University of Birmingham
Integrative and Interdisciplinary Engineering
EPC Congress 2019 Leading Change in Engineering Education
New Model Approaches
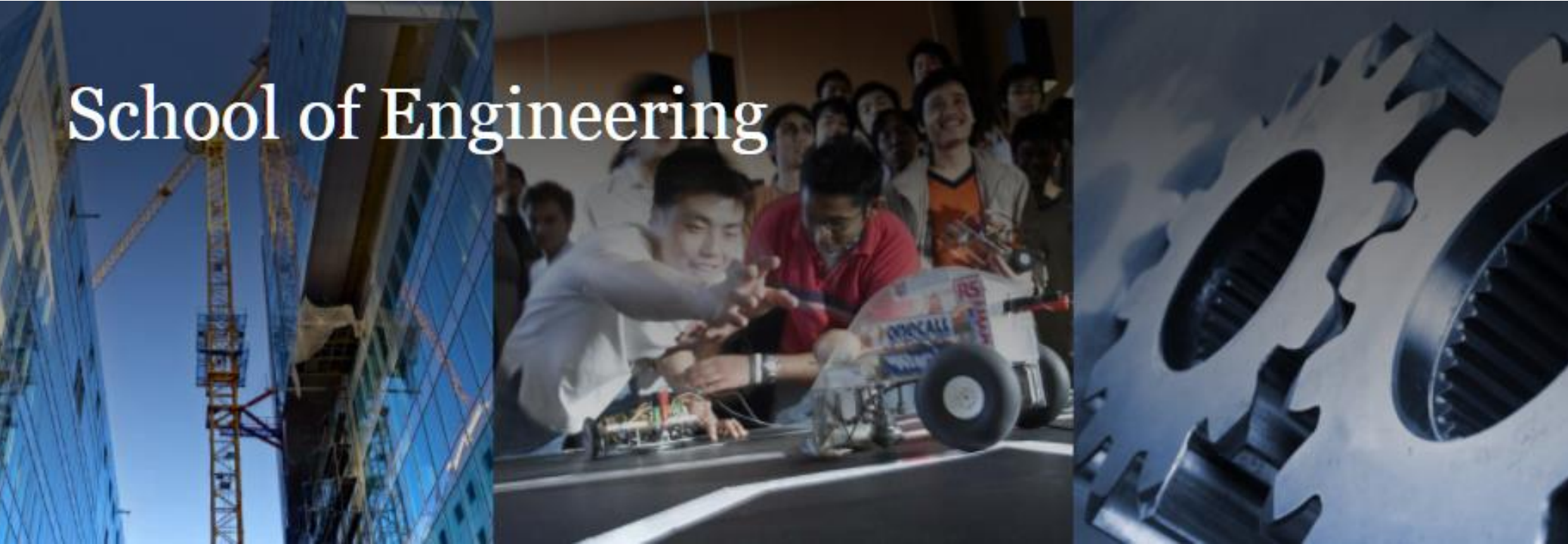
13/05/19

Dr Neil Cooke

School of Engineering, University of Birmingham

Senior Lecturer, Deputy Director Teaching and Learning Centre

Board of Directors, European Engineering Education society (SEFI)
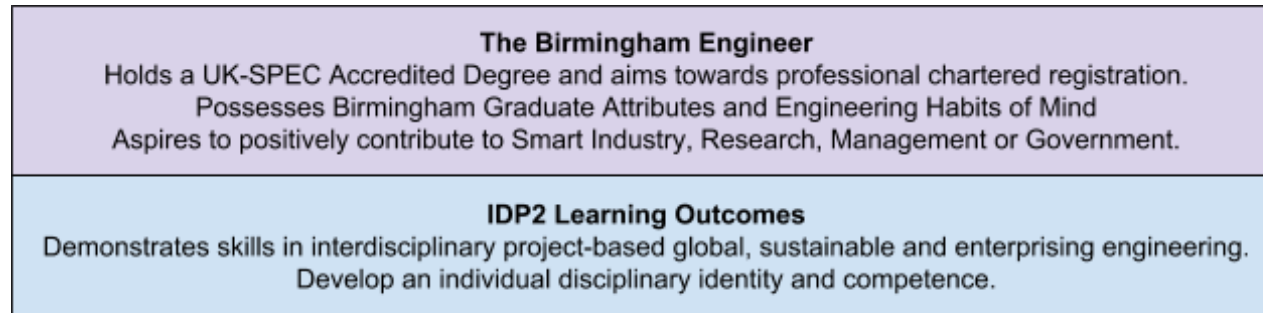
School of Engineering

- The School of Engineering combines Mechanical, Electrical and Civil engineering. 70 Academic Staff, 1200 Students.

