Transitions in University Lab Teaching In An Age of Pandemic

Tom Anderson

The University of Sheffield

The University Of Sheffield.

My Educational Background

- Part of the 2nd cohort to take A-levels (with AQA) following the introduction of AS-levels (2001-2003)
- Undergraduate MA in Natural Sciences at the University of Cambridge (2003-2007)
- PhD under Prof Jeremy Sanders also at Cambridge (2007-2011)
- Employed by the University of Sheffield's Department of Chemistry as Teaching Associate (2012-2016) and University Teacher (2016-present)

AQA

UNIVERSITY OF CAMBRIDGE

The University Of Sheffield.

My Educational Background

- Part of the 2nd cohort to take A-levels (with AQA) following the introduction of AS-levels (2001-2003)
- Undergraduate MA in Natural Sciences at the University of Cambridge (2003-2007)
- PhD under Prof Jeremy Sanders also at Cambridge (2007-2011)
- Employed by the University of Sheffield's Department of Chemistry as Teaching Associate (2012-2016) and University Teacher (2016-present)

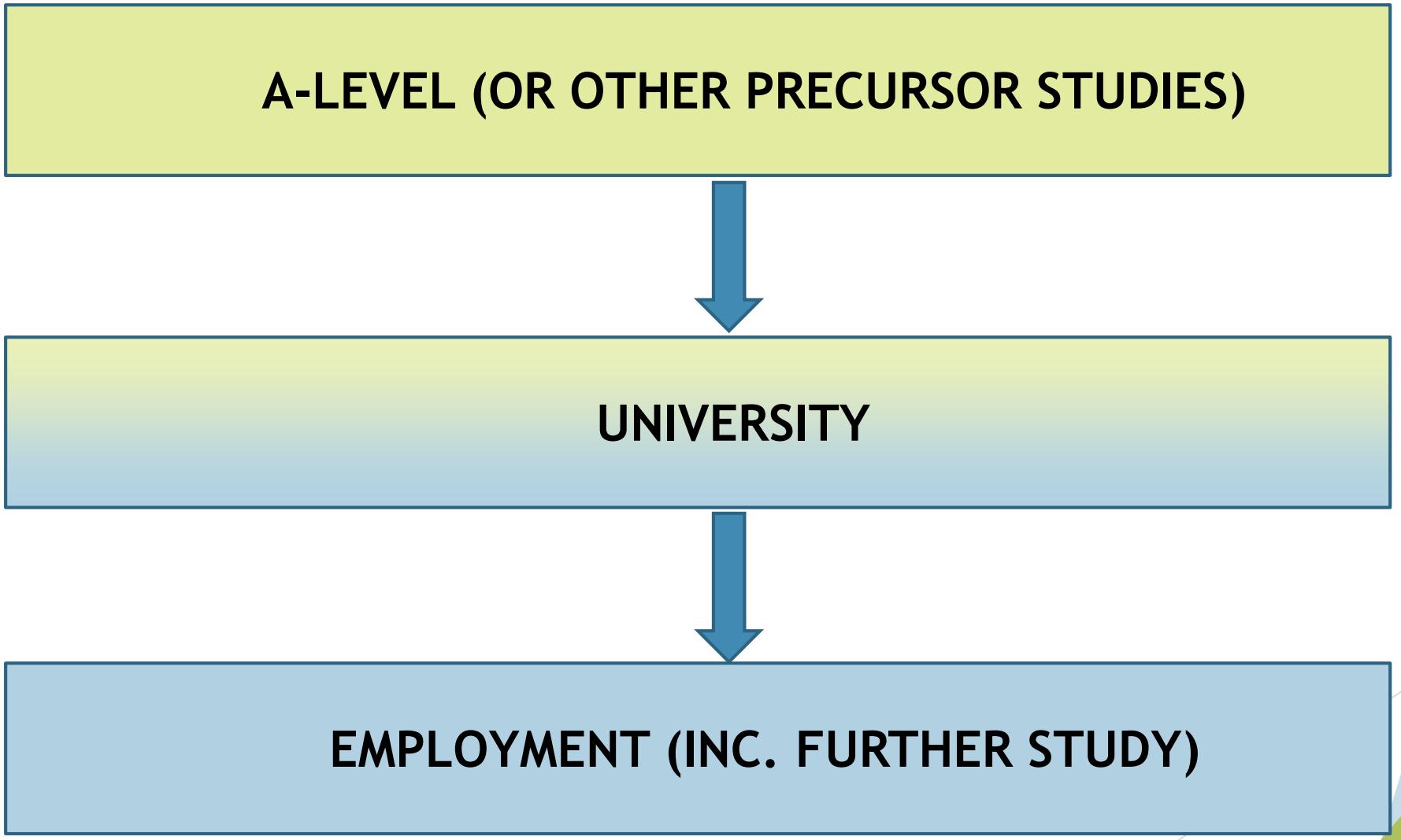
KEY TRANSITIONS

AQA

UNIVERSITY OF CAMBRIDGE

The University Of Sheffield.

The two key transitions

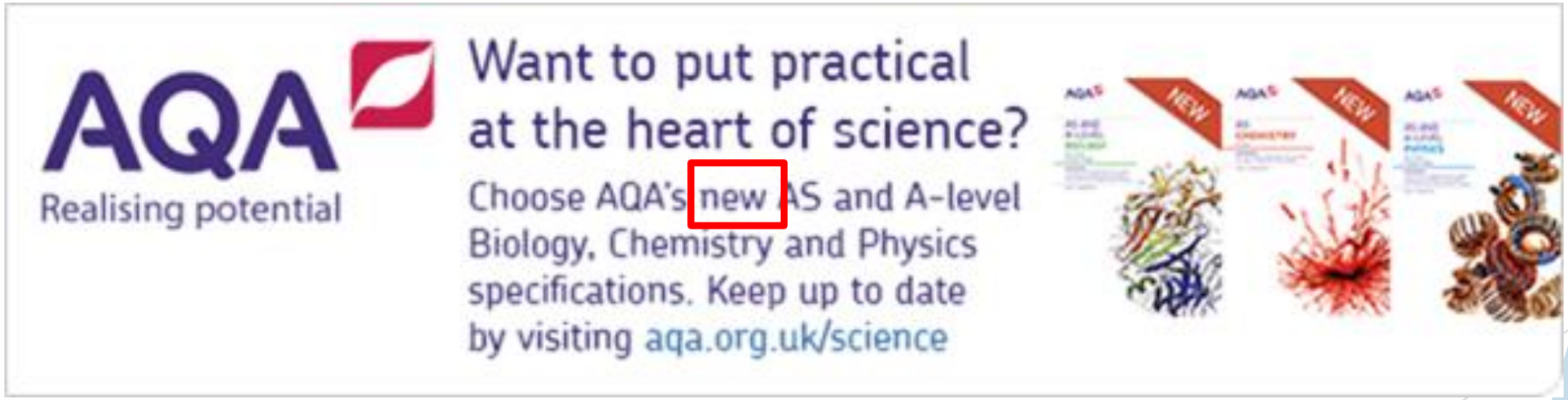


Advice on taking over the first-year lab course

- “Just keep it running the way it was before … if it ain’t broke don’t fix it … there’ll be a new [university] curriculum next year anyway”
- BUT!

