UNIVERSITY OF BIRMINGHAM

Mini-projects: CURE-like lab projects to increase student learning

ViCEPHEC21

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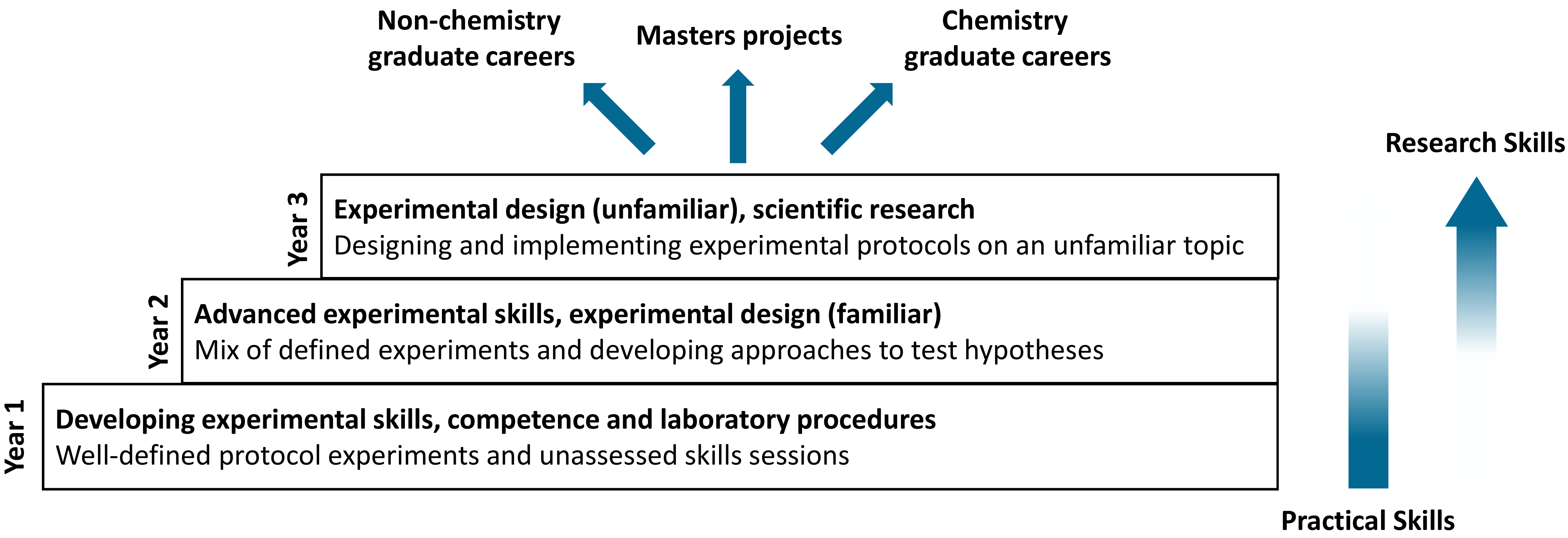
Chemistry Lab Course at Birmingham

- 150 students in Years 1 and 2
- Roughly 70 in Year 3
- Timetable allows for an average one day per week per student in the lab
- Year 1 – a day at a time
- Year 2 – 2 days every fortnight
- Year 3 – a whole week at a time

- In 2018/19 moved into CTL (CTL Website)
- Led to major redesign of our lab course

Chemistry Lab Course at Birmingham

New Lab Course focussed on development of practical skills into research skills (Seery, 2019)



Course-based undergraduate research experiences (CUREs)

What is a CURE? Dolan (2016) summarises some of the suggestions made in papers about what constitutes a CURE
N.B. there is no consensus!

- Discovery – novel results
- Relevance – of interest to external stakeholders
- Students' engagement in scientific practices including:

reading scientific literature

designing some aspect of the project

engaging in collaboration

analyzing data

making interpretations

framing work in the larger body of knowledge

communicating results

Advantages of CUREs:

1. **Cognitive gains** such as increased content knowledge, improved understanding of the nature of science, or skill development, including analytical, technical, collaboration, communication, and experimental design skills;
2. **Psychosocial gains** such as increased confidence, self-efficacy, project ownership, sense of community, and scientific identity, as well as more frequent and fruitful interactions with faculty;
3. **Behavioral gains** such as staying in a science major, pursuing additional research opportunities, or enrolling in graduate school; and
4. **Affective and other "non-cognitive" gains** such as enjoying science class more and being more motivated
5. Allows access to research for students from **more diverse backgrounds** (Eagan, 2013)

