Implementation of Project Based Learning in a Large Engineering Programme

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
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<tbody>
<tr>
<td>Sara Pavia</td>
<td>B.A., B.A.I. - Junior Freshman – Engineering Design I</td>
</tr>
<tr>
<td>Gareth J. Bennett</td>
<td>B.A., B.A.I. - Junior Freshman – Engineering Design II</td>
</tr>
<tr>
<td>Ruth Collins</td>
<td>B.A., B.A.I. - Senior Freshman – Engineering Design III</td>
</tr>
<tr>
<td>Frank Boland &amp; Ciaran McGoldrick</td>
<td>B.A., B.A.I. - Senior Freshman – Engineering Design IV</td>
</tr>
<tr>
<td>Kevin Kelly</td>
<td>B.A., B.Sc. - Programme Director</td>
</tr>
<tr>
<td>Kevin O'Kelly</td>
<td>Director of Undergraduate Teaching and Learning</td>
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</tbody>
</table>

Dr. Gareth J. Bennett
Trinity College Dublin

Page 1
Time for Change!

Drivers

- Industry demand it
- Irish Engineering Sector
- Bologna
  - 3+1+1. Five Year Accredited Degree (M.A.I.)
- Government Taskforce on Innovation
Time for Change!

**Old**
Engineering “labs”
- Out of sync
- Formulaic
- Prescriptive

**Objective**
Move from podium based, tiered lecture theatre structures to small group learning
Time for Change!
Time for Change!
Time for Change!

Objective
Move from podium based, tiered lecture theatre structures to small group learning

Challenges
- Old
  - Existing “labs”
  - Out of sync
  - Formulaic
  - Prescriptive

- Objective
  - Large student numbers (200)
  - Resource intensive –
    - Curriculum design
    - Demonstrators
    - Equipment
    - Workspaces
    - Time-tableing
    - Continuous assessment corrections
    - Group work evaluation
Time for Change!

Initiatives

- National “Knowledge Economy”
- TCD/UCD Alliance/Academy
- Vision 2020

*Engineering Innovation & Creative Design*
What is CDIO?

Conceive  Design  Implement  Operate
Time for Change - Proposals

Goals of CDIO to develop:

• A deep working knowledge of technical fundamentals.

• A refined ability to discover knowledge, solve problems, think about systems, and master other personal and professional attributes.

• An advanced ability to communicate and work in multidisciplinary teams.

• Skills to conceive, design, implement, and operate systems in an enterprise and societal context.
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Design Project – Mangonel

Conceive
Design
Implement
Operate

Engineering Design II
Design Project – Mangonel

Conceive  
Design  
**Implement**  
Operate
Outstanding Programme

**Introductory Lectures**
- Materials
- Structures
- Modelling
- Dynamics
- Digital Electronics

**Small Group Learning**

- In class assignments/laboratories
- 180 Students
  - 4 streams of 45
  - 9 groups per stream (2 demonstrators per stream)
Design Project – Mangonel

Conceive  Design  Implement  Operate

Laboratory Assignments

Mechanical
  Dynamics

Civil
  Structural Analysis

Electronics
  Angular Velocity Measurement Tool
Design Project – Mangonel

Conceive

Design

Implement

Operate

Trajectory Model

No drag

• Equations for linear motion
• Numerical methods

With Drag

• Fluid dynamics

Develop an analysis tool!

• What are important parameters?
• Check results once built!

![Graph showing the comparison of paths with and without drag at a velocity of 30 m/s and an angle of 70 degrees.](image)

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Structural Analysis

**Static**
- Failure stress (experimentally) of
  - Wood (bending)
  - Trigger chord (in tension)
  - Load at trigger (experimentally)

**Can design**
- Diameter of arm
- Diameter of spindle
Structural Analysis

Static

• Failure stress (experimentally) of
  • Wood (bending)
  • Trigger chord (in tension)
  • Load at trigger (experimentally)

Can design

• Diameter of arm
• Diameter of spindle
• Diameter of Chord
Structural Analysis

Dynamically
- Failure stress (experimentally) of
  - Wood (bending)
  - Velocity at impact (experimentally)

Can design
- Parameters for arm
- Discuss potential/kinetic energy balance
Build Mangonel

- Parts
- Bill of Material
- Tools
- Drawings
- Assembly Instructions
**Design Project – Mangonel**

- **Conceive**
- **Design**
- **Implement**
- **Operate**

**Measure Arm Velocity**

- *Instrumentation*
- *Software*
- *Hardware*

*Result is a useful measurement tool!*
Measure Arm Velocity

- *Instrumentation*
- *Software*
- *Hardware*

**Result is a useful measurement tool!**
Measure Arm Velocity

- Instrumentation
- Software
- Hardware

Result is a useful measurement tool!
Design Project – Mangonel

Conceive  Design  Implement  Operate

Measure Arm Velocity

• Instrumentation
• Software
• Hardware

Result is a useful measurement tool!
Design Project – Mangonel

Conceive  Design  Implement  Operate

Measure Arm Velocity

• Instrumentation
• Software
• Hardware

Result is a useful measurement tool!
Design Project – Mangonel

Conceive  Design  Implement  Operate

Testing
- Verify distances (vel., angle)
- Check structural integrity

Competition
- Optimise parameters
- Modify design
- €500 sponsorship
- Irish Times Coverage
Design Project – Mangonel

