Transforming engineering programs with Studios – the UTS experience

UTS

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UTS – University of Technology Sydney

- Number 1 young university in Australia (<50 years old)

COURSE TYPE	2020
Undergraduate + enabling + …	33,117
Postgraduate coursework	9778
Research postgraduate degree	2326
Total	**45,221**
Equivalent full-time student load (EFTSL)	34,344
Average load (% of F/T)	76%

Faculty of Engineering and Information Technology

(about 25% of UTS students)

Research Strengths

- Australian Artificial Intelligence Institute
- Robotics Institute
- Data Science Institute
- Global Big Data Technology Centre
- Centre for Quantum Software & Information
- Centre for Technology in Water & Wastewater
- Centre for Health Technologies
- See: https://www.uts.edu.au/about/faculty-engineering-and-information-technology/research-faculty-engineering-and-it/our-research/transforming-society

Australian statistics 2019

36 engineering schools

118,000 total students (78,800 effective full-time) in 2020

4,600 full-time equivalent academics

4-year Bachelor Honours graduates (75%) + 5-year MEng (25%)

Domestic 8,900 (18% women), International 6,000 (22%)

34% civil engineering, 26% mech & mech, 18% elec,
10% chemical/process, 4% software, 3.4% biomed, …

Employer overall satisfaction 90% (highest of all disciplines)

Full-time employment rate 80% (6 months after graduation)

ACED
AUSTRALIAN COUNCIL OF ENGINEERING DEANS

Engineering 2035 report – Drivers of change

1. rapid advances in a range of **technologies**
2. increasing **globalisation**
3. changes in **how we work**
4. changing **societal expectations**
5. evolving **human needs**

→ Greater diversity of engineering work

Urgent action is required to adapt engineering curricula to these changes

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https://aced.edu.au/index.php/engineering-2035

Key requirements

1. **Technical** expertise (of course!)
2. Holistic, **systems** approaches
3. Increasingly complex and **multidisciplinary**
4. Privilege lifecycle and **societal considerations,** expectations and **trust**
5. **Problem finding** with stakeholders
6. **Digital** tools will be pervasive, enabling more **creative** work

https://www.weforum.org/reports/the-future-of-jobs-report-2020/in-full/infographics-e4e69e4de7

Top 10 skills of 2025

- Analytical thinking and innovation
- Active learning and learning strategies
- Complex problem-solving
- Critical thinking and analysis
- Creativity, originality and initiative
- Leadership and social influence
- Technology use, monitoring and control
- Technology design and programming
- Resilience, stress tolerance and flexibility
- Reasoning, problem-solving and ideation

Type of skill

- Problem-solving
- Self-management
- Working with people
- Technology use and development

Source: Future of Jobs Report 2020, World Economic Forum.

Curriculum change

1. Better **integrated** curricula (focused on development of professional skills)
2. Collaborative and open-ended problem-finding and solving in multidisciplinary project teams (**society** + **complexity** + **systems**)
3. Greater emphasis on **digital design tools** and data analytics
4. stronger **industry** and community links in teaching.

Student and graduate views

(Rob Lawrence)

- Students are attracted to core disciplines + **emerging fields** of renewable energy, smart cities, AI, robotics
- However, **diversity** of engineering roles is poorly understood
- **Double degrees** = dual skills = increased employability (consider design disciplines)
- Engineering **projects** generate interest, e.g., solar car, F1 in Schools, hackathons
- Many students want to make a **contribution** → make this a greater focus at university
- **STEM** should not be the only pathway into engineering

The Academic Survey

(Carl Reidsema, Ian Cameron, Roger Hadgraft)

- Conclusion from 2035 Report:

  “Changing curricula, pedagogies and new kinds of engineering educators will also be needed.”

- **Are academics ready for such change?**

- Survey to examine Academic Workforce Capabilities
  - 673 Responses
  - 387 (100%) Completions
  - 16 Faculties (N = 318) with n > 9 - 40 responses
    - **LRU** 150; **METRO** 96; **REGIONAL** 72

The Survey Instrument

1. Real World Issues
2. Industry Collaboration
3. e-Learning
4. Digital Modelling
5. Human/Social Issues

- The **process of change** itself, that must underly any constructive response towards delivering a future (2035) curriculum,
- **five factors** of teaching change considered most likely to lead to the desired capabilities of future engineering graduates (Crosthwaite, 2019), and
- the respondent's **disposition** towards their professional development as an engineering educator.