Course-based undergraduate research experiences (CUREs)

Some background reading on CUREs:

Course-based Undergraduate Research Experiences: Current knowledge and future directions – Dolan (2016)
- good summary of CUREs in chemistry and life sciences, contains examples of CUREs from variety of institutions
- https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_177288.pdf

Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report – Auchincloss (2014)
- Summary of a meeting of CUREnet (a network of biology academics interested in CUREs) discussing logistics and assessment of CUREs
- *CBE-Life Sci. Educ.* **2014**, *13*, 29–40 (https://doi.org/10.1187/cbe.14-01-0004)

The Laboratory Course Assessment Survey: A Tool to Measure Three Dimensions of Research-Course Design – Corwin (2015)
- Describes in-depth development of Laboratory Course Assessment Survey (LCAS) for monitoring students interaction with CUREs
- *CBE-Life Sci. Educ.* **2015**, *14:ar37*, 1–11 (https://doi.org/10.1187/cbe.15-03-0073)

Characteristics of Excellence in Undergraduate Research – edited by Hensel (2012)
- Collection of essays on undergraduate research
- https://www.cur.org/assets/1/23/COEUR_final.pdf

Mini-projects: Logistics for students

	Activity	Assessment	
Semester 1	Week 3 – Research workshop		
	Week 5 – One-week mini-project	Poster + Supervisor Mark	**50% of module**
	Week 8 – Writing workshop 1		
	Week 9 – One-week mini-project	Chem Commun paper 1 + Supervisor Mark	**50% of module**
Semester 2	Week 7 – Two-week mini-project (1^{st} week)		
	Week 8 – Writing workshop 2		
	Week 9 – Two-week mini-project (2^{nd} week)	Chem Commun paper 2 + Supervisor Mark	**100% of module**

- Students also meet with supervisors in weeks before and after the mini-project weeks to plan and debrief
- Workshops help explain the assessment to the students
- Broken into three mini-project to allow for feedback to improve future performance

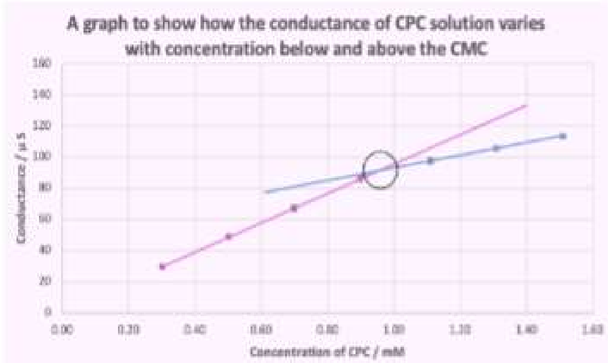
Exemplar Mini-projects: Critical Micelle Concentrations

Aim: Can bench-top NMRs be used to determine critical micelle concentrations?

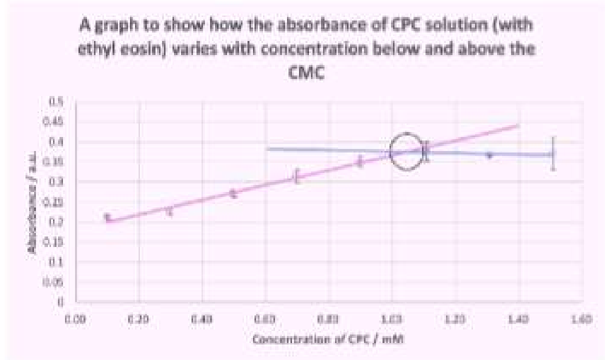
- Usually measured using techniques such as conductivity or UV
- Can NMR prove as useful - potentially even more so?

