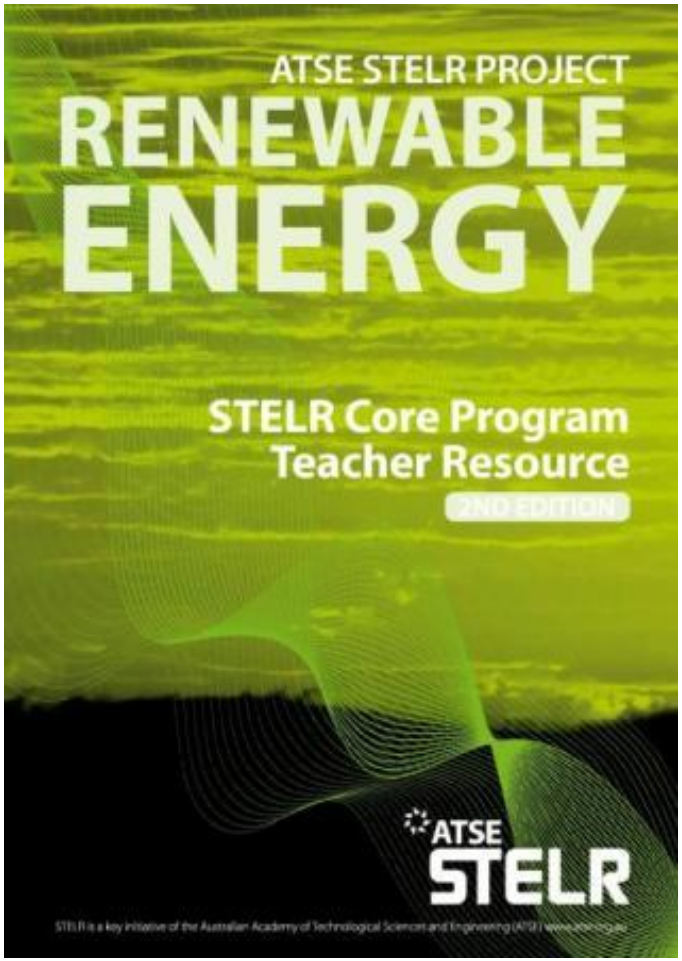
2. Embed ***contemporary*** teaching and learning practices