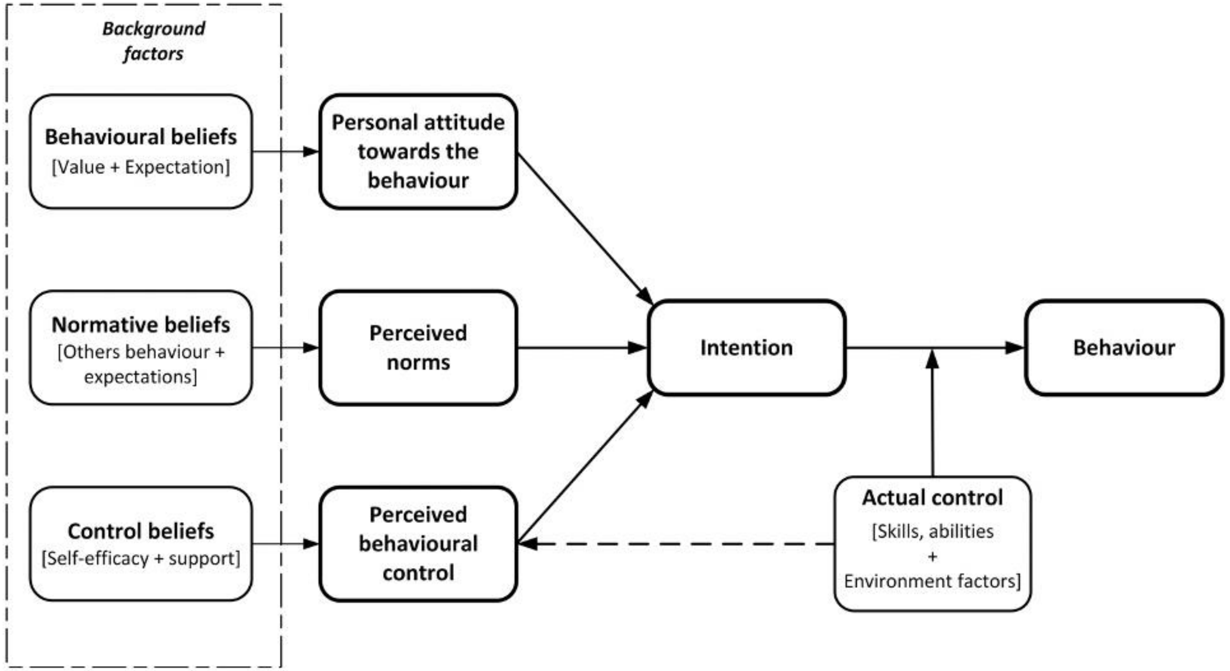
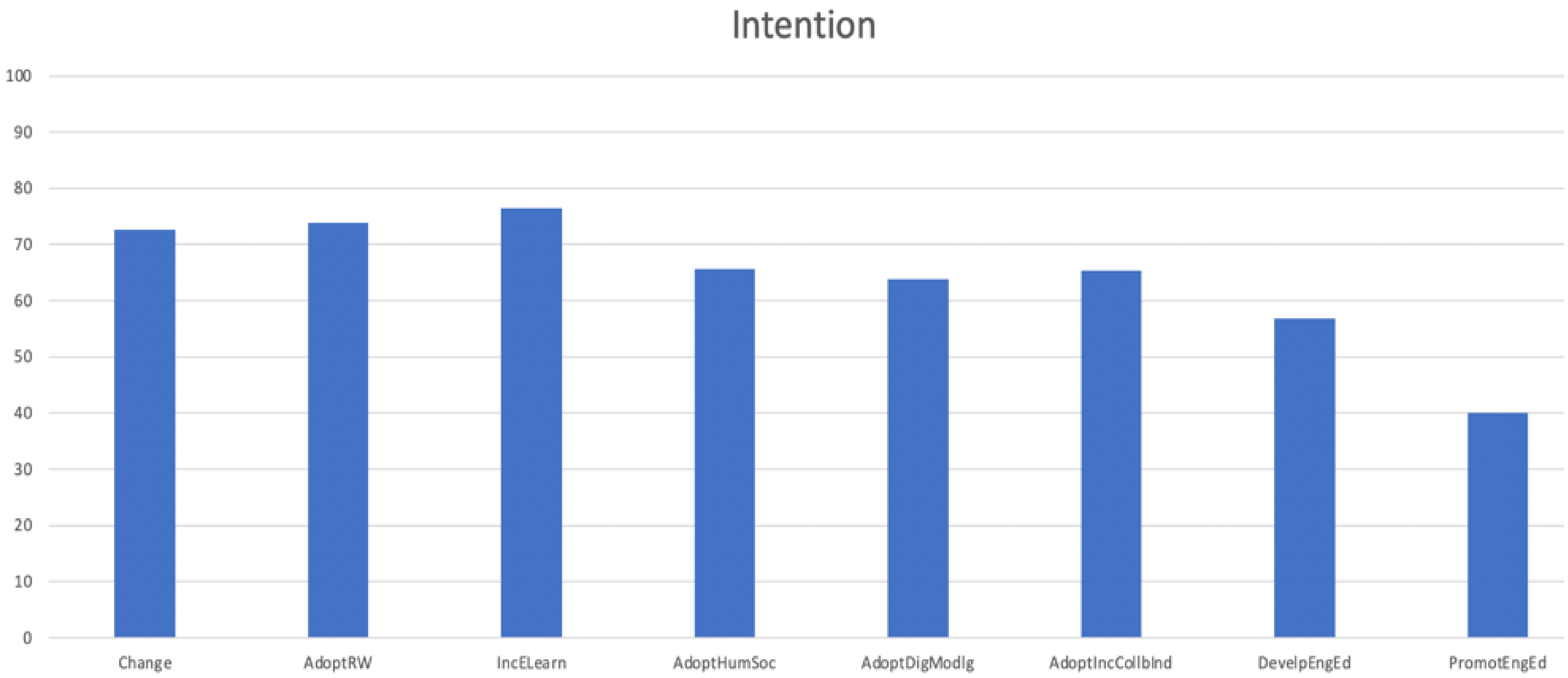


