Remote laboratories: lessons from the literature
Introduction and Aims

- Project aims: review ‘digital / material hybrid’ systems in learning

- Systematic literature review of ‘state of the art’:
  - digital/materiality,
  - networks
  - learning
Stage 1

DIGITAL/MATERIALITY SEARCH TERMS

<table>
<thead>
<tr>
<th>Term</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote laboratory</td>
<td>83.9%</td>
</tr>
<tr>
<td>Augmented reality</td>
<td>1.9%</td>
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<tr>
<td>Robotics</td>
<td>18.2%</td>
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<tr>
<td>Ubiquitous computing</td>
<td>1.4%</td>
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</tbody>
</table>

- A lab with one set of experiments for an inverted pendulum and another for coupled water tanks
- RePhys, an example of a hybrid used in biomedical and physiological systems studies with sensors for remote monitoring of blood pressure, heart rate etc along with webcam along with webcam
- Telecommunications systems labs involving switches and routers
- Webcams and microphones to allow students to observe experiments remotely
PERCENTAGE OF PAPERS BY DISCIPLINE, FOCUS AND TYPE OF PAPER (n=808)

### DISCIPLINE
- Science: 6.8%
- Engineering and Technology: 81.1%
- Not specified: [VALUE]%

### FOCUS
- Pedagogy: 14.9%
- Technology: 56.0%
- Organisation: 24.0%
- Other: 5.2%

### TYPE
- Evaluative: 9.5%
- Conceptual: 2.0%
- Descriptive: 87.3%
- Review: 1.0%
Stage 2

- In-depth text review of a subset of the papers (n=29)
  - remote laboratories
  - evaluative and pedagogical issues
  - review papers

3 themes emerged
1. the importance of real data and authenticity in learning
2. the importance of a sense of presence
3. the locus of control in, and responsiveness of, a hybrid system
1. Real data and authenticity

- possibility of ‘learning from failure’
- ‘real world’ experience of dealing with uncertainty and ‘noise’
- more motivating to have uncertain outcomes than those ‘already known’
- ‘real labs’ have time and space constraints
- remote materiality offers advantages over entirely digital virtual or simulated
2. A sense of presence

- immersion – sense of immediacy and control
- telepresence – sense of being there
- social presence – being there with others
- design – closeness of interface to real world system
3. Locus of control & responsiveness

- active involvement
- who controls the experiment
  - teacher demo, student, batch runs, scheduling
- responsiveness and feedback in a system – bandwidth issue
Conclusions

• Few pedagogical, evaluative studies = the field is still maturing
• Lessons about effective learning through remote laboratories
• New remote laboratories offer a lens with which to view – more traditional material pedagogies, e.g. lab-based, – and purely digital pedagogies, e.g. virtual labs.