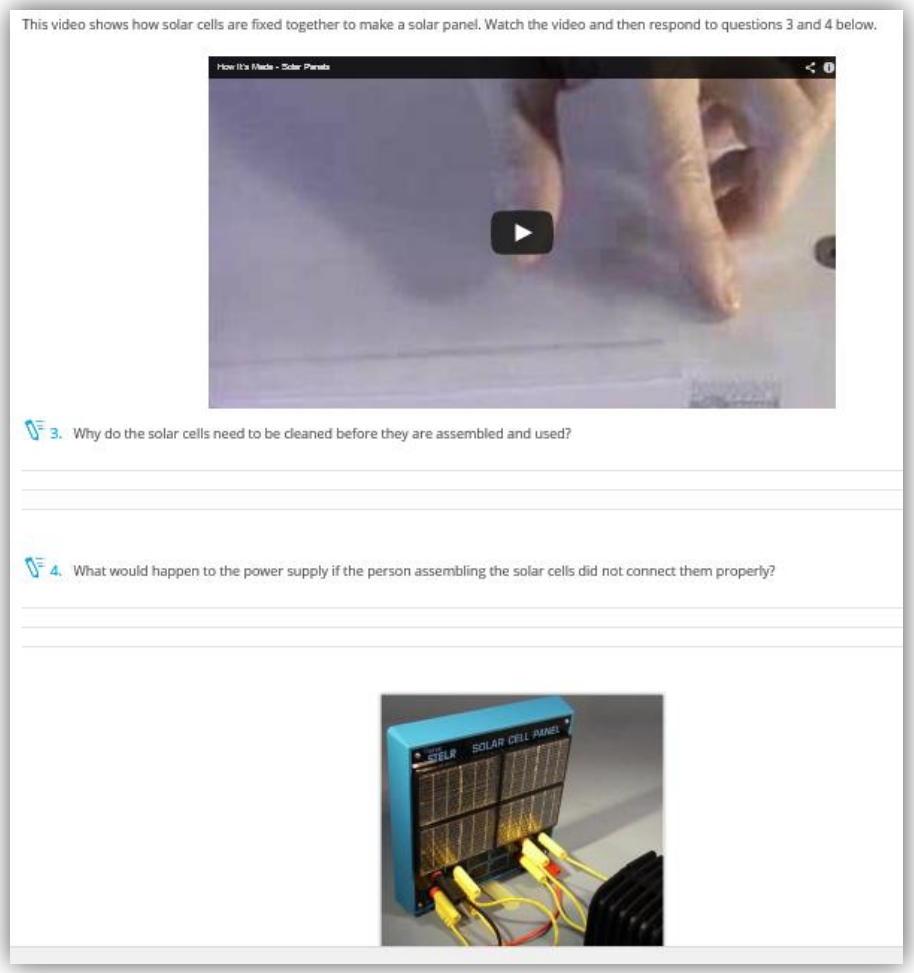
   Inquiry-Based learning

3. Implement ***within*** the curriculum

4. ***Align*** with Australian Curriculum guidelines for science and maths

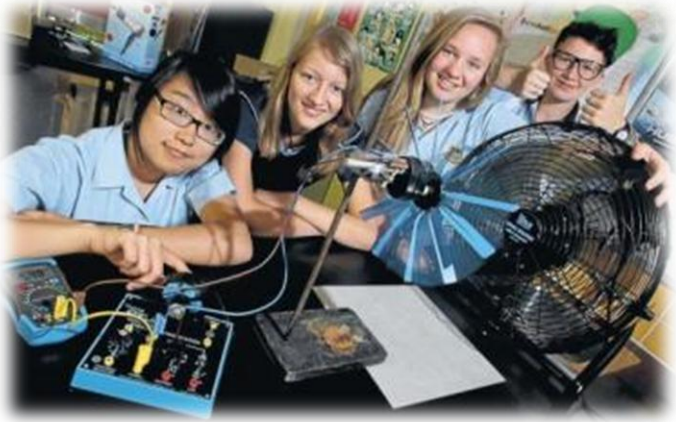
STELR: curriculum materials



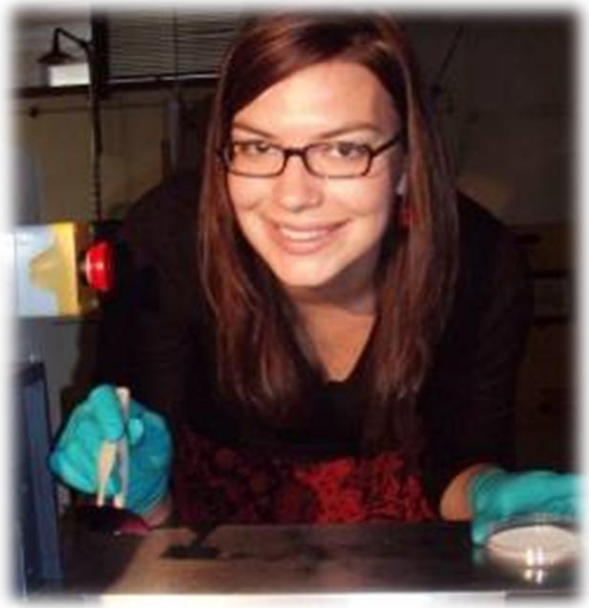


Equipment in a STELR Class Set

STELR in Class



STELR Career Profiles



TERTIARY EDUCATION - ENGINEERING

Existing Best Practice

- Best practice in Australian engineering faculties is well established
  - Integrating digital curriculum delivery
    - Blended learning, flipped classrooms
  - Learning practices to prepare graduates for real world engineering
    - An experiential approach makes for faster and more effective learning
  - Group work
    - Includes peer assessment and self assessment
- Project based learning
- CDIO framework (Conceive – Design – Implement – Operate)
- Engineering projects that contain
  - engineering and scientific aspects
  - financial, social, legal, human aspects
  - commercial computer packages that are used in practice
  - authentic, industry driven

Existing Best Practice

- Attribute training
  - But students still need core knowledge from which to launch their search
- Leadership training
  - Engineering fundamentals but also understand the societal context
- Systems engineering training
- Entrepreneurship (including challenges with real prizes)
- Project management
- Financial training (read a budget, a P&L, a balance sheet)
- Sustainability must be a constant consideration
  - beyond doomsday thinking
  - how to use resources sensibly and economically.

