A Relational Approach to “Wet Chemistry” Laboratory Learning: A Cultural Transformation Tool?

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SOLO Taxonomy

Structure of Observed Learning Outcome

Structure

Background – why?
The Learning Process and the Cultural Paradigm

The ‘Plan’ and materials
• Feedback on practicals
• Understanding student aspirations
• Double blinded practicals
• Use of technology

Interim Conclusions
Background – Why?

If the Learning Process and the Cultural Paradigm focus solely on “good grades”, hence the “what”, issue with big picture vs small picture.

Presents as: pre-knowledge; ‘focus’ on data, not understanding ‘why’, use of senior’s work to prepare write-ups, error analysis inability.....
“..we have a plan and some questions..”

Year III compulsory practical module. Test and control. Weekly feedback. In addition across Department rigorous help material with detailed examples, new sets of e-lectures about concepts and equipment respectively, new form of reporting (Lab Notebook).
“..we have a plan and some questions..”

Generally

- How do students perceive their grades and the effort required to get them?
- Do students act on written feedback?

Specifically on the ‘experiment’:

- Are either of the two models more effective than the other – how can we tell?
  - Q3,4 Is what staff are doing effective?
  - Q5 Do students feel this is a learning relationship (feedback)
  - Q6 Module add value to degree?
  - Q7 Module helping me grow as a scientist?
- Are the electronic gatekeeper systems working?
- Are students asking “why”?
The ‘Plan’ and materials

Students

Clarity around Expectations in the lab

Clarity around Expectations after the lab

Growth as scientists and lab competence

Take students outside their comfort zone

Staff

Departmental Guidance

Materials

Adoption by staff

Time to facilitate Higher Order learning

More feedback to students, less time spent

Modified write-up requirements

Science decisions without full information

‘sabotage’ the senior system*
Enhanced (qualitative) feedback on write-ups along with detailed specifications of requirements

Time and Motion study

Analysis of student feedback and evaluation

Enhanced Feedback on practical write-ups in coded form
<table>
<thead>
<tr>
<th>#</th>
<th>general skills issues</th>
<th>HELP see below</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>non compliance with assignment guidance (e.g. no aims, too long, etc.)</td>
<td>1,5</td>
</tr>
<tr>
<td>G2</td>
<td>lack of literature or theory comparison</td>
<td>1,4</td>
</tr>
<tr>
<td>G3</td>
<td>lack of or incorrect referencing or citation of references</td>
<td>1</td>
</tr>
<tr>
<td>G4</td>
<td>structure either muddled, lacking or non existent</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>G5</td>
<td>Lack of signed data-sheet Appendix</td>
<td>1,2</td>
</tr>
</tbody>
</table>

### Writing skills issues

<table>
<thead>
<tr>
<th>#</th>
<th>writing skills issues</th>
<th>HELP see below</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>grammatical/spelling errors</td>
<td>5</td>
</tr>
<tr>
<td>W2</td>
<td>graphs, figs and tables untitled</td>
<td>2</td>
</tr>
<tr>
<td>W3</td>
<td>graphs, figures, tables too spread out/too small, or too many/not enough</td>
<td>2</td>
</tr>
<tr>
<td>W4</td>
<td>graphs: unlabelled axes, titles inside, wrong scales, no best fit lines, equations</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>or R² on graph, no graph grid, extrapolation</td>
<td></td>
</tr>
<tr>
<td>W5</td>
<td>writing style closed, wordy, didactic, circuitous and/or repetitive</td>
<td>2,5</td>
</tr>
<tr>
<td>W6</td>
<td>writing style not evidence based: result was X, therefore this means Y.</td>
<td>2,5</td>
</tr>
<tr>
<td>W7</td>
<td>too long or short - surplus or irrelevant material</td>
<td>4</td>
</tr>
<tr>
<td>W8</td>
<td>Too similar to other work, or old version of practical written up</td>
<td>6</td>
</tr>
</tbody>
</table>

### Science skills issues

<table>
<thead>
<tr>
<th>#</th>
<th>science skills issues</th>
<th>HELP see below</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>raw data of poor quality or methodological issues (e.g. poor yield)</td>
<td>1,2,3</td>
</tr>
<tr>
<td>S2</td>
<td>lab notes: recording insufficient, no observations, incomplete data</td>
<td>2,3</td>
</tr>
<tr>
<td>S3</td>
<td>inability to develop concise accurate and comprehensive aims or RQs</td>
<td>2,3,4,5</td>
</tr>
<tr>
<td>S4</td>
<td>inability to form concise abstract</td>
<td>3,4,5</td>
</tr>
<tr>
<td>S5</td>
<td>introduction not accurate, focussed or comprehensive enough</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td>S6</td>
<td>methods not properly or appropriately recorded</td>
<td>2,3</td>
</tr>
<tr>
<td>S7</td>
<td>inability to critically evaluate error sources and impacts on methodology</td>
<td>2,3,4</td>
</tr>
<tr>
<td>S8</td>
<td>uncritical acceptance of experimental data</td>
<td>3</td>
</tr>
<tr>
<td>S9</td>
<td>non or unthinking quantification of errors in experimental data</td>
<td>2,3</td>
</tr>
</tbody>
</table>
Actual Grades vs Predicted Grades

Error bars $\pm 2$sd.
Prediction varies with grade, extremes significant $p=0.05$.