Advice on taking over the first-year lab course

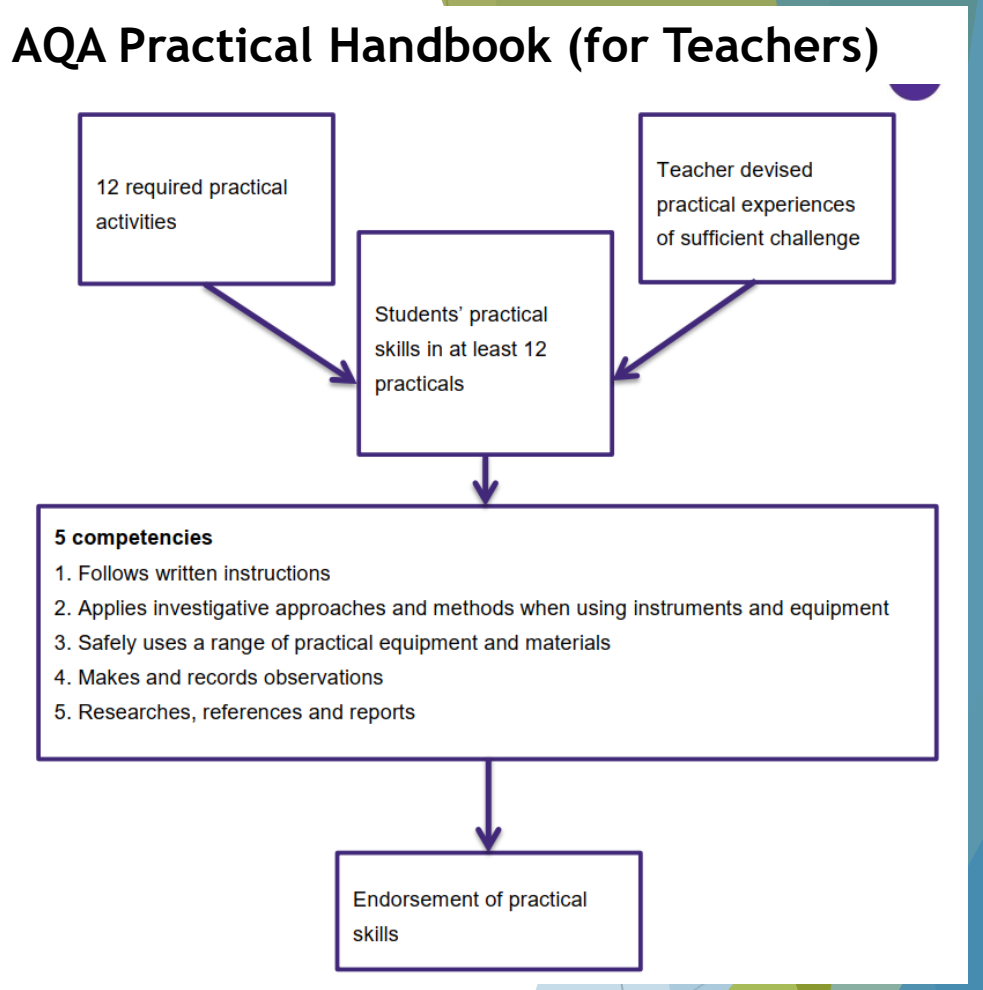
- "Just keep it running the way it was before … if it ain't broke don't fix it … there'll be a new [university] curriculum next year anyway"
- BUT!



A summary of the reformed A-level practical chemistry assessment, as discussed in the Higher Education Stakeholders group, can be found here: https://www.aqa.org.uk/subjects/science/as-and-a-level/chemistry-7404-7405/a-level-practical-assessment [accessed 24/01/2020]

New A-levels, summarised

- Minimum of 12 assessed practical experiments
- Students must pass 5 competencies in order to receive the Endorsement (separate to other A-level qualifications)
- The experiments chosen **invariably** cover the techniques of recrystallisation and titration (as examples).



Consultation:

- Consult students on their responses to the course and record their reactions to ideas for the next year
- Consult GTAs and Lab Teachers on their overall assessment of the year group compared to previous years.

*Via the Student Observation Of Teaching programme organised by Tim Herrick.
Consultation by L3 BMS student PN [redacted]
Further information on this program can be found here:
https://www.sheffield.ac.uk/ssid/301/soot [accessed 24/01/2020]

Key findings:

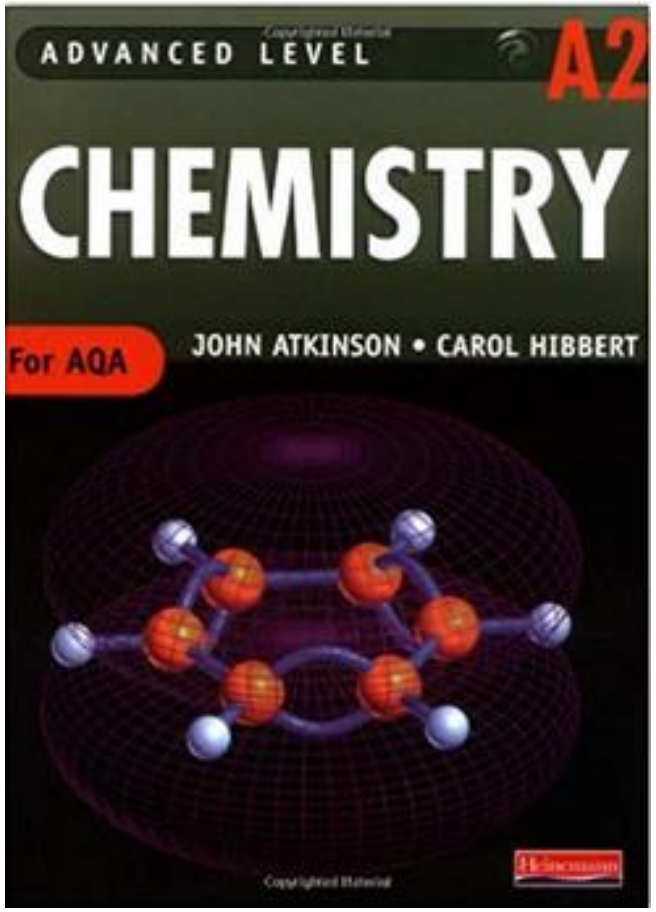
- GTAs and Lab Teachers felt this group of students was not more *knowledgeable* about chemistry, but was more *confident* in practical work. Opportunity to challenge them further.

- Students enthusiastic about more concise laboratory manuals. Why? Further research is required… (see later)

Key principles for reform

- Focus on resolving problems before innovating! (Although the two can be combined)
- To gain student engagement and respect, students must have confidence in staff knowledge of their previous experiences
  - Unknowingly reinventing the wheel is not just wasteful of time, but fatal for losing student engagement!

Thinking back to my own experience as a student…



Q 15 The n.m.r. spectrum of an alcohol Z, $C_5H_{12}O$, shows a triplet, a quartet and two singlets. The measured integration trace gives the ratio 0.9:0.45:2.7:1.35.

a) How many different types of protons are present in Z?

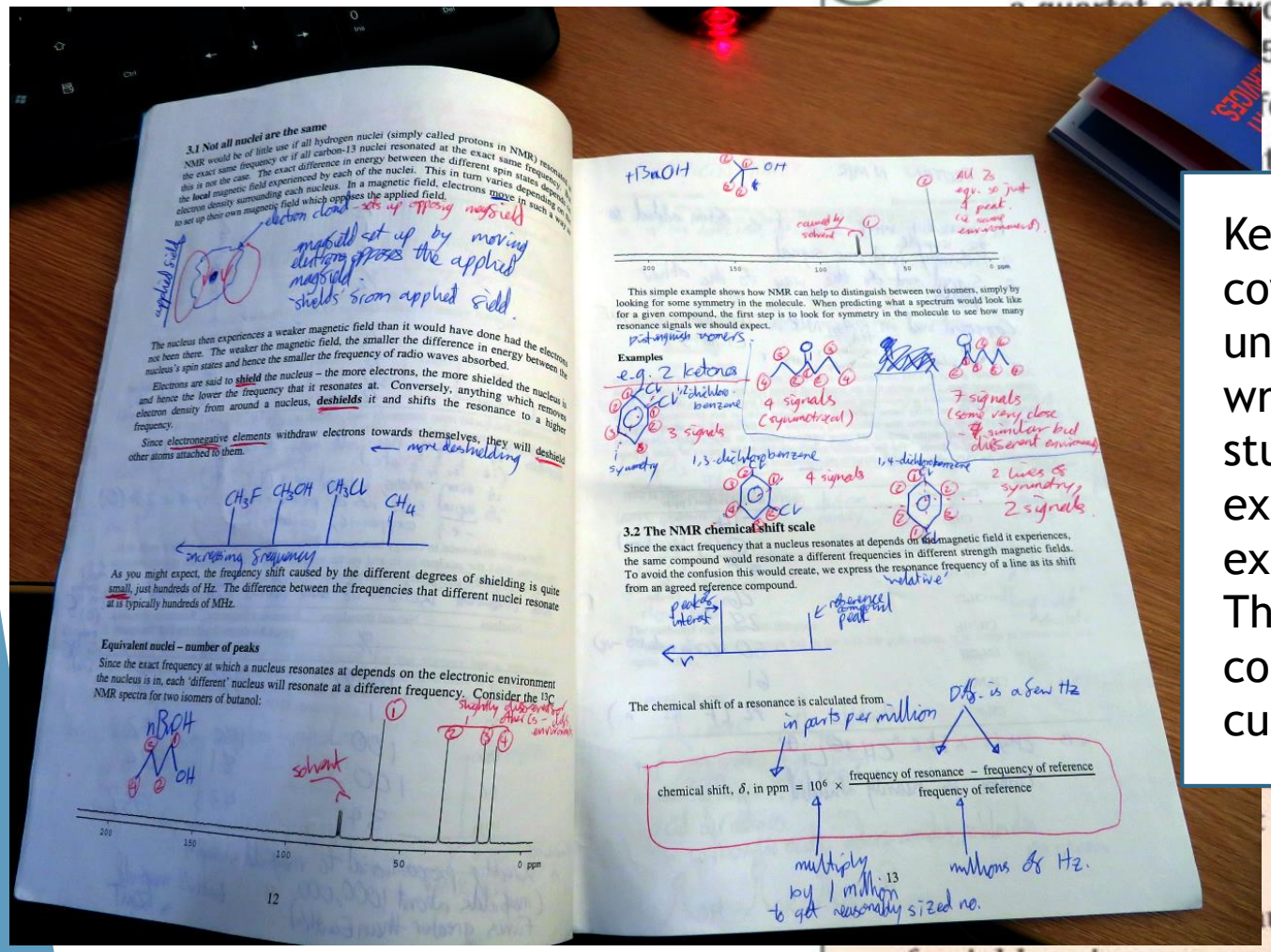
b) What is the ratio of the numbers of each type of proton?