Areas for Improvement

- Need more authentic (e.g. industry inspired) projects in the 2nd and 3rd year engineering courses
- More group work and collaboration
- Retention is too low
  - Completions at 65% - 70% national average (like USA)
  - Top faculties are 75% – 85%
- Enrichment for students who have prerequisites
- Build interest within secondary schools
  - STELR program as an example
- Low participation rates of women: 16%, trending down

EDUCATION MODELS

A Systems Model for Accreditation

Educational accreditation by national university regulator: license to run award programs

Professional accreditation by national external agency (Engineers Australia for the Washington Accord)

Washington Accord

- from 6 Signatories in 1989 to 15 in 2013
  - plus 6 provisional members
- signatories are national agencies independent of government and providers
- signatories obligated to provide equivalent status to graduates of others
- protocols for cross-border accreditation
- agreed ‘graduate attribute’ exemplar

Washington Accord Graduate Attributes

engineering knowledge
problem analysis
design/solution development
investigation
modern tool usage
the engineer in society
environment & sustainability
ethics
individual & teamwork
communication skills
project management & finance
lifelong learning

Extracurricular programs maximize attributes

Leadership In a Technological Environment (LITE)

A three year, non-award program

Responds to industry feedback that the lack of ability to communicate and show leadership is a weakness in engineering graduates.

Structure of LITE program

Year 1

3 day residential:
Understanding self and others

1. What is Leadership?
2. Communications for leadership
3. Critical thinking & problem solving

Half-day industry visits in groups of up to 10

Year 2

2 day residential:
Team building

4. Ethics
5. Sustainability
6. People skills

1 or more weeks industry placement

Year 3

non-residential:
Project Management

7. Innovation & entrepreneurship
8. Globalization
9. Change management

12 week industry vacation placement

CDIO educational protocol

Conceive – Design – Implement – Operate

- is an innovative educational protocol, taking an engineering approach for curriculum design and implementation
- stresses disciplinary knowledge, and work skills, in the context of real-world systems and products
- outcome of original collaboration between MIT and Swedish universities (Chalmers, KTH, Linkoping)
- now more than 50 universities in 25 countries have adopted CDIO for their programs
- New in Australia, 10% of faculties

Engineering design: the introductory stage

Many engineering faculties have introductory engineering design unit:

- conceptual design and creative thinking
- project planning and management
- teamwork and communications

Such projects and courses are usually successful at

- encourage thinking about engineering solutions in the real world – especially human needs and sustainability
- include basic costing and risk analysis
- motivating students in engineering

Most faculties in Australia use the *Engineers Without Borders* Challenge

- small-scale, basic engineering problems
- EWB develops project briefs and supporting material, in collaboration with target community
- student teams compete across Australia

Engineers Without Borders – Challenge 2011

Community: Devikulam, Tamil Naidu, India

Goal: innovative and appropriate solutions for sustainable development

Design areas:

industry development, building and construction, transportation, water supply and sanitation, energy, information, communication and technology for educational activities, waste management, and housing

teams may address one issue or provide an integrated design solution for two or more

Breadth and depth of design is left to individual universities and design teams to scope

Engineers Without Borders – Challenge 2011

Senior (capstone) projects in engineering design

Most engineering degrees include a final year project with a design and/or research focus

- meet accreditation requirements
- may be done as individual or group
- topics may be derived from
  - industry problems
  - national and international competitive schemes such as SAE
  - supervisor's research

Project outputs

- reports (primarily for assessment)
- artifacts – built and tested demonstration or simulation, or design drawings (discipline dependent)
- presentations (primarily for assessment)

Competitions are very popular and motivating

Osaka University wins 2010 FSAE Japan

some SAE projects are organised as “extra curricular” activities – others are assessed

Canada’s McGill University Electric Snow Mobile in the SAE Clean Snowmobile challenge

Problem based learning: pedagogy formalization

"Whole program" PBL was developed for medicine (McMaster, Canada) and engineering (Aalborg, Denmark)

- focus on system problems - "diagnosis" or "design"
- mostly implemented with group work
- context for understanding subsystems and techniques
- teaching, supervision and assessment load is high and different from "lecture-laboratory-tutorial" units

Students are "forced" to engage with project topics and their groups to achieve required outcomes

- evidence that key learning outcomes from design-based PBL are better than those from conventional courses
- balance required

