Teaching engineering to non-engineering teachers
[slideshow presentation]

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Teaching Engineering to Non-Engineering Teachers

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Loughborough University
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• “Teaching with Lasers” CPD Course
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Introduction
The utilisation and teaching of technology in schools

Current engineering and STEM In D&T
• Engineering is underrepresented in Design and Technology at schools
• There are many good programmes aimed at delivering special STEM events in schools but that are not part of the normal curriculum.
• This is having an effect on the supply of engineering undergraduates.

Integrating STEM into normal lessons using existing equipment
• Yet schools are often equipped with advanced modern manufacturing technologies such as laser cutters.
• Currently poorly utilised
• These are excellent tools not just for design but for engineering applications
• Also can be leveraged as a learning tool for pupils

http://www.tes.co.uk/teaching-resource/Laser-cut-coaster-and-holder-Task-for-Year-9-CAD-6219611/
http://www.tes.co.uk/teaching-resource/Angry-Bird-Clock-6064643/
STEM projects for schools
Schemes of work that introduce pupils to Advanced Engineering and Technology

- Created and tested some advanced laser cutting projects. With student and teacher guides.
- Introducing concepts such as precision mechanical components and the use of lasers in the textile industry.
- Projects available at [http://clocks.lboro.ac.uk](http://clocks.lboro.ac.uk)
- Very positive and enthusiastic responses from pupils.
- Poor results in their understanding of the technology
- Teachers were the limiting factor in delivering the projects

### Qualification held prior to D&T PGCE training (2000-2013)

<table>
<thead>
<tr>
<th>Qualification</th>
<th>BA</th>
<th>BSc</th>
<th>BEng</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative arts &amp; design</td>
<td>67.9%</td>
<td>13.1%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Engineering &amp; technology</td>
<td>0.3%</td>
<td>3.4%</td>
<td>7.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Architecture, building &amp; planning</td>
<td>1.6%</td>
<td>0.6%</td>
<td>0.0%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Agriculture &amp; related subjects</td>
<td>0.0%</td>
<td>0.6%</td>
<td>0.0%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Business &amp; administrative studies</td>
<td>0.9%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Librarianship &amp; information science</td>
<td>0.0%</td>
<td>0.3%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Physical sciences</td>
<td>0.0%</td>
<td>0.3%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

**Total**

- **81%**
- **11.2%**
- **2.5%**
- **1.9%**
- **2.8%**
- **0.3%**
- **0.3%**

Note: Other qualifications: CGLI, HNC, HND, BDes, MA, MDes, MEng. n=321.
Creating the “Teaching with Lasers” CPD Course

Using the TPACK framework[1] to identify the specific requirements for teachers

Existing Knowledge
- Currently used as a workshop machine not a piece of learning technology.
- Evidence shows that the technology is not well understood.
- Varying levels of experience
- Do not currently teach about the technology.
- Teachers do not currently produce products that are unique or advantageous to produce on lasers.

Developing Technological Pedagogical Knowledge
- How it is safe for students to use the machinery.
- How the machinery can be beneficial to teaching.
- What specific functionality is beneficial to pupil learning.

Developing Pedagogical Content Knowledge
- Classroom relevant information about the technology is delivered through the course.

Developing Technological Content Knowledge
- Deep understanding of materials and capabilities of the machinery.
- Industrial relevance and knowledge.

Delivery and Evaluation
- Exercise to identify participants needs.
- Lecture covering fundamental information on industry, science materials, processes and safety.
- Laboratory activities to reflect on lecture learning and to experience machinery in more detail.
- Discussions of projects that will advance the use of technology.
- Discussion about the use in classroom throughout all activities.
- Pre and post course questionnaires
- Electronic voting systems
- Observations

Course results
Confirming the status of technology use and understanding

Teaching with Lasers Course
The course was run in February 2014, during half-term, with 20 participants who were a mix of experienced teachers and PGCE students doing their initial teacher training.

Previous Training

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>94%</td>
<td>Have used a laser cutter</td>
</tr>
<tr>
<td>82%</td>
<td>Have been trained to use the laser cutter</td>
</tr>
<tr>
<td>0%</td>
<td>Have laser safety training</td>
</tr>
</tbody>
</table>

- **Only 38%** thought that pupils should be allowed to use the laser cutter.
- This lack of appropriate knowledge and training is limiting the effective teaching and learning with the equipment.