c) Give a possible structure for alcohol Z which matches this information.

Key Ideas 126 – 136

- Nuclear magnetic resonance gives information about the relative number and position of hydrogen atoms in a molecule.
- Spectra are obtained using samples dissolved in proton-free solvents.
- Tetramethylsilane (TMS) is used as a standard to calibrate the spectrometer.
- The number of peaks on the spectrum indicates the number of different types of hydrogen atoms present in the molecule.
- The area under the peaks is proportional to the number of equivalent hydrogen atoms present in the molecule. This can be calculated from the integration trace.
- Splitting of the peaks caused by spin–spin coupling indicates the number of neighbouring non-equivalent hydrogen atoms present in the molecule, using the n+1 rule.

Thinking back to my own experience as a student…



Q 15 The n.m.r. spectrum of an alcohol Z, $C_5H_{12}O$, shows a triplet, …o singlets. The measured integration trace gives …5:2.7:1.35.

…ferent types of protons are present in Z?

…tio of the numbers of each type of proton?

…ches this

…relative number

…ee solvents.

…he spectrometer.

…ber of different

…f equivalent

…in the molecule. This can be calculated from the

…used by spin–spin coupling indicates the number of neighbouring non-equivalent hydrogen atoms present in the molecule, using the $n+1$ rule.

Key NMR concepts were covered at A-level, yet university curricula were written as though students had no previous experience of this (for example).
This could undermine confidence in the curriculum design.

Therefore, if students have an existing skill…

- Acknowledge they have it!
- Give them the opportunity to practice it – don't leave dead zones in the curriculum!
- If you **choose** to repeat an exercise, make it clear **why** you are doing so (e.g. higher level theory)

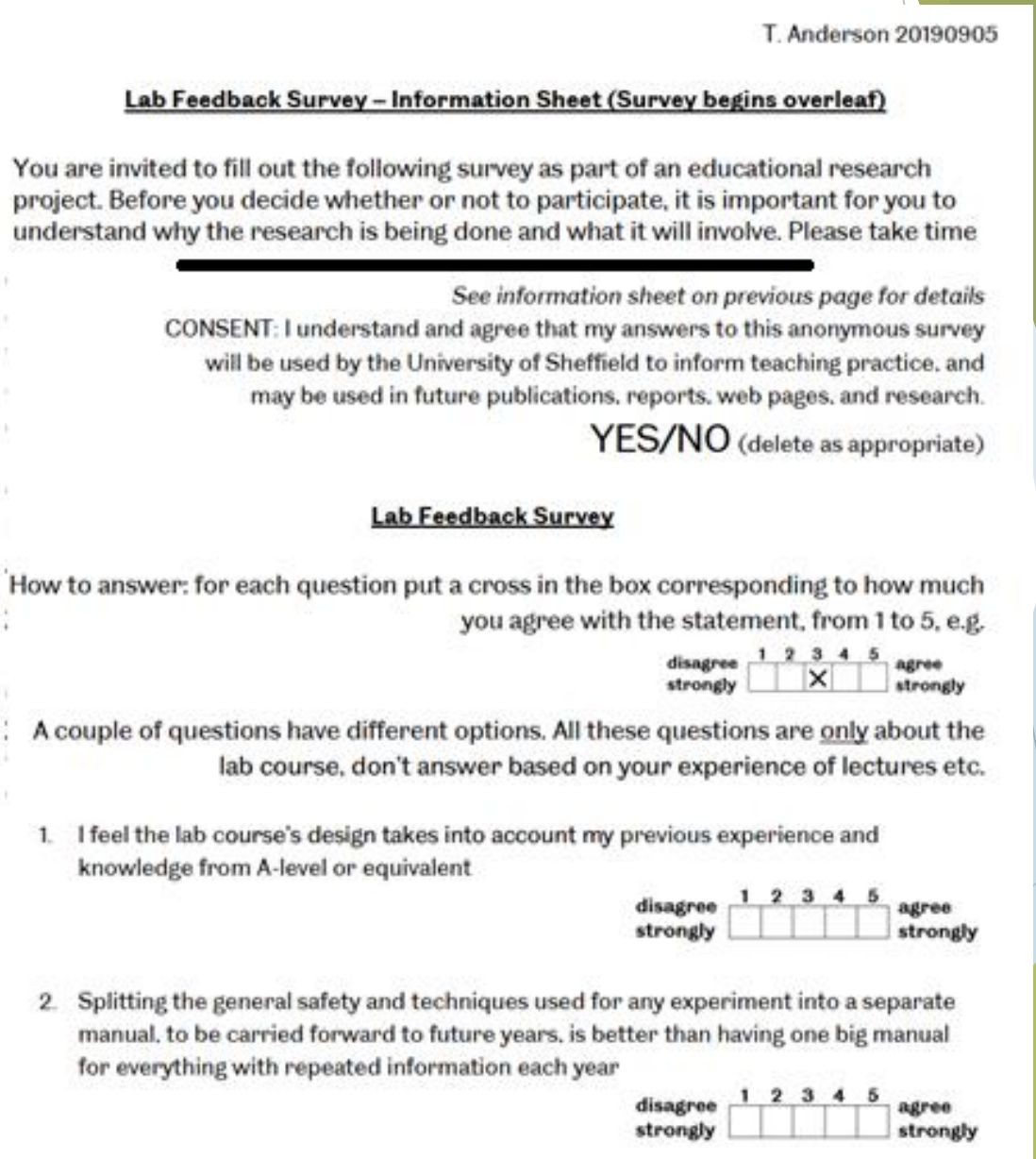
Pedagogic research

- Conducted anonymous surveys in Semester 1

- Planned to follow these up

with focus groups in

Semester 2 to discuss results…



T. Anderson 20190905

Lab Feedback Survey – Information Sheet (Survey begins overleaf)

You are invited to fill out the following survey as part of an educational research project. Before you decide whether or not to participate, it is important for you to understand why the research is being done and what it will involve. Please take time

See information sheet on previous page for details

CONSENT: I understand and agree that my answers to this anonymous survey will be used by the University of Sheffield to inform teaching practice, and may be used in future publications, reports, web pages, and research.

YES/NO (delete as appropriate)

Lab Feedback Survey

How to answer: for each question put a cross in the box corresponding to how much you agree with the statement, from 1 to 5, e.g.

disagree strongly | 1 | 2 | 3 | 4 | 5 | agree strongly

A couple of questions have different options. All these questions are only about the lab course, don't answer based on your experience of lectures etc.