Self and peer assessment

Validates group work

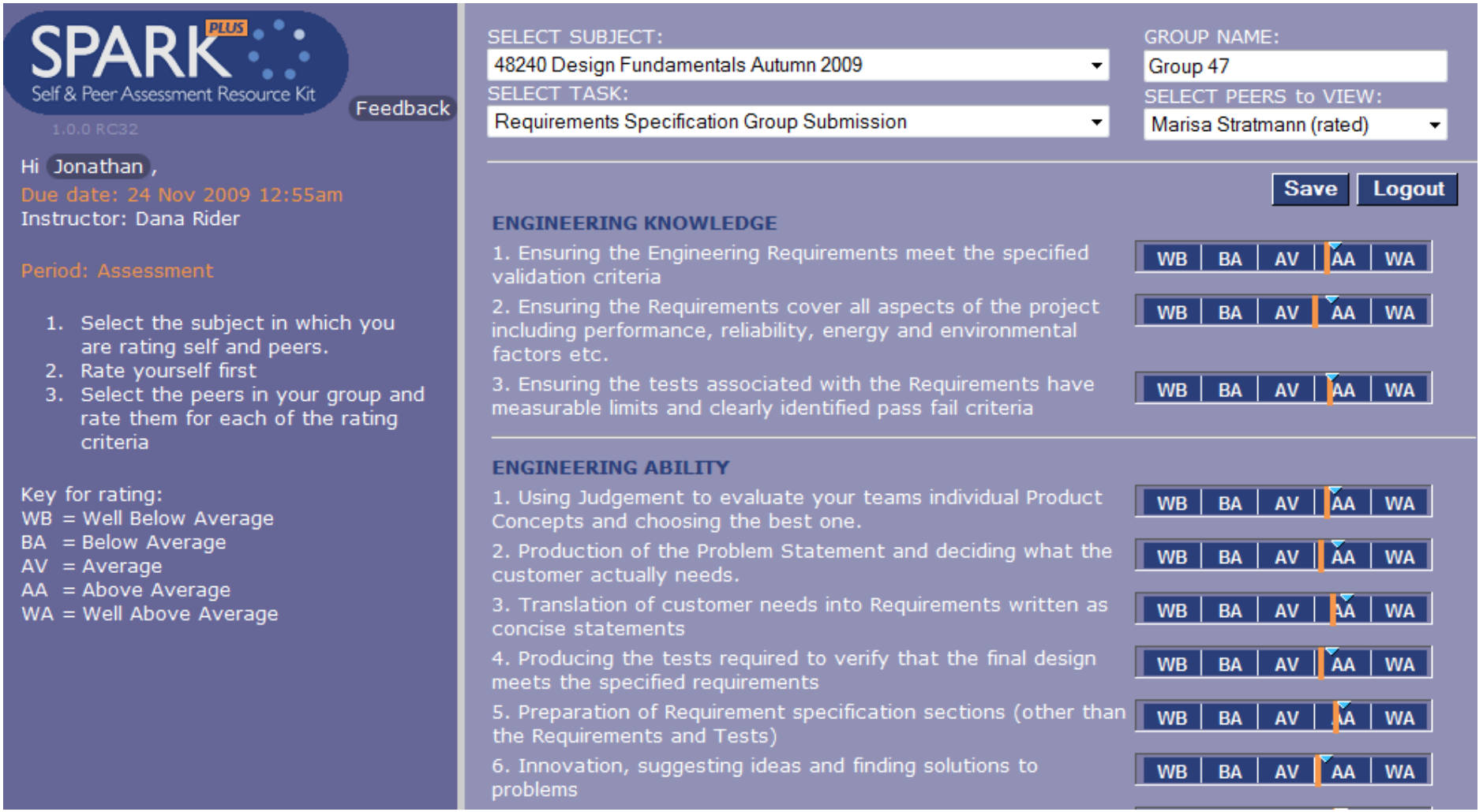
Engineering students do not (typically) do self reflection of their learning, or welcome making accountable judgments on other students

As group design work is a valuable pedagogy we need to have reliable learning-oriented assessment and provide learner-oriented feedback

An Australian development is SPARK^{PLUS}

- **provides support for individual and group assessment**
- **tutor moderation and benchmarking between groups**
- **confidential "feed-forward" to group members**
- **demonstrates emergence of different views on same topic**

SPARK^{PLUS} for self and peer assessment



INDUSTRY AUTHENTICATION

Australian National Engineering Taskforce

ANET is an education-industry collaboration to create a national strategy for the development of Australia's current and future engineering workforce.

- the Association of Professional Engineers, Scientists and Managers Australia (APESMA)
- Engineers Australia
- The Association of Consulting Engineers Australia (ACEA)
- The Australian Council of Engineering Deans (ACED)
- Australian Academy of Technological Sciences and Engineering (ATSE)

Summary

- Start with secondary STEM inspiration
- Engineering courses in Australia modernised since 2000
- International accords
- Graduate attributes
- CDIO course design is coming
- Problem based learning throughout
- Self and peer assessment
- Industry authentication and projects are crucial