

A New Bridging “Introduction to University Chemistry” Module for Cardiff University

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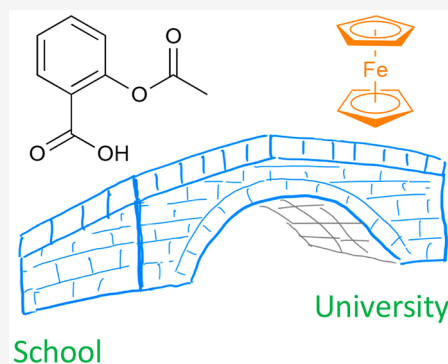
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ABSTRACT: A new module designed to ease the transition from school to university was devised and implemented at Cardiff University School of Chemistry. Two iterations of the module are described, both of them conducted under restrictions imposed by COVID-19 pandemic regulations. Over a two-week period, students attended 15 different sessions, each designed to address a different aspect of the transition. The sessions varied from a treasure hunt to more formal laboratory classes. Extensive feedback from the students attending the module was sought and was generally very appreciative. Suggestions for improvement from the student cohort include additional laboratory sessions and training in the use of specific technical software.

KEYWORDS: *bridging, introduction, transition*



INTRODUCTION

The transition from school to university can be a tough challenge in a student’s educational journey as they encounter many new and different aspects of life in a relatively short period of time.^{1–3} So many aspects of a student’s life change at this critical juncture that it can be difficult to isolate the effects and influences. To appreciate some of the relevant aspects, it is important to first understand the educational path to university.

In England and Wales children normally study a broad range of subjects up to the age of 16, whereupon they are assessed for the award of so-called General Certificate of Secondary Education (GCSE) qualifications. Typically children are required to study a core of English (language and literature), mathematics, sciences (either the separate subjects of chemistry, physics, and biology or a hybrid “double science” course that covers aspects of chemistry, physics, and biology), and religious education. Children then choose a number of options (modern languages, history, geography, art, PE, IT, etc.) to study alongside the core subjects to give a total of 8–10 GCSE qualifications. In Wales, the study of Welsh language is compulsory to the age of 16. After GCSE qualifications, students who are contemplating a university-level education (which normally begins at age 18) usually choose three or four subjects to study in more detail for two years, leading to A-Level qualifications. In the U.K., chemistry A-Level is considered a compulsory qualification for entry into B.Sc.-level degrees in Chemistry, with some institutions (though not Cardiff) insisting on A-Level mathematics too. Some schools in the U.K. offer the International Baccalaureate⁴ as a two-year

program of study post-GCSE, and this qualification is widely accepted in lieu of A-Levels in the U.K. and by universities across the whole of continental Europe for entry into degree-level university courses.

The transition to university has been discussed in the chemical education literature over the years⁵ and has been shown to be influenced by academic aptitude, prior knowledge, self-efficacy, self-confidence, preparedness,⁶ and other factors.¹ Subsequent student success can be increased by creating a sense of belonging in a learning environment.⁷ As well as the general transition to university, it is important to consider key skills such as mathematics and laboratory skills. It has been shown that student’s preuniversity grades in mathematics are strongly related to their subsequent university grades,^{8,9} and it has been indicated that prospective undergraduate chemists significantly benefit from studying A-Level mathematics.¹⁰ It is therefore important to consider students that have not done an A-Level in mathematics and how they can be helped.

Voluntary introductory modules that bridge the gap from school to university have been introduced at other chemistry departments, where students who attended performed significantly better than students who did not.¹¹ Other

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Table 1. Module Design Criteria