Figure 1 Elements in the Theory of Planned Behaviour

%Agreement - Intentions



Change Real-world E-learning Societal Digital Industry Personal Dev Promotion

Areas of Concern

1. **Leadership** more positive than Rank and File wrt Support/Reward
2. **Incremental Change** more favoured than Rapid Change
3. **High confidence** in abilities vs Low support expectations
4. Risk Management higher than Risk Taking
5. Risk Taking not perceived as welcome by leadership
6. Innovative pitches to leadership less than welcome

Key issues to address

What methods can we use to ensure that student expectations are appropriately met?

What are appropriate curriculum and pedagogical approaches that will develop the professional engineering graduate?

Do we have the staff now and in the future to deliver this curriculum and pedagogy?

Outstanding Programs & Pedagogies

(Caroline Crosthwaite)

- Have a distinctive program level **philosophy**
- Engage with **industry** and **community,** including **placements + projects**
- Make systematic use of **student-centred, project-based learning**, beginning in first year
- Use **human-centred** and empathic design projects, on-line simulations, competitions
- Employ a range of **authentic assessments,** including competencies typical of professional practice
- Provide enabling people, processes, systems and **resources**

Where to from here? – 6 work packages

- Digital Engineering
- Multidisciplinarity (Socio-technical)
- Integration of research and practice within curriculum
- Industry Collaboration
- Academic development
- Workforce and Student Diversity

We used a workshop at the 2021 AAEE conference (the Australasian Association for Engineering Education) to prioritise.

AT UTS, we implement these ideas through **Studios**

What is a Studio?

A studio is typical in design disciplines, such as architecture …

1. A **challenging scenario** – from industry with multiple solutions
2. Students work in **teams**
3. Using the latest computing **tools**
4. Learn **technical skills** when required (or pre-learned)
5. Each student defines their personal learning through a **contract**
6. And demonstrates achievement through a **portfolio** (career focus)

Key innovation for change at UTS:

Summer Studios

A place for experimentation +

Student-led studios

An elective for students

UTS

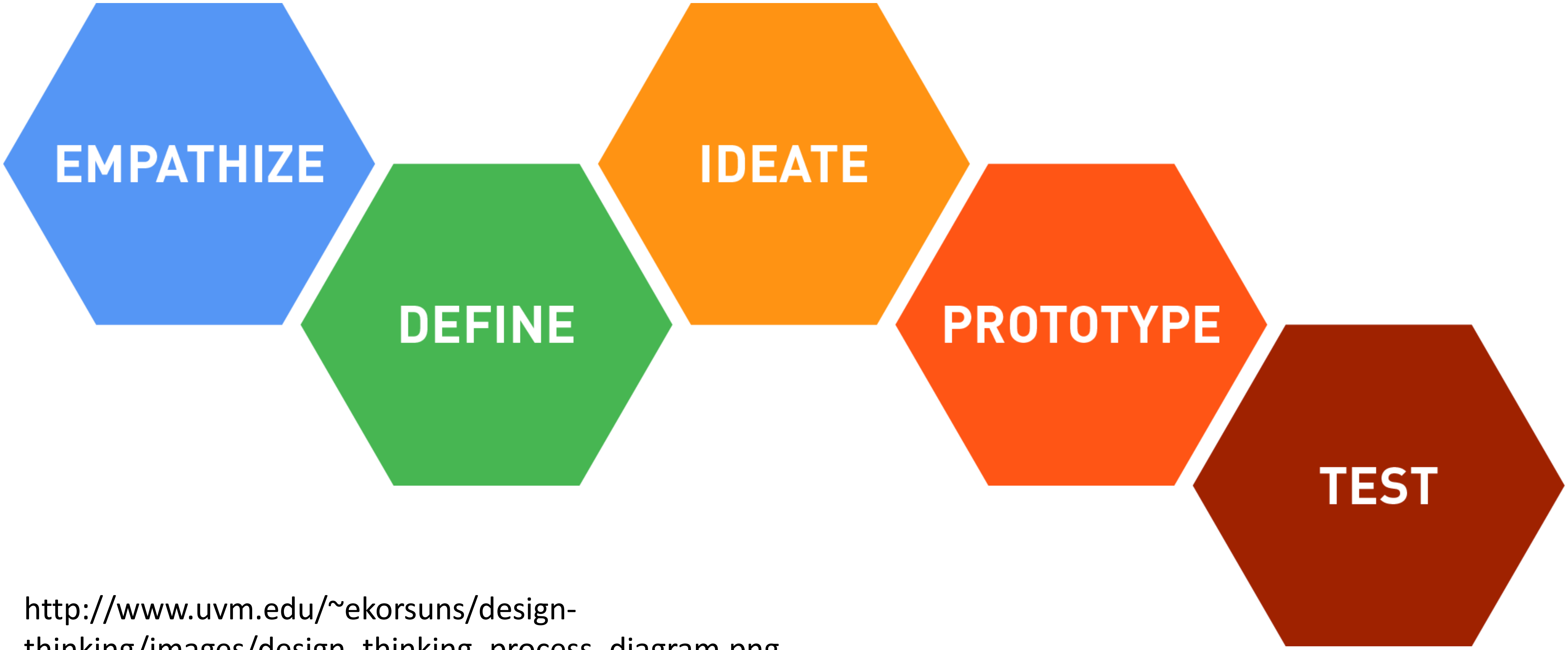
Some of the Summer Studios in Jan/Feb 2018, 2019, 2020

1. Humanitarian Engineering
2. Activating the Smart City
3. Combatting heat island effect in CBD
4. Computer vision machine learning
5. Vivid 2018 light show
6. Space Challenge
7. Internet of Things
8. Robotics (autonomous vehicle)
9. Cybersecurity

Learning objectives

1. *Engage with **stakeholders***
2. *Apply **design thinking***
3. *Demonstrate **technical skills***
4. *Use **collaboration tools***
5. *Conduct self, peer and team **reflection***