1. I feel the lab course's design takes into account my previous experience and knowledge from A-level or equivalent

disagree strongly | 1 | 2 | 3 | 4 | 5 | agree strongly

2. Splitting the general safety and techniques used for any experiment into a separate manual, to be carried forward to future years, is better than having one big manual for everything with repeated information each year

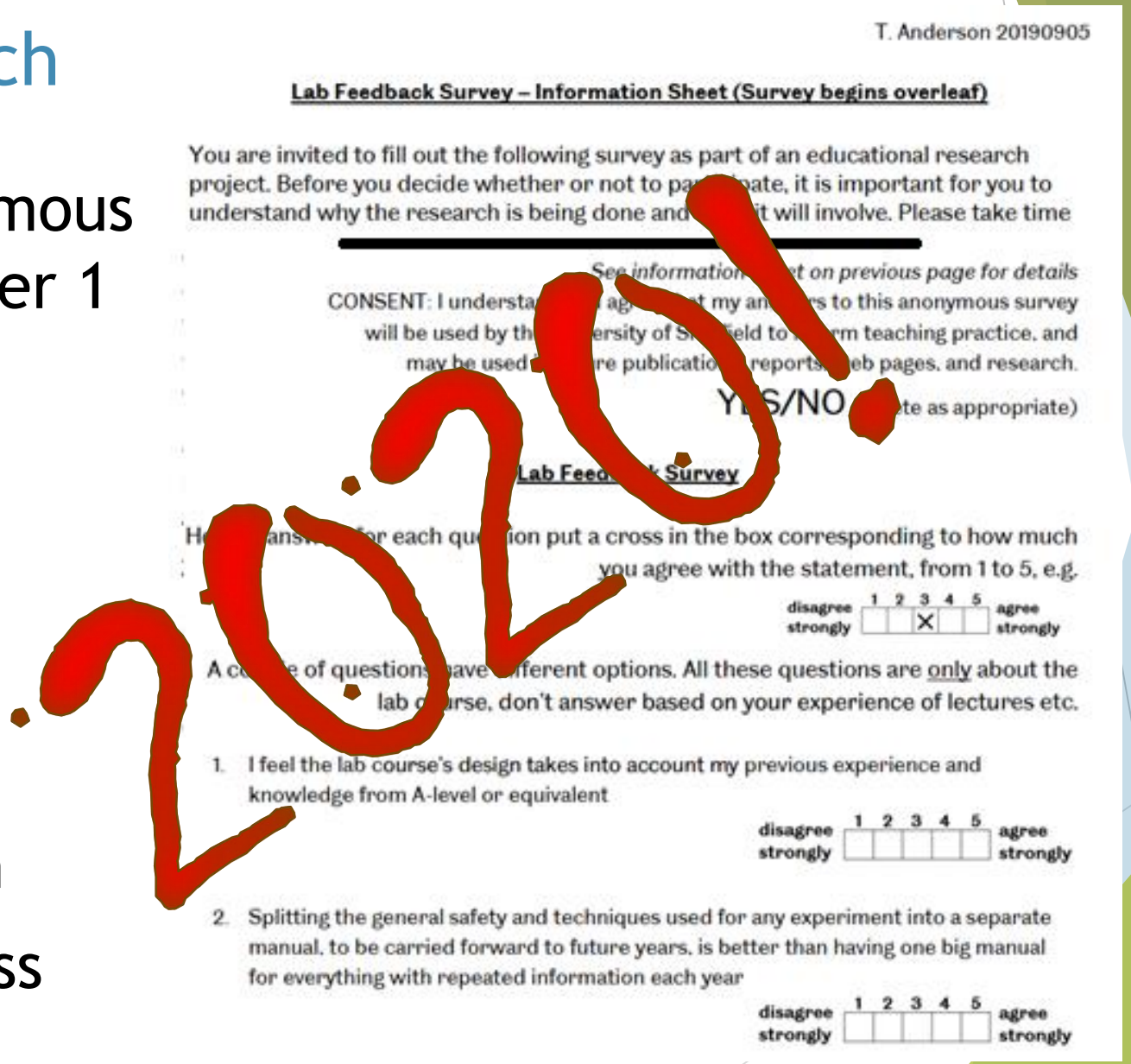
disagree strongly | 1 | 2 | 3 | 4 | 5 | agree strongly

Pedagogic research

- Conducted anonymous surveys in Semester 1

- Planned to follow these up

with focus groups in Semester 2 to discuss results…



T. Anderson 20190905

Lab Feedback Survey – Information Sheet (Survey begins overleaf)

You are invited to fill out the following survey as part of an educational research project. Before you decide whether or not to pa[illegible]ate, it is important for you to understand why the research is being done and [illegible]t will involve. Please take time

See information sheet on previous page for details

CONSENT: I understa[illegible] ag[illegible]t my an[illegible]rs to this anonymous survey will be used by th[illegible]ersity of S[illegible]eld to [illegible]rm teaching practice, and may be used [illegible]re publicatio[illegible] reports[illegible]eb pages, and research.

YES/NO (delete as appropriate)

Lab Feed[illegible]k Survey

H[illegible] ans[illegible]r each qu[illegible]ion put a cross in the box corresponding to how much you agree with the statement, from 1 to 5, e.g.

disagree strongly 1 2 3 4 5 agree strongly

A co[illegible]e of questions gave [illegible]fferent options. All these questions are only about the lab c[illegible]urse, don't answer based on your experience of lectures etc.

1. I feel the lab course's design takes into account my previous experience and knowledge from A-level or equivalent

disagree strongly 1 2 3 4 5 agree strongly

2. Splitting the general safety and techniques used for any experiment into a separate manual, to be carried forward to future years, is better than having one big manual for everything with repeated information each year

disagree strongly 1 2 3 4 5 agree strongly

2020!

The pandemic's impact on research

- Fortunately, almost all lab classes from 2019-20 had already been completed, with small online activities covering the remainder

- But this meant the planned focus groups could not be carried out. The same survey has been repeated for the 2020-21 group and focus groups are due to be held soon.
- **All data presented here is from 2019-20 as the second survey is not yet complete.**

Another example of teacher-student disconnect…

"…the most useful designation I have found for them is ***Digital Natives***. Our students today are all "native speakers" of the digital language of computers, video games and the internet."

-Marc Prensky, 2001 [1]

"I could use more help with this [assignment] … I've never really used a computer before"

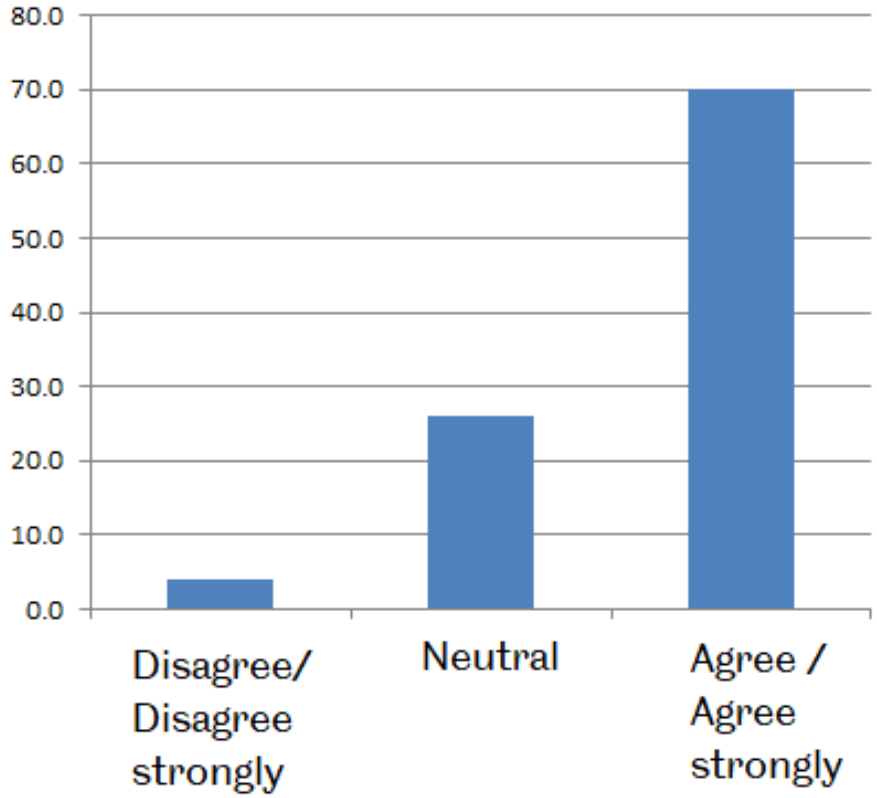
-A current first-year UK home student from an average economic background, born in 2002 [2]

This became very relevant in 2020!