About 600 responses from Year II and Year III practical modules. GP 5 is A/A+; GP 4.5 is A-; ... 1 is D.
Uncertainty varies with grade

As grade increases, so does student uncertainty about how well they did

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Time taken and grade achieved


N.B. data cut at 80 hours, this meant two data points (grade 2, 168 hours and Grade 3 144 hours removed), about 400 student-practicals.
No statistically significant relationship, but much stronger. Students think more time = better grade?

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Gate-Keeper Technology: background aims of flipped classroom eLearning for labs

• increase effectiveness as a teaching team by reducing non-learning facilitation jobs.
• cope with round-robin (different students do different practicals each week)
• 4/5 lab modules Flipped Classroom eLearning style

To get most out of labs, familiarity with the content and safety implications essential.

Scrap traditional “test” (sat at the beginning of each lab), and excise from assessment balance.
Students have to pass (>70%) a Pre-Lab, (online quiz on IVLE) pertaining to the experiment and its safety implications to gain admittance to the lab. Prelab results also a way to assess the Flipped Classroom.

<table>
<thead>
<tr>
<th>Real-Life Lectures</th>
<th>Flipped Classroom eLearning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM1191 (6 Pre-Labs, 7 expts)</td>
<td><strong>CM2192</strong> (8 Pre-Labs, 10 expts)</td>
</tr>
<tr>
<td>11 ± 9 %</td>
<td><strong>8 ± 5 %</strong></td>
</tr>
<tr>
<td><strong>CM3291</strong> (2 Pre-Labs, 8 expts)</td>
<td><strong>CM3292</strong> (12 Pre-Labs, 14 expts)</td>
</tr>
<tr>
<td></td>
<td><strong>39 ± 31 %</strong></td>
</tr>
</tbody>
</table>
Limitations to use of data. Wk1 was “planning-booking. Wk2 – 6 (in lab) then swap.
Q3: The GTAs are helping me to think and are improving my ability to learn.

‘The Experiment’ Q3
Q4: The Prof is helping me to think and is improving my ability to learn.

‘The Experiment’ Q4
Q5: The Prof is incorporating my feedback as the weeks progress

‘The Experiment’ Q5

‘experiment’  ❄️
‘traditional’ ⬇️
Q6: The module is of high quality and adding to the value of my degree course
Q7: The teaching is of high quality and is helping me grow as a scientist

'Experiment'  Q7

‘experiment’  ▢  ‘traditional’  ▲

strongly disagree

strongly agree

‘The Experiment’  Q7
Conclusions...or rather questions

The grade a student ‘expects’ depends on the grade they get

• feet on the ground?
• humility/persuasion?

The degree of “uncertainty of prediction” varies with grade

Time taken has no relation to grade achieved, but possibly to grade expected

• Do students think more time = better grade?
Conclusions...or rather questions

“Gatekeeper” pre-labs show traditional-experiment difference?

Staff are facilitating learning (mean<3)
  • difference between modes?

Most other Qs below 3, but weak

Potentially views change (negative to positive) with time on quality of teaching and module
End-words from the feedback

Start

Prof can ask some easier questions. Otherwise, students will feel stressful...

Please improve the structure of module booklet. Listing the points clearly is the must. Sometimes, the module booklet makes students quite confused...

The preparation for each week's experiment takes a longer time than what I am used to for CM2191 and CM2192. More effort is required to maintain the momentum for each week.

Make the planning less chaotic, as things were going all over the place on week 1. There was a mad rush for booking of the limited slots at last minute.

xx
End-words from the feedback

End

Fourth week into module and it has proven not to be easy...

I would like to say that I pretty much appreciated the efforts of modelling expt modules to conventional research and independent studies....

I think the inclusion of unknown unknowns and minimal materials or instructions provide good training for independent research....

The difficulty of research work is inevitable. It has made the lab session more fun, interesting and challenging, but the expense of a great workload makes it unworthy being a 4 MC module...
“..Judge a man not by his answers, but his questions..”

Voltaire