Conceive  Design  Implement  Operate

Testing
- Verify distances (vel., angle)
- Check structural integrity

Competition
- Optimise parameters
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- €500 sponsorship
- Irish Times Coverage
Design Project – Mangonel

Conceive  Design  Implement  Operate

Testing
Verify distances (vel., angle)
Check structural integrity

Competition
Optimise parameters
Modify design
€500 sponsorship
Irish Times Coverage
Evaluation

Continuous Assessment (WebCT based)

Assignments

• Dynamics
  • Questions and Excel Spreadsheet X 2
  • Online M.C.Q. X 1
• Structural Analysis
  • Questions Spreadsheet X 2
• Electronics
  • Questions X 1
  • Software Evaluation
  • Hardware Evaluation
  • Online M.C.Q. X 1

Competition

• Monetary Prize (& prestige!)
Initiatives

Engineering Design III

Design and Construction of a Refugee Shelter

• Design a refugee shelter for an extreme climate
• Design of a solar cooker to boil one litre of water based on a solar flux of approximately 1kW/m2

‘The Cardboard Cradle’, a design which incorporated recycled cardboard tubes from cardboard manufacturers
Initiatives

Engineering Design IV
Design of Wireless, Autonomous Vehicle

• Design and implement a micro-simulation of a light rail system
• Create an autonomous vehicle, that is under wireless supervisory control from a remote station
## Results

### Independent Survey

- **Students Motivated**
- **High Attendance**

#### Q9. Overall I found this module:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Excellent</td>
<td>21%</td>
</tr>
<tr>
<td>Good</td>
<td>72%</td>
</tr>
<tr>
<td>Neutral</td>
<td>17%</td>
</tr>
<tr>
<td>Poor</td>
<td>4%</td>
</tr>
<tr>
<td>Very poor</td>
<td>3%</td>
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#### Q14. The material presented by this lecturer has usually been:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very interesting</td>
<td>18%</td>
</tr>
<tr>
<td>Interesting</td>
<td>75%</td>
</tr>
<tr>
<td>Neutral</td>
<td>14%</td>
</tr>
<tr>
<td>Uninteresting</td>
<td>2%</td>
</tr>
<tr>
<td>Very uninteresting</td>
<td>2%</td>
</tr>
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</table>

#### Q19. The lecturer stimulated me to think critically about the subject:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>20%</td>
</tr>
<tr>
<td>Regularly</td>
<td>60%</td>
</tr>
<tr>
<td>Neutral</td>
<td>23%</td>
</tr>
<tr>
<td>Rarely</td>
<td>5%</td>
</tr>
<tr>
<td>Never</td>
<td>4%</td>
</tr>
</tbody>
</table>

#### Q18. The lecturer was enthusiastic about the subject matter of the module:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>44%</td>
</tr>
<tr>
<td>Regularly</td>
<td>52%</td>
</tr>
<tr>
<td>Neutral</td>
<td>13%</td>
</tr>
<tr>
<td>Rarely</td>
<td>4%</td>
</tr>
<tr>
<td>Never</td>
<td>1%</td>
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Conclusions

- Project Based design courses implemented in Freshman Cycle
- Large Class sizes
- CDIO “compliant”
  - Provided only cursory technical fundamentals
  - Encouraged to research independently
  - Work in groups
  - Promote Innovation
- Resource Heavy
- Well Received
Thank You
must compete internationally on quality and innovation
- aims to provide an environment that fosters the curiosity that enables creativity to thrive

2020 Vision for Trinity Engineering which will focus on Engineering innovation & Creative Design
- envisages a remoulding of the traditional concepts of discipline based activities in both our teaching and research activities to produce the interdisciplinary education necessary to underpin breakthrough technologies for the future
- Our undergraduate curriculum has been extensively revised to ensure that students are introduced to the concept of “making things” as a focus for the engineering sciences and mathematices so that context is the most relevant aspect of their education.
- plan to extend our established international research activities so that our graduate education and research programmes continue to be of high impact and industrial relevance so that design and innovation are integral to our activities.
- nurture a multidisciplinary, broad-based approach to solving critical aspects of relevance to key global issues.
- an education that combines rigorous academic study with the excitement of discovery
- To establish an environment which encourages the understanding, curiosity and creativity necessary to provide innovative solutions for the global challenges
- engineers will always require an understanding and mastery of specific disciplines, innovative solutions will increasingly come from collaborative efforts involving technical, social and medical partnerships.
- curiosity and creativity as important influences in the pursuit of discovery and entrepreneurship
- innovation is multidisciplinary and occurs at the interface between traditional disciplines
- Government's taskforce on Innovation recommended six principles as fundamental to creating the innovation ecosystem necessary to transform Ireland into a Global Innovation Hub.

education
- Our undergraduate curriculum has been extensively revised with the introduction of design and build projects in the first two years of the undergraduate programme. This is to ensure that students are introduced to the concept of “making things” as a focus for the engineering sciences and mathematices so that “context” is the most relevant aspect of their education;