Criteria	Module Components and Considerations
To be inclusive and engaging and to promote success among all students, taking into consideration:	<ul style="list-style-type: none"> • Different learners. • Past experience. • Language ability. • Numeracy skills. • Disability.
Inclusion of essential skills:	<ul style="list-style-type: none"> • Lots of opportunities, through group work and bonding exercises, to settle in and get to know one another. • Simultaneously working on key skills. • Time spent aligning academic horizons.
Begin at induction:	<ul style="list-style-type: none"> • Students undertake bonding exercises, group work, and fun challenges. • They are also introduced to Cardiff and guided through a range of information such as: <ul style="list-style-type: none"> – The school handbook and school website. – Plagiarism and unfair practice procedures. – Library resources and the library as a learning environment.
Progress to University working:	<ul style="list-style-type: none"> • Lab work, safety, etc. • Simultaneously work on key skills, including note taking, synthesizing information, structuring and writing essays/reports, referencing, and reflection.
Provide significant benefits to students:	<ul style="list-style-type: none"> • Self-confidence and better integration of students within the cohort. • More realistic alignment of academic expectations at the University level. • Better student–staff relationships. • Get into the habit of a working day. • Better prepared for their future studies.

successful approaches have included a preparatory course that runs concurrently with the main chemistry teaching.¹²

Herein we describe a new compulsory “Introduction to University Chemistry” module at Cardiff University, designed to assist all students with the transition to university.

MODULE DESIGN

What is now Cardiff University was first established in 1883 as the University College of South Wales and Monmouthshire, then a founding college of the University of Wales in 1893, before becoming a fully independent entity in 2005. Chemistry has been taught at Cardiff University since its founding in 1883. Currently the School of Chemistry has one of the largest undergraduate intakes of any U.K. university, with about 150 students admitted annually to its undergraduate programs. An intake of this size inevitably gives rise to a very diverse student body with a variety of backgrounds, potentially leading to multiple issues upon commencement of study (Table 1).

Ultimately these issues can manifest themselves as poor performance and increased dropout rates later in the degree program. Thus, to address these issues, a new compulsory bridging module that would come right at the beginning of all of Cardiff's chemistry students' university career was proposed. Unlike other examples^{11,13} of bridging modules, the Cardiff module was to be compulsory, so that all subsequent teaching could build upon it. The module was to be made core (must be passed) and assigned a credit and exam weighting to encourage participation.

While the level of prior knowledge has been shown to have an influence on subsequent student performance,¹⁴ the emphasis of the module was not so much an introduction to additional chemistry-related material but rather an introduction to a new way of learning within a university context. The entry requirement for A-level chemistry (or an equivalent qualification) was felt to be sufficient at a subject-specific level for academic success at Cardiff. At other institutions, bridging modules have focused on providing chemistry-related materi-

al,^{11,13} as it has been shown that improved prior knowledge can lead to reduced dropout rates.¹⁵

Thus, part of the emphasis of the new module would be to foster a sense of belonging^{7,16} and to improve attitudes toward chemistry,¹⁷ as these have been shown to improve performance.

Other institutions have introduced semester-long introductions,^{18,19} but this model was rejected in favor of an up-front approach, as introduced elsewhere in person¹³ and online.²⁰ The advantages of concentrating solely on an introduction at the beginning of university were felt to be over-riding. In practice, given the practicalities of fitting students into the teaching laboratories and a number of other timetabling constraints, the delivery window of the new module was set at two weeks, right at the beginning of the academic year. Two weeks also roughly corresponds to 10 credits (an allowed subdivision) in the system of 120 credits per year taught over 24 weeks in place at Cardiff University.

The key aims of this module were therefore to prepare students for their subsequent independent learning and teaching and to build a sense of belonging to both Chemistry and Cardiff that would provide a support network in all subsequent years. The intention was to stop the better students from disengaging and the weaker students from getting left behind in their degree program. Table 1 summarizes much of the initial thinking concerning the parameters of the module design, and the full module learning outcomes are included in the Supporting Information.