- The School is transforming its curriculum
  - A shared first year of study across the UG programmes
  - Interdisciplinary Design Projects for all years
  - A School Teaching and Learning Centre (TLC) which is an incubator for innovation in the curriculum and seeks to develop and value excellent teaching.
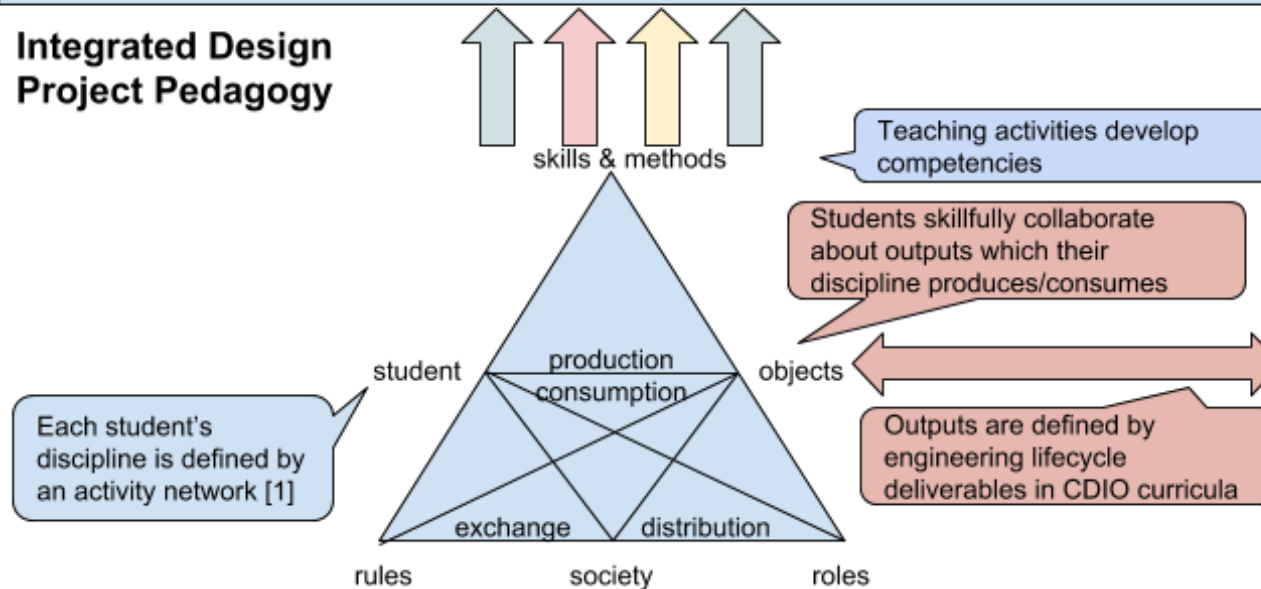
Questions

- **How to strengthen disciplinary identity in a multidisciplinary engineering curricula?**

- **How to cultivate 21st / 22nd century engineers: Skills and Purpose**.

- Digital (automation, convergence, big data, production)

- Growing scarcity of natural resources.

- Resource conflicts and climate disaster.

IDP Pedagogy: Integrative and Interdisciplinary

The Birmingham Engineer
Holds a UK-SPEC Accredited Degree and aims towards professional chartered registration.
Possesses Birmingham Graduate Attributes and Engineering Habits of Mind
Aspires to positively contribute to Smart Industry, Research, Management or Government.

IDP2 Learning Outcomes
Demonstrates skills in interdisciplinary project-based global, sustainable and enterprising engineering.
Develop an individual disciplinary identity and competence.

Integrated Design Project Pedagogy

skills & methods

Teaching activities develop competencies

Students skillfully collaborate about outputs which their discipline produces/consumes

student — production consumption — objects

Each student's discipline is defined by an activity network [1]

Outputs are defined by engineering lifecycle deliverables in CDIO curricula

exchange   distribution

rules   society   roles

Conceive Design Implement Operate lifecycle objects [2]:
Conceive (Mission): *Business strategy, technology strategy, customer needs, goals, competitors, program plan, business plan*
Conceive (Conceptual Design): *Requirements, function, concepts, technology, architecture, platform plan, market positioning, regulation, supplier plan, commitment.*

Design (Preliminary): *Requirements allocation, model development, system analysis, system decomposition, interface specifications*
Design (Detailed Design): *Element design, requirements verification, failure & contingency analysis; validated design.*

Implement (Element creation): *Hardware manufacturing, software coding, sourcing, element testing, element refinement.*
Implement (Systems Integration & Test): *System integration, system test, refinement, certification, implementation ramp-up, delivery.*

Operate (Lifecycle support): *Sales and Distribution, Operations, Logistics, Customer Support, Maintenance and Repair, recycling, upgrading.*
Operate (Evolution): *System improvement, product family expansion, retirement.*

[1] Akkerman, Sanne F., and Arthur Bakker. "Boundary crossing and boundary objects." *Review of educational research* 81.2 : 132-169.(2011)
[2] Crawley, E., Malmqvist, J., Östlund, S., Brodeur, D, Edström, K, *Rethinking Engineering Education. The CDIO approach 2nd Edition*, Springer (2014).