[1] Prensky, M. "Digital Natives, Digital Immigrants", *On the Horizon*, MCB University Press, 2001, 9(5) 1-6

[2] Verbal comment to myself, reproduced with permission.

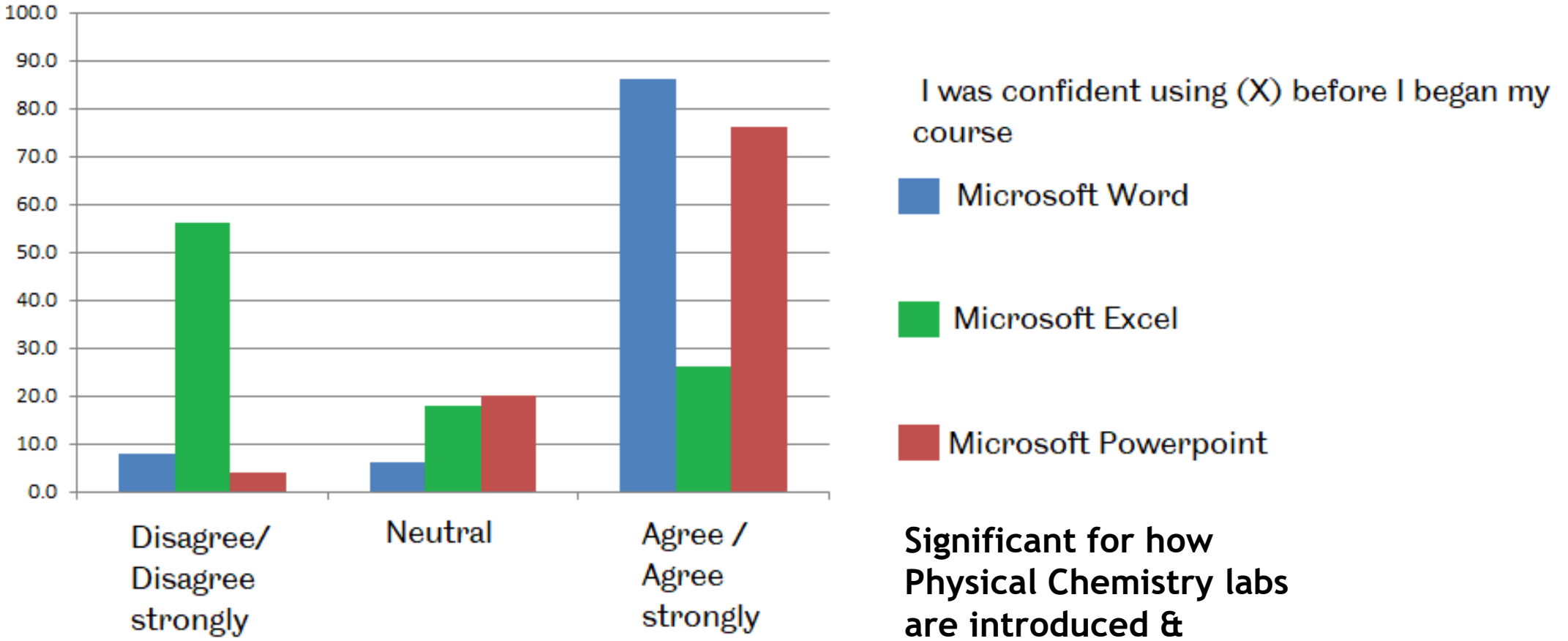
The importance of avoiding stereotypes!



Modern students are sometimes described as 'digital natives', i.e. they grew up with computers and the internet and are accustomed to using them from a young age. Would you consider yourself a 'digital native' by this definition?

Survey by T. Anderson. N=63 (97% response rate), using an anonymised paper survey approved by the University of Sheffield's ethics approval process. Further details available on request.

The importance of avoiding stereotypes!

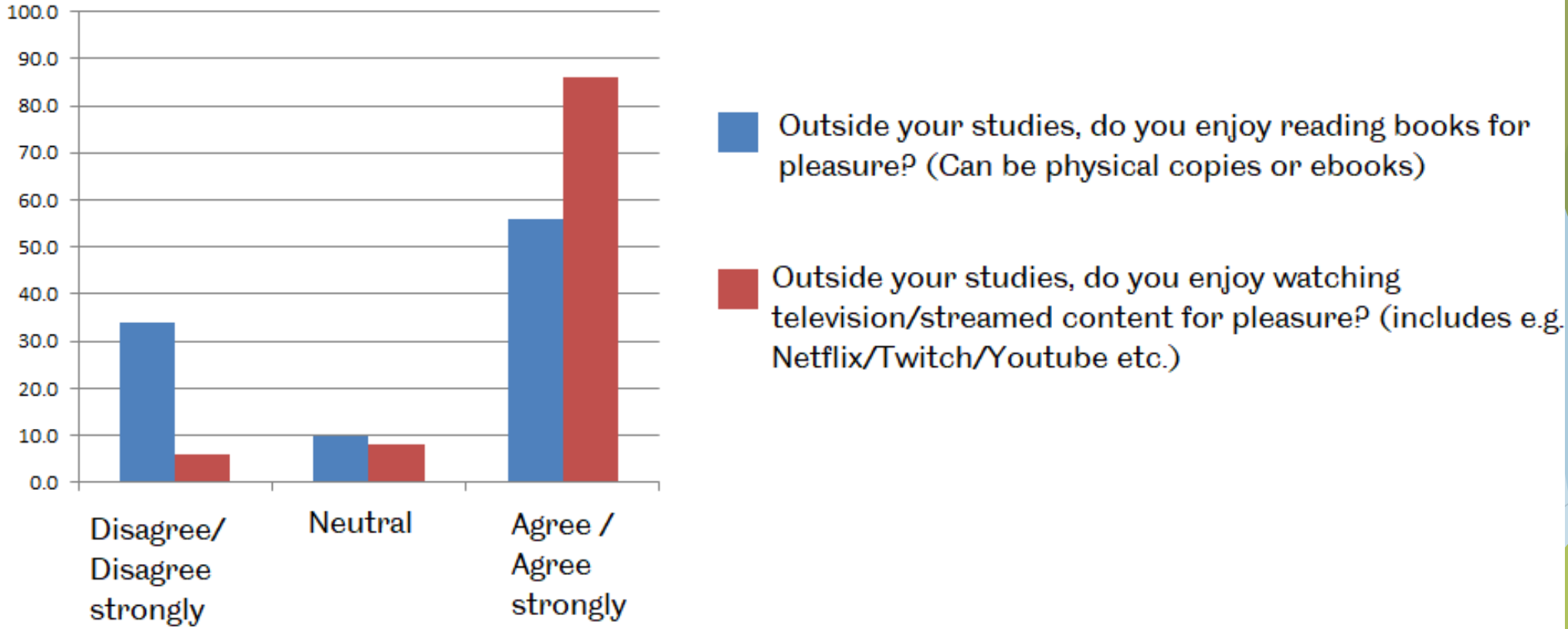


Significant for how Physical Chemistry labs are introduced & presentation skills development

Survey by T. Anderson. N=63 (97% response rate), using an anonymised paper survey approved by the University of Sheffield's ethics approval process. Further details available on request.

Are students still “scholars”?

Students were enthusiastic about more concise laboratory manuals. Why?