NMR gives good approximation to the CMC for two surfactants

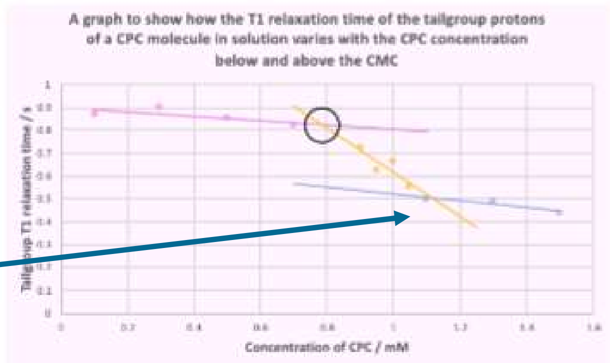
Physical parameter	CPC CMC (mM)	DPC CMC (mM)
T_1 relaxation	0.65	14.22
T_2 relaxation	0.72	16.27
UV (EE)	1.02	13.26
UV (Fluorescein)	-	10.36
Conductivity	1.02	18.66
Conductivity (EE)	1.20	17.05
Literature values	0.90[2]	14.9[3]



Conductance



UV-vis



T1 relaxation

NMR identified a phase change in the micelles not picked up by traditional methods

Exemplar Mini-projects: Upcycling Plastic Waste

Aim: Can we improve the efficiency of plastic recycling?

- Building on Prof Andrew Dove's work on recycling plastics
- Students are given free reign to explore the area based on their own ideas

Group 1 – optimisation of catalytic regime for depolymerisation

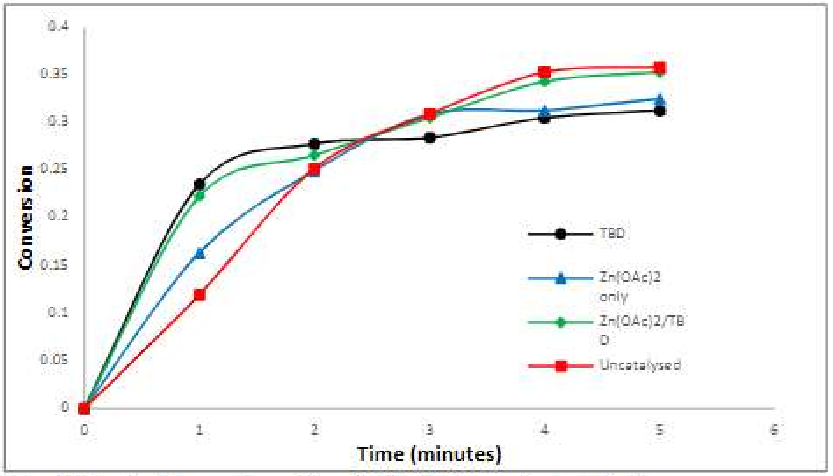
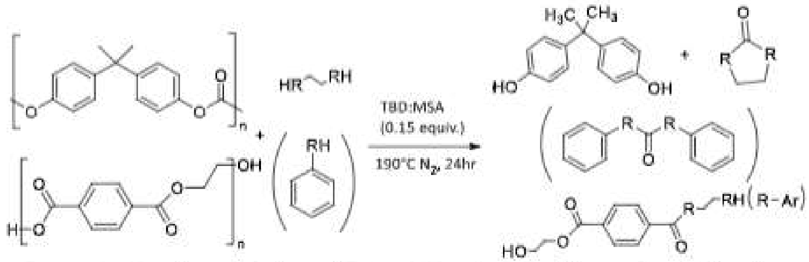


Figure 3 Graph of Conversion vs Time for 5-minute reaction monitoring



Scheme 3: Depolymerisation of BPA-PC and PET with a nucleophile where R = O/NH. Schemes carried out with aliphatic nucleophiles yielding a heterocycle and (aromatic) nucleophiles yielding a (diphenol derivative). Monomers include a BPA and a BHET derivative (see table 4)