The new module was designed to bring the new students up to speed on many aspects of university life, such as basic lab practice, study skills, and tutorial engagement. There was to be an emphasis on group working and peer-led teamworking²¹ that should foster a sense of community among the students, who might otherwise feel isolated in their initial few months at university. Though four different laboratory instruction styles have been identified (expository, inquiry, discovery, and problem-based),²² for this stage in the students' career it was decided to concentrate solely on expository-style laboratory

Table 2. Suggested and Delivered Timelines

Week	Day	Suggested Program at Planning Stage	Delivery in October 2020 with Covid Restrictions in Place
1	Monday	<ul style="list-style-type: none"> Head of Department welcome. Introduction to other key staff (Director of Learning and Teaching, Senior Tutor, Education and Students Manager), then split into tutorial/lab groups for ice-breaking/team-building exercises. Cardiff University and City (i.e., Students' Union, sports facilities, food/drink, halls of residence). ChemSoc introduction at 4 pm, followed by a student-led social event Meet personal tutor, find the lecture theaters, laboratories, library, etc. Email setup, communications and comms protocol. Study skills: IT resources, Panopto, VLE, SIMS, etc. Safety and lab protocols: issue of PPE, correct clothing, COSHH. (25% of module mark from multiple-choice quiz on safety.) 	<ul style="list-style-type: none"> Welcome and elemental treasure hunt ("In My Element") in individual tutorial groups, all outside with staggered arrival times. Online welcome from the Head of Department leading into an introduction from ChemSoc and a virtual "escape room" exercise at 4 pm. Meet personal tutor (face-to-face, socially distanced).
	Tuesday		
	Wednesday		
	Thursday	<ul style="list-style-type: none"> First lab "work": simple glassware assembly, rotavaporator. Study skills: What a lab/lecture/tutorial/workshop is (and expectations of time commitment). What the degree is: journey through it. M.Chem. vs B.Sc., mark requirements. Placement opportunities. Careers service Exercise on identifying and categorizing scientific content in newspaper articles. 	<ul style="list-style-type: none"> "Chemistry in the Media" optional session on depiction and perceptions of chemists in the popular media. Safety: Lab tour and safety briefing: issue of PPE (lab coats, safety specs), in individual tutorial groups. Online safety simulations and then online laboratory safety quiz (33% of module mark from multiple-choice quiz on safety). Parallel sessions, with a rotation system. Half the students do lab 1 on Thursday and study skills on Friday, half the other way around. Lab 1: making up standard solutions and the use of UV/vis to determine concentrations.
	Friday		
2	Monday	<ul style="list-style-type: none"> Exercise on identifying and categorizing scientific content in newspaper articles. Second lab "work": weighing, measuring volume (making up a standard solution). Reproducibility of measurements (leading to errors). 	<ul style="list-style-type: none"> Study Skills 1: concentration on the role lectures, tutorials, workshops, and laboratories have in learning and teaching. Parallel sessions, with a rotation system. Half the students do lab 2 on Monday with study skills on Tuesday, half the other way around.
	Tuesday	<ul style="list-style-type: none"> Third lab work: choosing correct size of glassware and running spectra (IR, UV/vis, NMR). Study skills: time management. Exam/past papers/adjustments. Plagiarism. 	<ul style="list-style-type: none"> Lab 2. Recrystallization of aspirin Study Skills 2: Library access and information retrieval; use of Cardiff IT, VLE, and SIMS. Additional session on the journey through the Cardiff Chem degree.
	Wednesday	<ul style="list-style-type: none"> Maths skills: basic algebra; density/yield/mole/purity calculations; significant figures; units (micro, nano, etc.) and units conversions (25% of module mark from multiple-choice quiz from this part.) 	<ul style="list-style-type: none"> Maths: three one-hour online sessions (one hour gap between); nomenclature, units (micro, nano, etc.) and units conversions; basic algebra; chemical calculations (33% of module mark from multiple-choice quiz on this mathematical content).
	Thursday	<ul style="list-style-type: none"> Lab experiment that wows (25% of module mark from report/presentation on lab). Finding information: the library (emphasis on books in year 1) Assessment/standards/feedback: expectations of staff; module evaluation; staff–student panel 	<ul style="list-style-type: none"> Initial one-hour online session on how to write a lab report. Then 2 h livestreamed lab experiment (synthesis and purification of ferrocene) Then students asked to write up the experiment and submit their own report (34% of module mark from this report).
	Friday	<ul style="list-style-type: none"> Interview a researcher (personal tutor?) and present to rest of group Groups collectively present to other groups (design a t-shirt that encapsulates what they've learned in the first two weeks—fashion show?) (25% of module mark from group presentation at fashion show.) Finish with pizza and a ChemSoc social event. Voluntary: start to build a guide to Cardiff Chemistry (first lot of students draft, next year added to and so on) in order to build up a community knowledge (like a Wiki on student life). Coordinated by ChemSoc? 	<ul style="list-style-type: none"> Several online briefings: Students' Union; optional modules; Welsh support; careers support. Then "Final Challenge": preparing an innovative presentation on the elements the group collected in their initial treasure hunt and presenting that to the entire year (online); awarding of prizes (cojudged by ChemSoc).