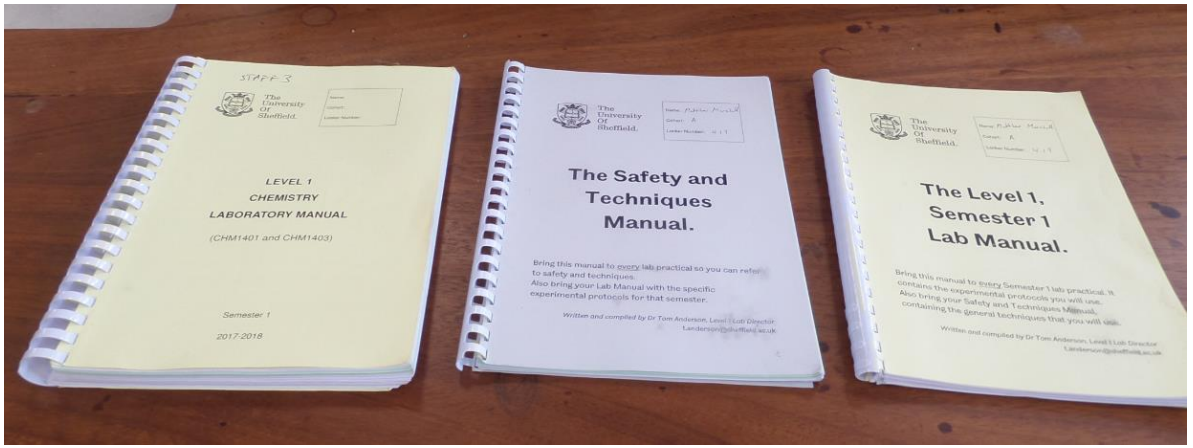


Survey by T. Anderson. N=63 (97% response rate), using an anonymised paper survey approved by the University of Sheffield’s ethics approval process. Further details available on request.

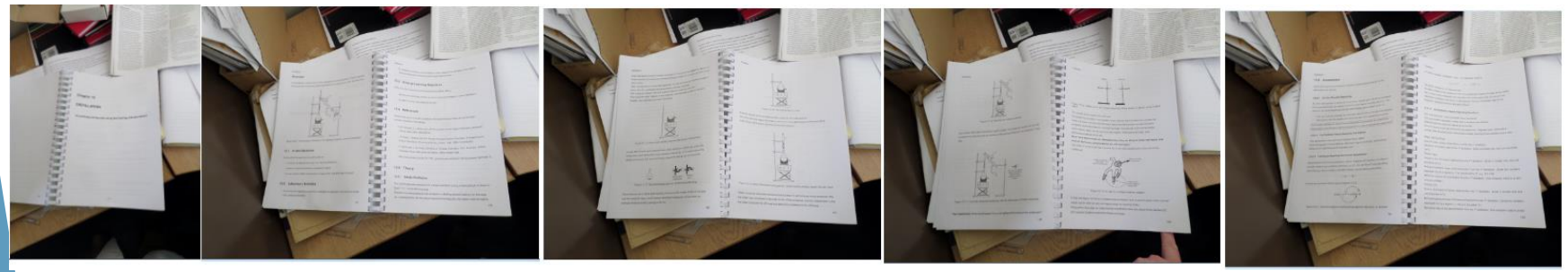
What is the best way to communicate information and maintain skills development continuously?

- The lab manuals I inherited were very lengthy (270 pages per semester) – every time a student asked a question, the answer was added in again by my predecessor…
- There is no point in everything being in there if the size of the book only intimidates a non-habitual reader into never opening it (or as little as possible)!
- Safety & skills were repeated redundantly year on year - it was tacitly acknowledged that it would be impossible for students to carry around the earlier year books too…

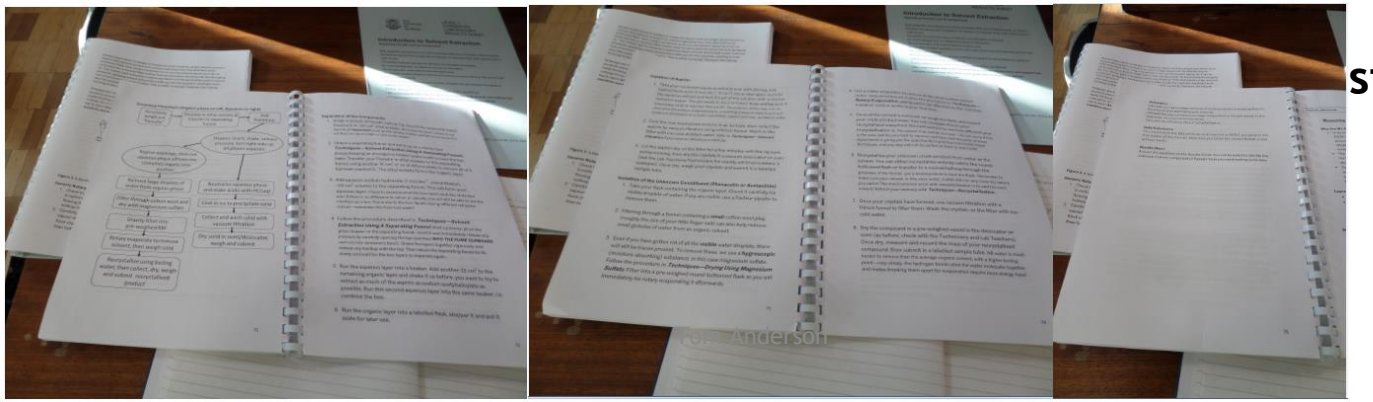
The old manual compared to the two new split ones



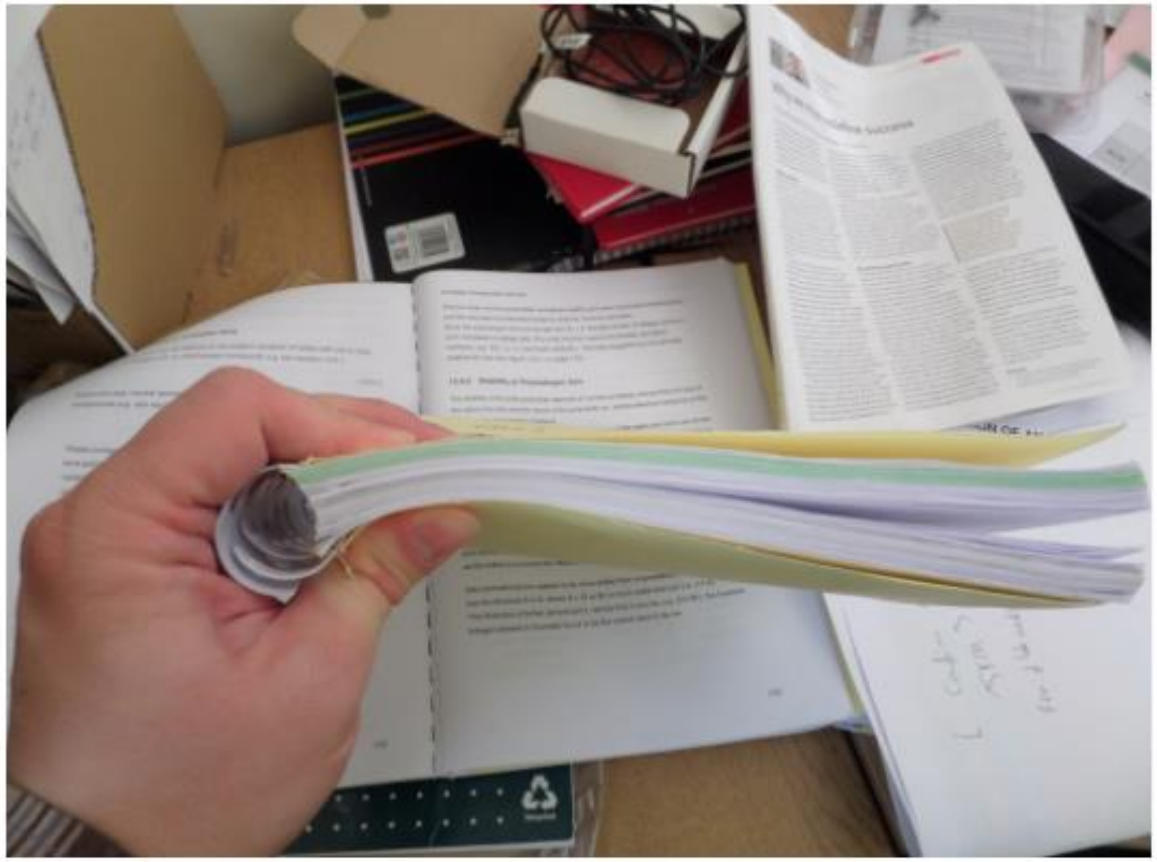
A 9-page experiment in the old lab manual…



…becomes 5 pages in the new lab manual, but still with all the extra explanation needed for a student doing something for the first time.



The thickness of just one of the old 270-page manuals...