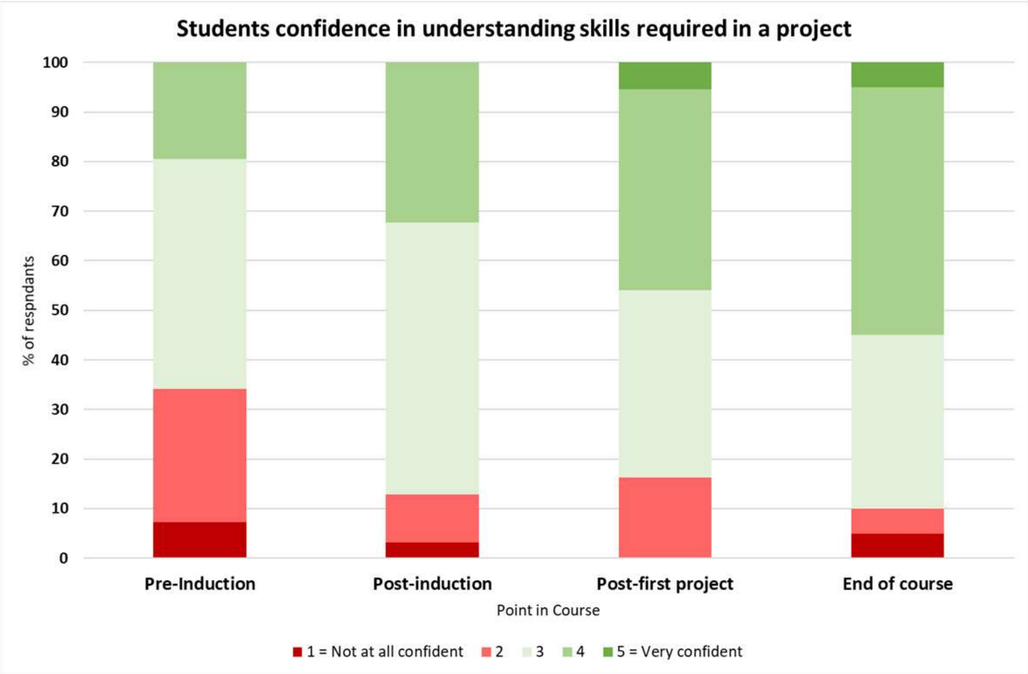
Group 2 – Can BPA-PC be recycled selectively in presence of PET

Table 3 BPA and BHET derivative yields from BPA-PC depolymerisation reactions

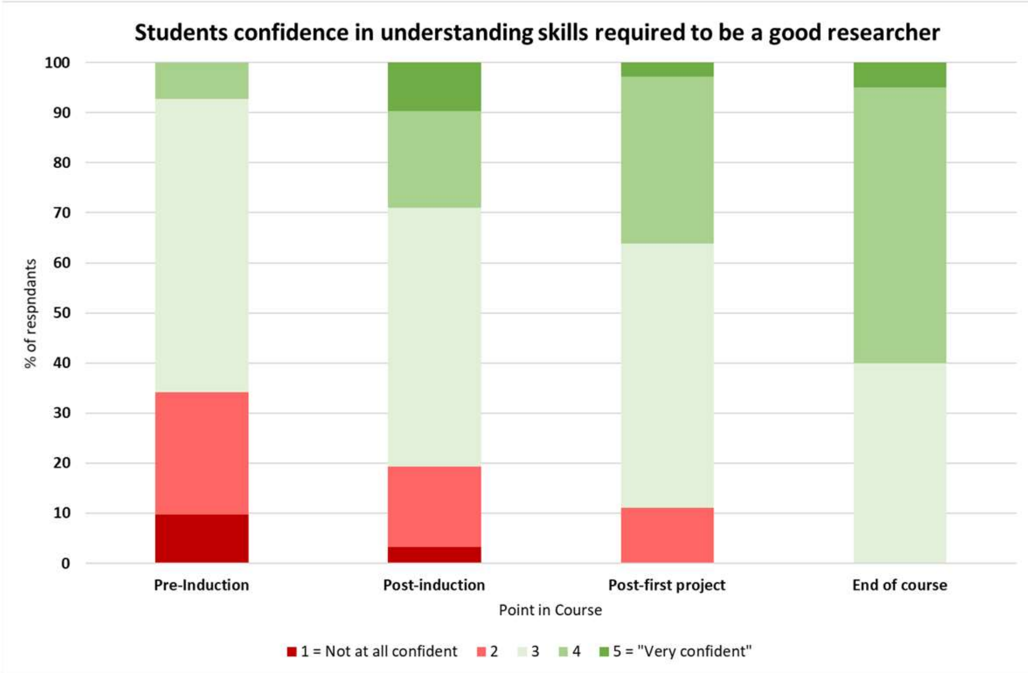
Entry	Nucleophile	T (°C)	Time (h)	BPA yield (%)*	BHET derivative (%)*
1	**1A**	190	24	73	25
2	**2A**	190	24	76	32
3	**3A**	190	24	52	3
4	**4A**	190	24	22	13

* Yields calculated from 1H NMR using TBD:MSA as an internal standard

Mini-projects: Student Feedback



Over the course of the mini-projects, students understanding of the skills required for research increased