Design thinking framework

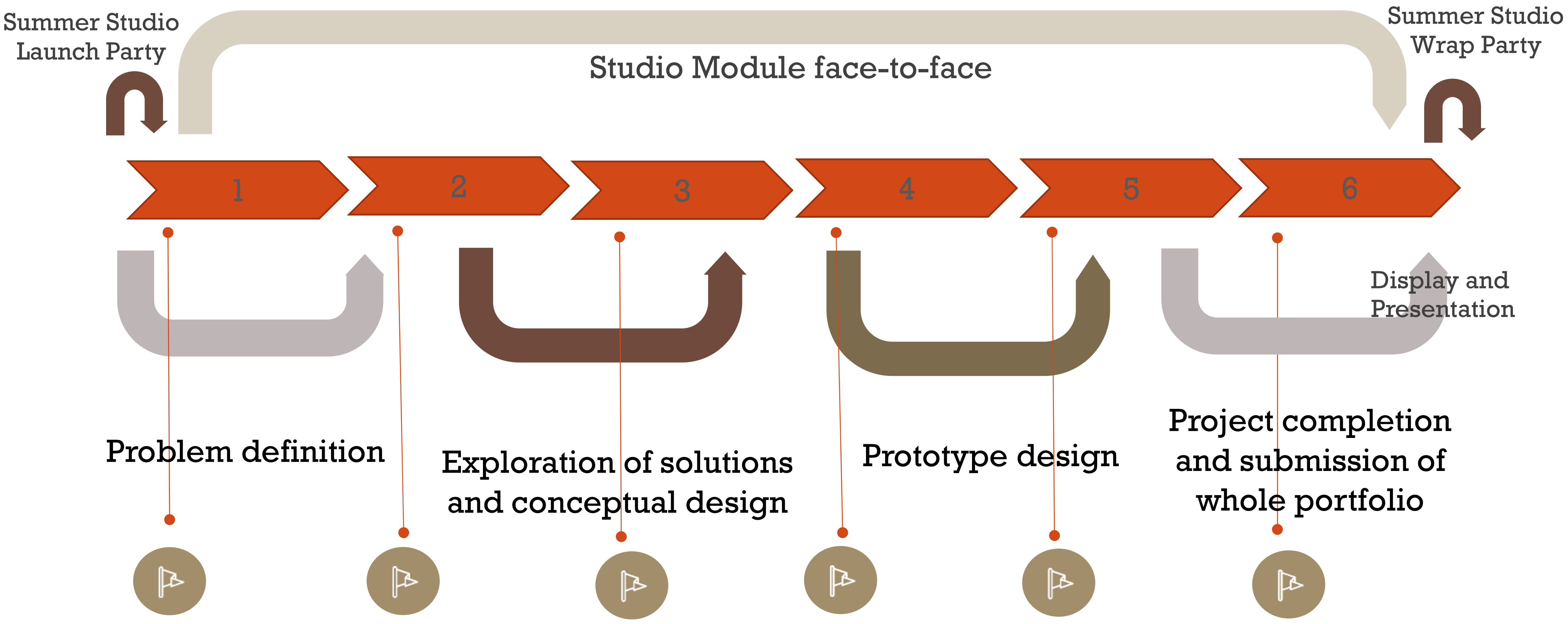


http://www.uvm.edu/~ekorsuns/design-thinking/images/design_thinking_process_diagram.png

Agile project management

MIDAS SUMMER STUDIO IN 6 WEEKS

MIDAS = More Innovative Design Able Students



A student commented:

*I liked the open-ended scope, **freedom** and **creativity**.*

*I had freedom to learn using my own practical **experiences** instead of a regimented assessment schedule.*

6 key principles for student learning experiences

Challenging ideas and people

Active engagement

Supportive environments

Active, **real-world** learning

Collaborative

Reflective

Tomorrow's Professor #1818

How to change?

Who leads?

- **Deans, Heads of School** establish and enable curriculum change
- **Associate Dean** leads and coordinates the change with …
- **Deputy Heads of School** who make it happen (by coordinating the new curriculum and the academics) and …
- **Learning Designers** – who help academics create learning modes
- **Academics** – who teach and facilitate their subjects
- **Students!** – who become leaders as teachers

Ruth Graham’s report, 2012

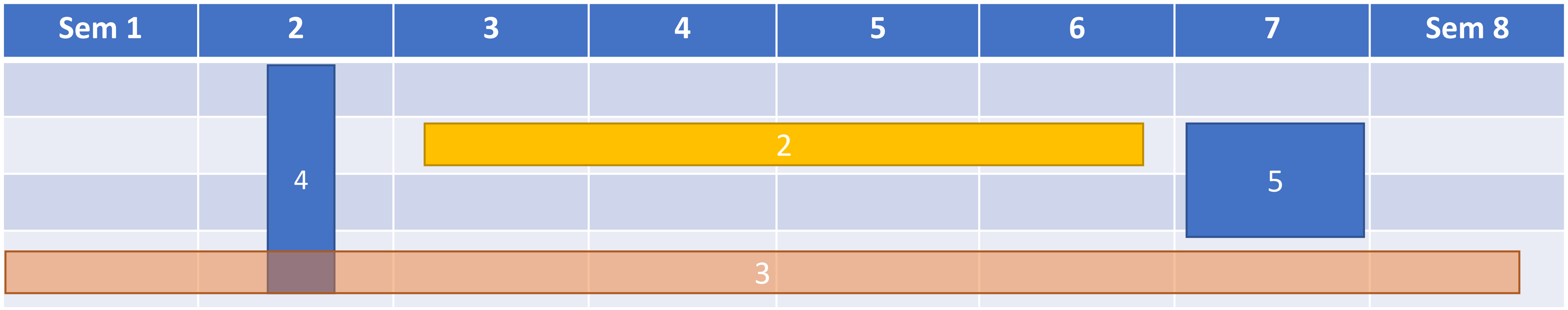
“Achieving excellence in engineering education: the ingredients of successful change” – critical success factors:

1. Helps to have a **crisis** as trigger, e.g., falling enrolments
2. Be **ambitious** and aim high (interconnected and wide-ranging)
3. **Heads** of Departments/Schools are primary players
4. **Academic** engagement is critical – work with the willing
5. **Team teaching** helps sustain innovation
6. Nevertheless, many innovations are **not sustained**

How to remake a traditional curriculum?

Easy Transition to a PBL curriculum

1. **Start small**: make small **projects** in many/most subjects
2. Rethink **sequences** of subjects, e.g., fluids/thermo, structures
3. Identify a project course in **each semester**
4. **Share** a project *across* a semester (UCL's Integrated Eng)
5. **Combine** courses into bigger units with bolder objectives



New Mechanical Engineering Curriculum (5)

First Year			Second Year			Third Year			Fourth Year			Fifth Year	
Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring
Stage 1	Stage 2	Free	Stage 3	Stage 4		Stage 5	Stage 6	Free	Stage 7	Stage 8	Stage 9		Stage 10
Mathematical modelling 1	Engineering computations and modelling		Mathematical Modelling 2	24 week Internship		Design for Sustainability,Safety and Risk	Engineering Economics and Finance		Engineering Project Management	Entrepreneurship and Commercialisation	24 week Internship		Sub-Major/Elective or Mech Choice Studio
Physical modelling	Structural design A (simple systems)		Thermal/fluid design A (simple systems)			Structural design B (complex systems)	Advanced Manufacturing (B) (Industry 4.0)		Mechanical system dynamics, vibration, measurement and control A	Mechanical system dynamics, vibration, measurement and control B			Sub-Major/Elective or Mech Choice Studio
Engineering Communications	Materials and Manufacturing (A)		Design of machines and mechanisms A (kinematics)			Thermal/fluid design B (complex systems)	Design of machines and mechanisms B (kinetics and adv kinematics)		Sub-Major/Elective or Mech Choice Studio	Engineering Research Preparation			Sub-Major/Elective or Mech Choice Studio
Introduction to Mechanical Engineering	Introduction to Mechatronic Engineering		Mech Studio A (machine/product design)			Mech Studio B (Thermal/fluid system)	Application Studio A		Application Studio B	Professional Studio A			Professional Studio B (Capstone)
			Engineering Practice Preparation 1			Engineering Practice Reflection 1				Engineering Practice Preparation 2			Engineering Practice Reflection 2

Key ideas

1. We need to **change** curricula for a rapidly changing world
2. Students need to deal with **complexity** such as climate change; *and*, engineering projects are, themselves, **increasingly complex**
3. A systematic, **team-based** process is required
4. **Heads** of Departments/Schools are critical allies and opponents
5. **Students as partners** are key enablers

However, change is not guaranteed

Current survey as part of the ACED 2035 project:

81% of academics acknowledge substantial change is necessary

65% report their leadership team demonstrates good practice

53% will emulate their leadership

44% say their institution rewards their efforts

BUT **94%** are confident they can rapidly change their teaching – as COVID has demonstrated!

Carl Reidsema, Ian Cameron, Roger Hadgraft ‘Are we ready to transform engineering education?’ AAEE2020 conference, Sydney.

How will you change your teaching?

Questions and comments

Phase 1 proposal

1. Establish a mechanism for change – the **Engineering Futures Initiative**, which will have oversight of, and drive Engineer 2035 objectives over time
2. Make **real world, industry sponsored, and socio-technically focused projects** available to all students as quickly as possible
3. Monitor the change – a **national benchmarking methodology** to measure the change in educational models
4. Inform and make visible the change – compiling and promoting **exemplars, practice guides,** and case studies