Testing Teachers Knowledge

<table>
<thead>
<tr>
<th>Question</th>
<th>% Correct answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Lasers can only be used to cut and mark materials?</td>
<td>55%</td>
</tr>
<tr>
<td>Q2. A laser beam can be focused smaller than a standard light source?</td>
<td>40%</td>
</tr>
<tr>
<td>Q3. Compressed air can help the laser cut materials?</td>
<td>70%</td>
</tr>
<tr>
<td>Q4. Lasers cannot cut brittle materials such as glass?</td>
<td>70%</td>
</tr>
<tr>
<td>Q5. The hardness of a material affects the laser cutting process?</td>
<td>15%</td>
</tr>
</tbody>
</table>

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## Course results

### Improvements to teaching confidence

<table>
<thead>
<tr>
<th>Likert Scale</th>
<th>I would feel confident teaching pupils about the technical capabilities of a laser</th>
<th>I would feel confident teaching pupils how to use the CAD software to produce designs for a laser cutter</th>
<th>I would feel confident teaching pupils how to use the laser cutter</th>
<th>I would feel confident teaching pupils laser safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
<tr>
<td>Strongly Disagree (1)</td>
<td>1 0</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>Disagree (2)</td>
<td>3 4</td>
<td>0 2</td>
<td>1 2</td>
<td>2 1</td>
</tr>
<tr>
<td>Neither Agree nor Disagree (3)</td>
<td>7 2</td>
<td>4 0</td>
<td>4 1</td>
<td>6 2</td>
</tr>
<tr>
<td>Agree (4)</td>
<td>4 8</td>
<td>6 7</td>
<td>7 6</td>
<td>4 10</td>
</tr>
<tr>
<td>Strongly Agree (5)</td>
<td>2 3</td>
<td>7 9</td>
<td>4 9</td>
<td>3 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median</th>
<th>Strongly Disagree (1)</th>
<th>3.00</th>
<th>4.00</th>
<th>4.00</th>
<th>4.50</th>
<th>4.00</th>
<th>4.50</th>
<th>3.00</th>
<th>4.00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Disagree (2)</td>
<td>12.00</td>
<td>7.00*</td>
<td>10.00*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neither Agree nor Disagree (3)</td>
<td>22.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agree (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strongly Agree (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistical Significance</th>
<th>Wilcoxon Signed Rank Test, Exact Sig. (1-tailed), *p&lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>No significant improvement</td>
<td>Significant Improvement</td>
</tr>
<tr>
<td>No significant improvement</td>
<td>Significant Improvement</td>
</tr>
<tr>
<td>Significant Improvement</td>
<td>Significant Improvement</td>
</tr>
</tbody>
</table>

Note: Wilcoxon Signed Rank Test, Exact Sig. (1-tailed), *p< .05

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### Areas of the course that are relevant to pupils

- Industrial applications of lasers
- How a laser works
- How a laser beam interacts with materials
- What materials can be processed by laser
- Details of the laser cutting process

### Areas of the course that are not-relevant to pupils

- The different types of lasers
- Details of the optical systems and parts of the machine
- Details of the laser drilling process

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For the Wilcoxon Signed Rank Test, the *p-value < .05 indicates significant improvement.
Course results

Understanding engineering

Difficulties with the science
“There was way too much science about lasers…”
“I know basic physics, but the information we were given was too specialist and most went over my head…”

Teachers could not relate this work to engineering, or why it would be important to pupils
“This felt irrelevant to course on lasers”
“I would also suggest that the discussion regarding engineering is removed as this isn't relevant”

More pedagogic knowledge development required
“there was a lot of scientific information which was relevant but not simplified enough for pupils to understand or relate to”
“this course needs to be pitched at a 'lower' level with more concern to how this knowledge can be translated to a classroom”

Sessions to explain what engineering is
“I found most of the information irrelevant to what I wanted to understand”
Conclusion

**Successful improvements in teaching**
- By understanding that if the appropriate safety controls and procedures are in place with this technology pupils can be given greater access and responsibility with the machinery.
- There were significant improvements in certain areas that will have an impact on pupils' abilities to engage and learn with engineering technology.

**Format of course**
- Positive feedback about access to labs and industrial equipment.
- Interest in other courses in CAD, 3D printing and mechanics.
- Need for more development of teaching knowledge forms
- Need for sessions on engineering and how this knowledge is needed for HE and industry.

**Benefits to HE and EER**
- A new area of postgraduate engineering teaching with some unique requirements
- Opportunity for engineering educational research to have a social impact on the supply of engineering undergraduates
Teaching Engineering to Non-Engineering Teachers

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Project and resources available at http://clocks.lboro.ac.uk