(and there used to be another 270-page manual for each semester!)

...again on left, compared to the two slim 100-page ones...

The Safety and Techniques Manual contains all the skills information students will need to carry forward, in a concise form without the extra breakdown for someone doing it for the first time. **Self-led learning not repetition.**

Rotary evaporators (rotavaps or rovaps for short) work by using a vacuum pump to reduce atmospheric pressure so solvent evaporates from the attached round-bottomed flask, then using a condenser to re-cool the solvent vapour so it can be collected into a receiver flask (rather than being sucked into the pump and damaging it). The 'rotary' part is because a stationary flask will froth and bubble under reduced pressure, spraying solvent and product alike up into the machine—leading to both loss of product and contamination. This is called 'bumping'. However, the rotavap also has a powerful motor that can spin the flask, effectively preventing bubbles from forming to the point that they could froth and bump.

Rotavaps are fairly simple to use and a very powerful piece of equipment, but some students persistently make errors due to treating them as a 'magic device' and not really thinking about what they are doing—so making silly mistakes like staring at the rotavap for an hour wondering why nothing is happening when (e.g.) the stop-cock tap is open! **Always think about what you are trying to achieve and how the machine works; do not mindlessly fall back on a list of instructions alone.**

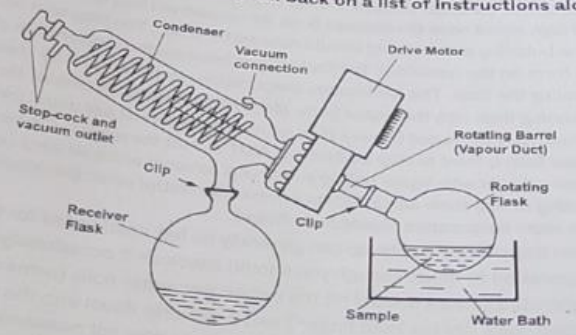


Figure 2. A labelled rotary evaporator setup.

Generic Rotary Evaporation Procedure:

1. Check the receiver flask is empty, the vapour duct is clean, the vacuum pump is switched on (ask a Lab Teacher if you cannot access this) and the water is flowing through the condenser. *It will save you a lot of time if you do not get halfway through and then realise there is a problem with one of these!*
2. Carefully attach your round-bottomed flask with your reaction mixture to the vapour duct with a clip; most rotavaps use the appropriately-sized plastic Keck clip, but a few have a built-in metal one. Your flask should not be more than half full of your reaction mixture; use a bigger flask or split it between

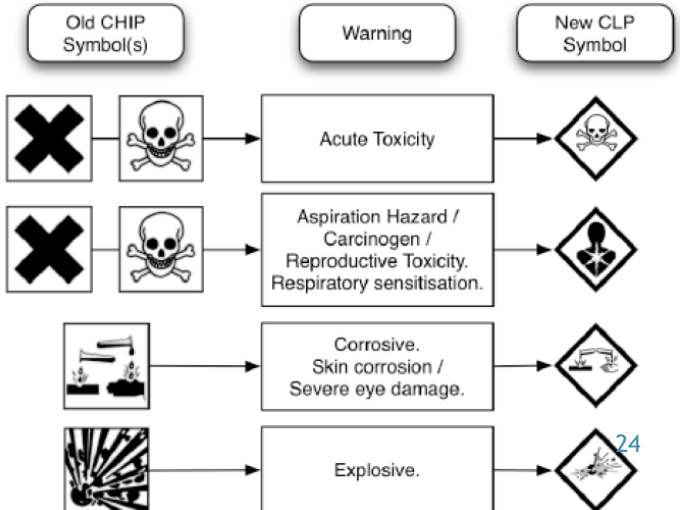
Tom Anderson 49

Safety 'Musts' For Any Lab

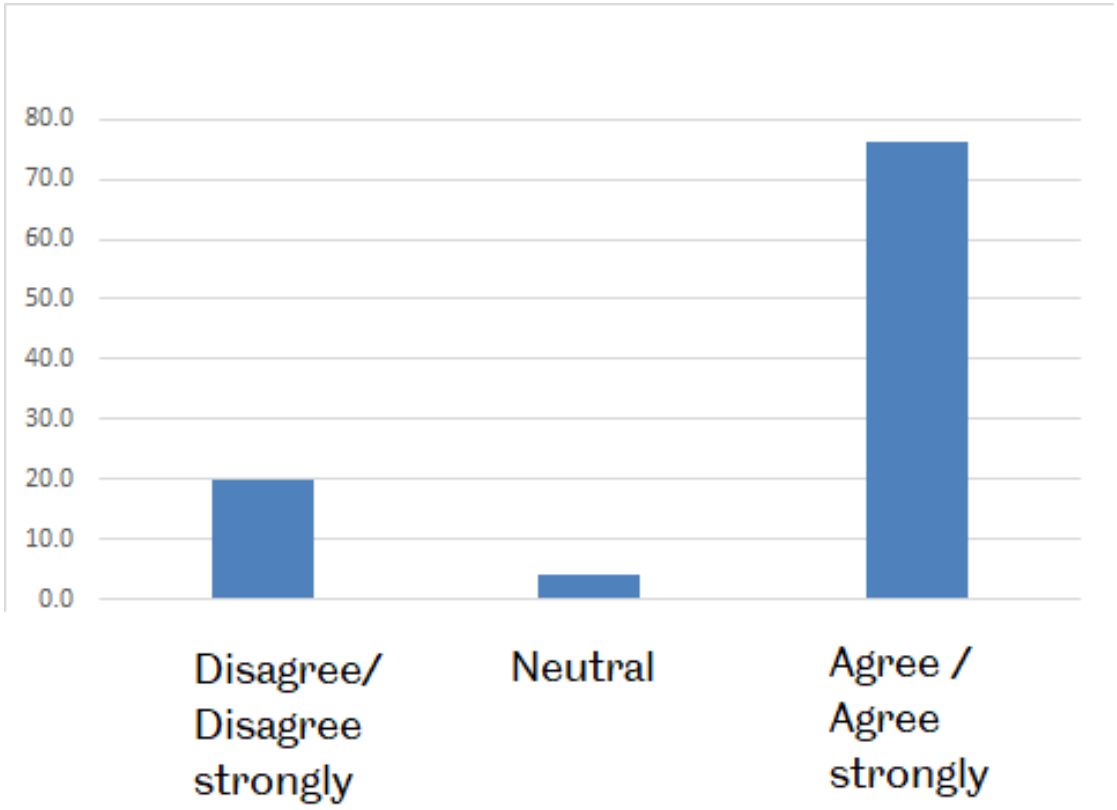
These are requirements for entering any lab and you will not be permitted to enter unless you have complied with them.

- Wear your **safety glasses** ("safety specs") at all times. If you need to scratch an itch, etc., do so with clean hands and leave the lab to do it.
- Wear your **lab coat** and make sure it is buttoned up with the sleeves rolled down. Remember the point of a lab coat is that if a dangerous chemical is spilt on it, the coat can be quickly pulled open and discarded: you do not want that chemical to go on your clothes beneath!
- You are given a pair of **black rubber gloves** which you should wear for handling chemicals and washing up, but **not** while using a computer or calculator, writing in your Lab Notebook, opening doors, etc. The idea is to keep chemical contamination separate