IDP Progression Model / Learning Outcomes

Year	Title	IDP Learning Outcome: "IDP students will demonstrate a broad range of interdisciplinary competences primarily developed through engineering design-oriented experiences." realised by:
UG1	IDP-1	• Creative conceptual design i.e. simple prototype, qualitative analysis, oral presentation, written report. • Identifying own enterprise and interdisciplinary competencies
UG2	IDP-2	• Multidisciplinary considerations, customer driven design i.e. more advanced prototype for customer with some quantitative simulation, oral presentation, and written report. • Developing individual enterprise and interdisciplinary competencies.
UG3	IDP-3	• Multiple objectives, re-design requirements i.e. prototype (as needed) and advanced simulation, oral presentation, written report • Evidencing enterprise/collaborative competencies.
PGT		• Creative design including business development aspects, prototype, simulation, business plan, oral presentation, written report. • Evidencing entrepreneurial/interdisciplinary competencies.

How to cultivate 21st / 22nd century engineers:
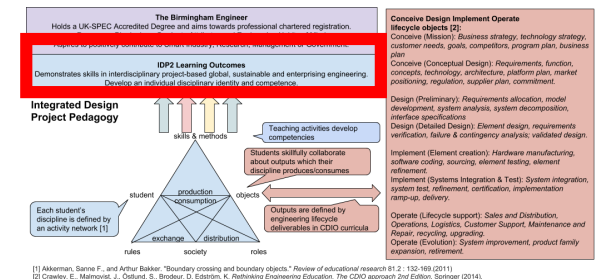
Authentic Challenges/ Assessment

Industrial Partnerships

3 Comments from Industry: Arup

We have consulted with leading Engineering consultancy Arup on this challenge. They have kindly made the following comments on this challenge and will be inspecting your final outputs:

"An observation wheel is prominent, expensive and of no functional purpose other than entertainment. So if it doesn't look good and offer an exciting experience that people are willing to pay for then it won't get built. The structural engineering of a large observation wheel is particularly challenging – few other structures will work so hard in tension and compression and be subject to so many load cycles. Passenger safety is critical and will influence almost every aspect of the design concept. You must have a plausible plan for evacuation and safety in the event of failure of any of the critical components. Just as important as getting people off in an emergency is getting them on in the first place. Why will people visit and ride the wheel? Something about your wheel must be innovative and enduringly attractive. You could decide that yours will be the biggest in the world – but be wary of this, the biggest wheels are the hardest to design and the most expensive to build. And like the tallest buildings, they often only hold this title for a short period of time. Will visitors still want to ride the 2nd, 3rd, 4th biggest wheels in 10 years time?"

IDP2 Challenge 2018/19: Future Light Aircraft

7. Comments from BAE Systems:

BAE SYSTEMS

BAE Systems Plc are this year's IDP2 industrial partner. They are an international defence, aerospace and security company with a workforce of over 80,000 throughout the world. Here is their advice on your challenge:

"We've seen a great deal of progress since Sir George Cayley codified flight in 1799 and the Wright brothers demonstrated powered flight a hundred years later. Technology has played a key role since with powerful and efficient piston engines followed by turbo machinery in the form of the turbo prop and the jet engine (both the turbo jet and the turbo fan). We are now in an exciting new era of powered flight which we might describe as electrified and optionally autonomous.

Electrification comes on a scale starting with combustion engines and attached generators powering an all

Interdisciplinary Activities

- **Project Management**
  - Team Role Test
  - Detailed Project Planning
  - Critical Path Analysis
- **Sustainability**
  - Sustainability Literacy
  - Sustainability Design Considerations
- **Design Process/Creativity**
  - Creativity frameworks – TRIZ
  - IBM Design Thinking

- **Health and Safety**
  - Risk Identification and Assessment techniques.
  - Reliability Engineering
- **Enterprise**
  - Business Case Analysis
  - Marketing, Finance
- **Emerging technology research**
  - Additive Manufacturing
  - Virtual/Mixed Reality
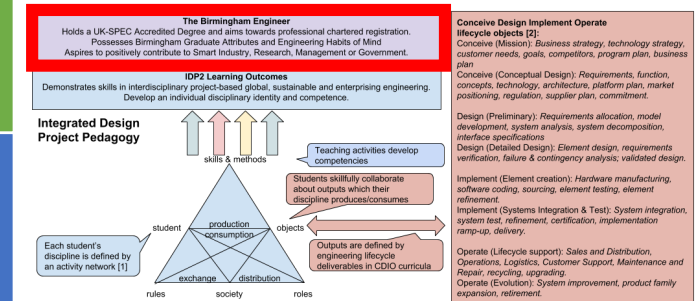
The Birmingham Engineer

Accredited Degree aiming towards professional chartered registration.

Birmingham Graduate Attributes including Research and Enterprise Skills.

The Birmingham engineer

Destined to be Highly Employable

Cultivates Engineering and Learning Habits of Mind.

Leadership of Change

- **School of Engineering Teaching and Learning Centre:**
- Home for all teaching-focussed academic staff
- Engineering Education research dissemination
- Education Network engagement

- **Curriculum Embedding Activities**
- Habits of Mind for managing change
- Concept Inventories for measure learning
- Action Research for piloting