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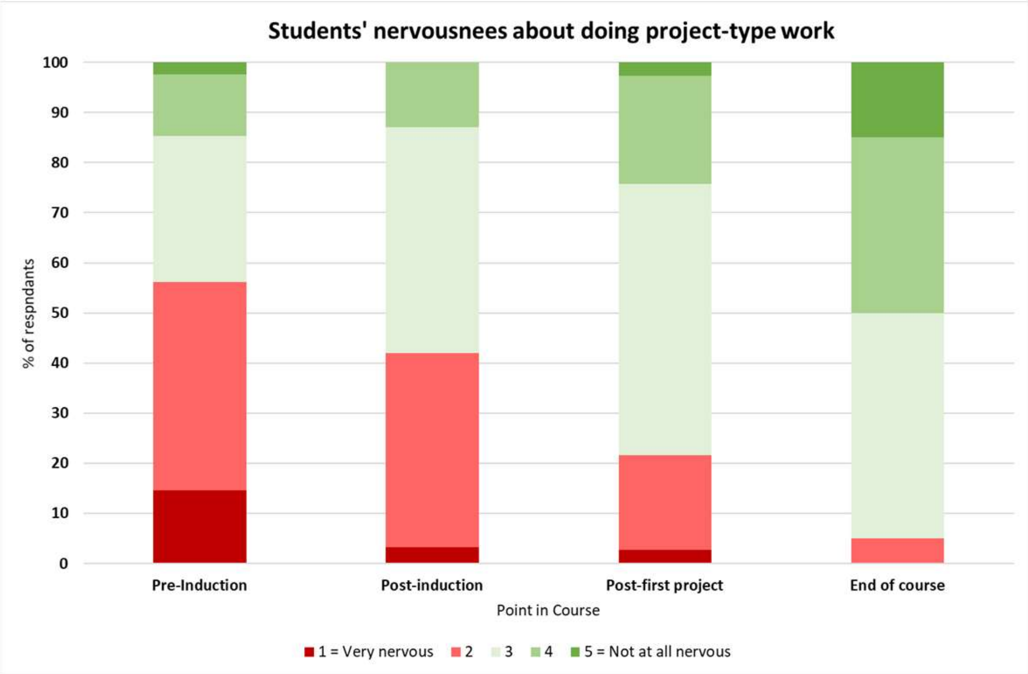