Chemical Warning Symbols



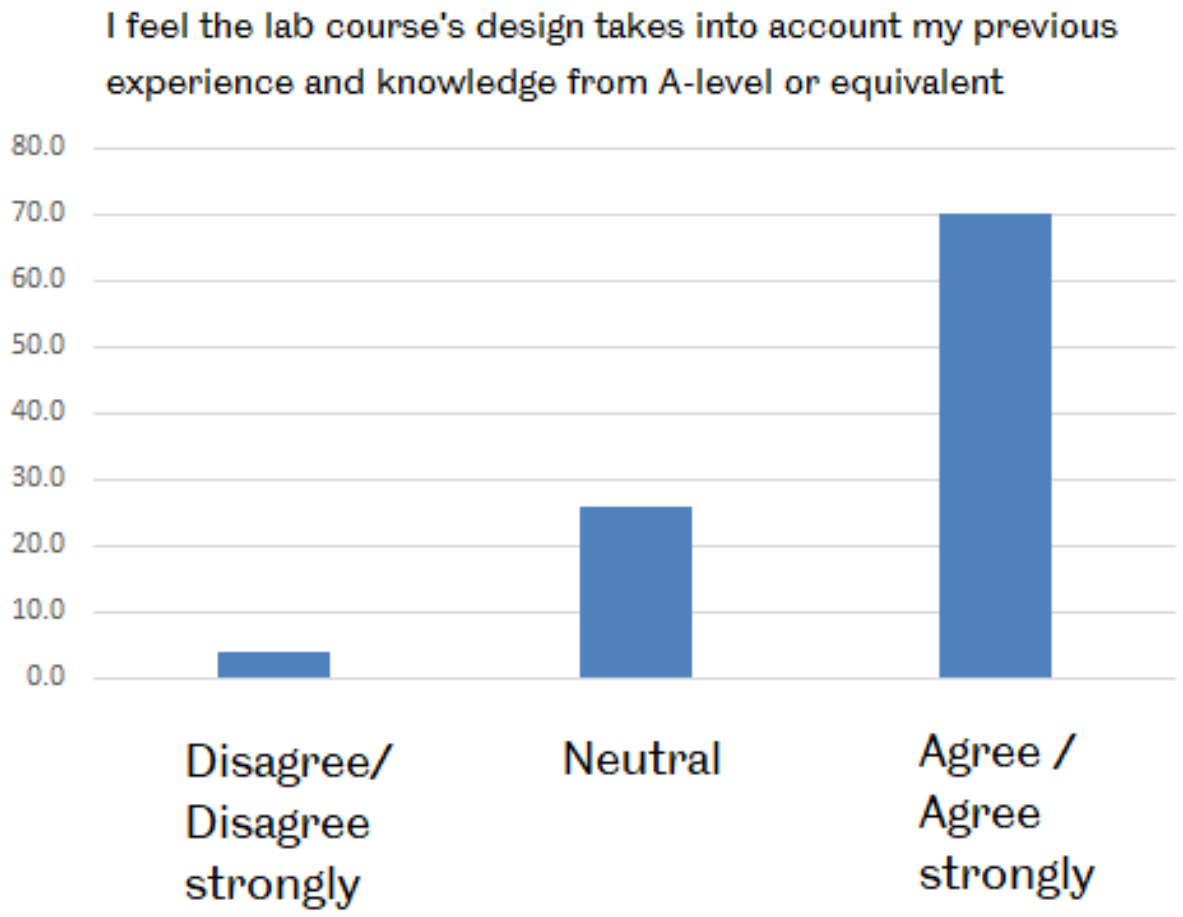
Student feedback...



Splitting the general safety and techniques used for any experiment into a separate manual, to be carried forward to future years, is better than having one big manual for everything with repeated information each year

NB students do not have a basis for comparison for this, but it is important to respect their views and find out the basis for them – focus groups to follow.

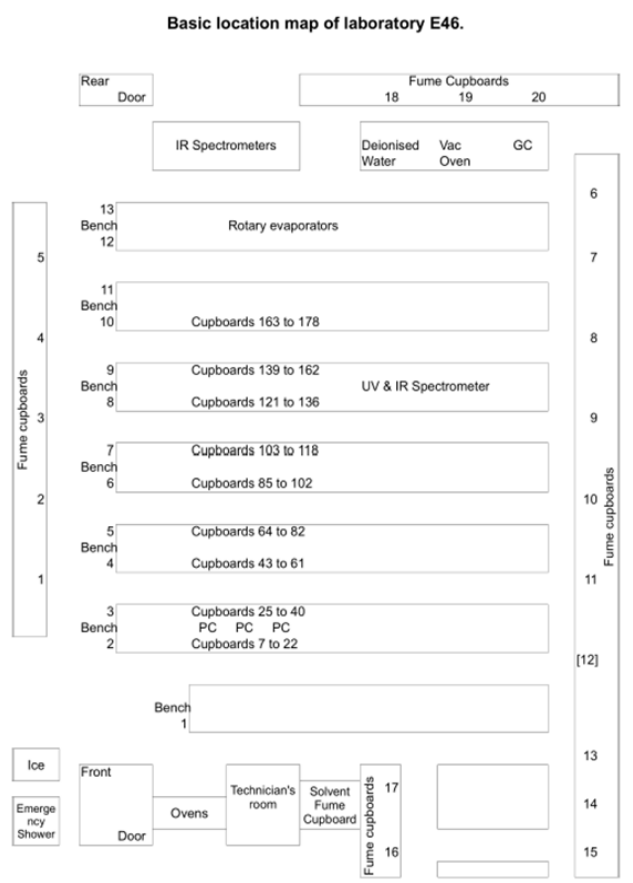
Student feedback...



Pandemic response!

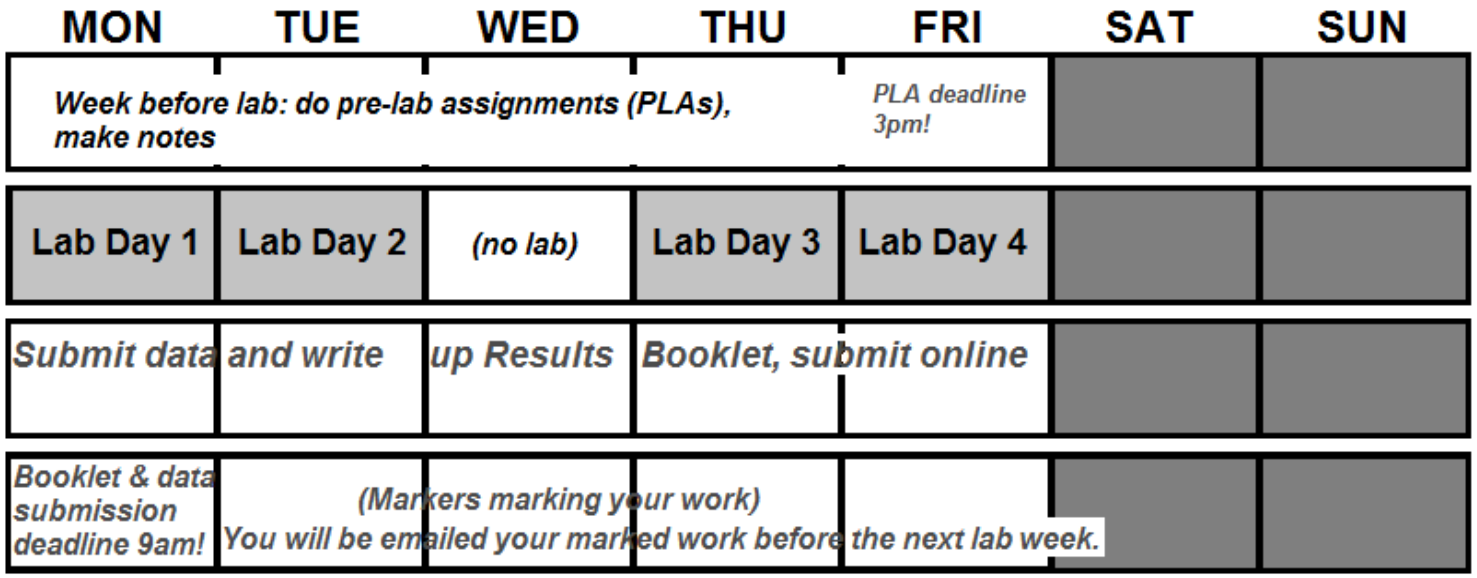
- We have access to large, spacious teaching labs that make social distanced teaching possible. Full risk assessments showed a lab usually capable of holding 55 students could accommodate 18 safely: 4-day lab week system implemented.

(An old pre-pandemic photo for illustration only!)



Pandemic response!

- Social distancing means that work previously carried out in pairs, or closely supervised by postgrads, now has to be done more independently.
- The new A-levels and my innovations in this direction thus paved the way for pandemic teaching!



Conclusions

- We must respond to changes in A-levels – but this problem is also an opportunity to challenge our students.

- My self-led learning innovations stood us in good stead when students had to work more independently during the pandemic

- The student experience cannot be reduced to stereotypes. Close consultation with and survey of the student population not only informed my reforms to manage the transition from the altered A-level course; it was also a vital tool in building a Covid-safe lab course. This illustrates the importance of pedagogic research-led teaching in the modern university.

Thank you for listening