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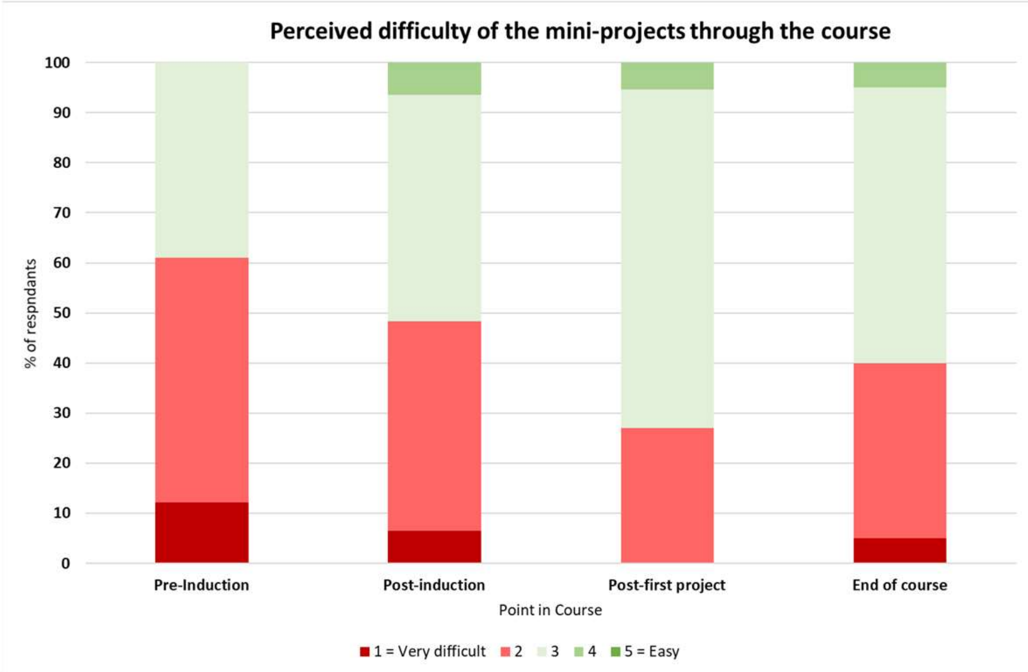
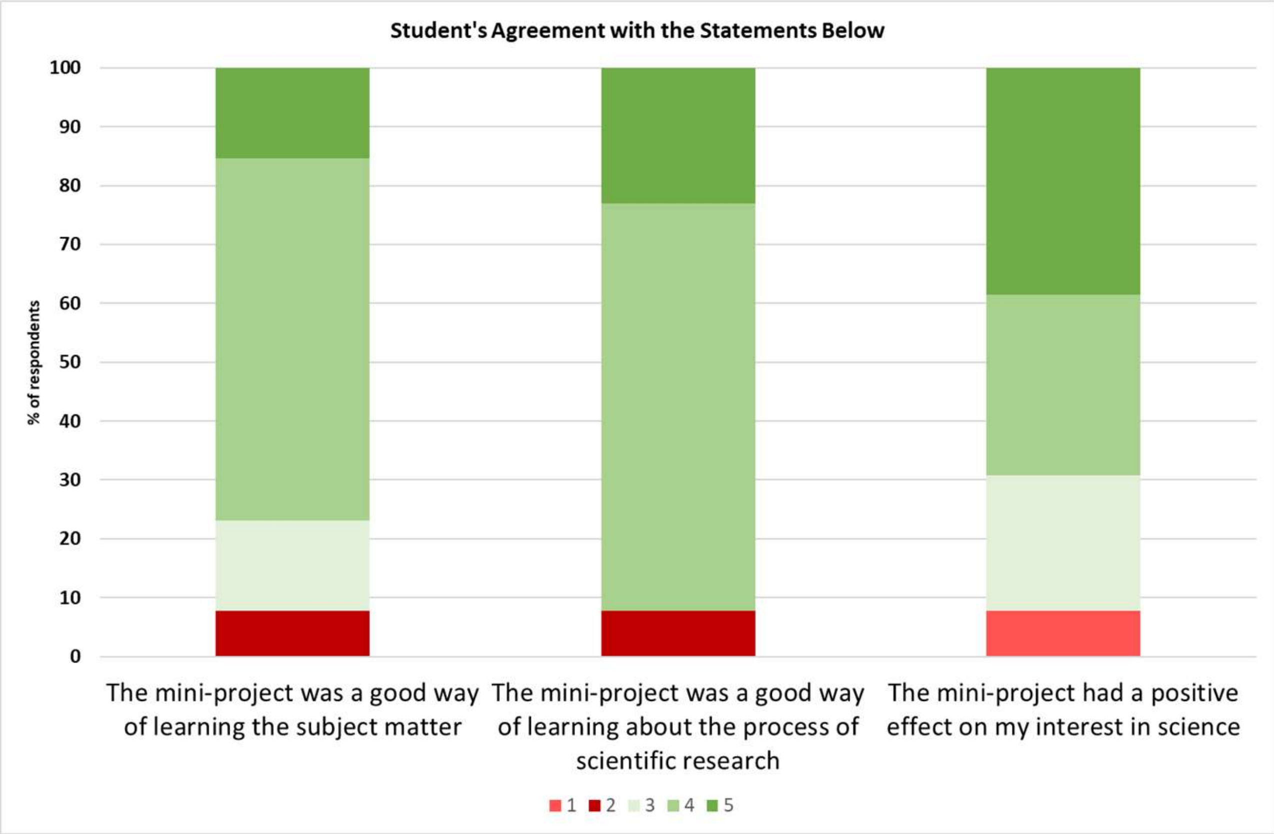


Their confidence also increased – importantly not linked to the mini-projects seeming easier

Mini-projects: Student Feedback



Sample of student quotes:

"The last two years of labs makes sense now"

"I didn't know that this is what physical chemistry was, I understand why people like it now"

"I now know what subject I want to research now" **– student went on to do Masters in Polymer chemistry in Europe**

- Student survey shows the students enjoyed their mini-projects and found it increased their interest in science and the subject area of their mini-project
- Also highlights the students learnt about the process of scientific research

References & Acknowledgements

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DNDi
Drugs for Neglected Diseases *initiative*