experiments. It was envisaged that good practice inculcated in this initial two-week block would be reinforced throughout the year with support from lecturing staff and weekly group tutorial meetings.

As part of the formal process of seeking University approval for the introduction of a new module and associated major changes, it was necessary to seek external input from two advisors, both of whom were acknowledged experts in the field of chemical education; their feedback (see the [Supporting Information](#)) was incorporated into the design. Student feedback was also sought at a preliminary stage, and some additional input was gained by remaining in contact with a number of students throughout the entire design period. For the particular time frame and circumstances in which the new module was delivered, the impact COVID has had on the transition to university cannot be ignored. It has been noted that student–student interactions are key to student integration and that even in times of adversity, technologies can and should be used to maintain these interactions.²³

MODULE ROLLOUT

The new module was devised over the summer of 2019 and received formal University approval in September 2019 for delivery in October 2020. At this point a two-week schedule was envisaged, as summarized in the second column of [Table 2](#). When it came time to deliver the module for the first time in October 2020, the global COVID-19 pandemic had severely changed the educational landscape. Even within the U.K., restrictions were different, and at Cardiff University the Welsh Government rules applied. The Departmental Safety Team agreed that no inside teaching of large groups could take place and that face-to-face teaching of small groups (up to 10 students) could take place only in a suitably distanced manner (in practice this meant spreading those 10 students out across a large lecture theater). Laboratory classes were allowed to run, but only with laboratories occupied at a much-reduced capacity (14 students max) with one-way systems, face shields, and social distancing.

The three chemistry teaching laboratories at Cardiff University were completely closed until two weeks before the start of the term, and hence, it was only with relatively short notice that it became possible to adapt the original plan to something of value. The actual delivered schedule is summarized in the third column of [Table 2](#).

Come October 2021, COVID restrictions were still in place, although they were less stringent than the previous year. Larger groups were allowed to meet inside (with social distancing and face coverings), and the teaching lab capacity had been increased to 30. This did not result in any fundamental changes to the module timetable but did allow refinements to various activities to improve the experience (for instance, rather than gathering in the carpark, outside, for the start of the treasure hunt, it became possible to meet the students in a lecture theater). There were two significant changes that it was possible to make, though. The first of these related to the treasure hunt, where a mobile-phone-based app (“Action-bound”²⁴) that directed students to targets via GPS data was utilized. The second change was related to the livestreaming of the ferrocene experiment, with significant enhancements made through better use of technology. Other than these two changes, the “Introduction to University Chemistry” module ran in a very similar fashion in both years.

ASSESSING THE IMPACT OF THE MODULE

Student participation in the module was high, with 100% attendance recorded at the laboratory and safety sessions. In terms of how the students performed in the module, the average mark obtained in both years was $75 \pm 1\%$, with essentially no failures (those recorded as fails actually had transferred course or discontinued their studies). Feedback was immediately sought from the student body to try and begin to understand how well the aims of our new module had been achieved. Thus, within one month of the end of the module (after the final piece of assessed work had been handed in but before their marks were known to the students) the students were asked to fill in a questionnaire hosted on Cardiff's VLE. The [full questionnaire](#) and [responses](#) are available in the [Supporting Information](#), but in summary, it sought to establish the value of each of the 15 individual components of the module by using a Likert scale rating and asking students to summarize the activity in one word. The questionnaire was initially tested and validated by the authors and four academic colleagues prior to deployment, with adaptations being made as appropriate.

Feedback was collected from the students for the module as delivered in October 2020 and 2021 and was voluntary. The level of participation in the feedback (12 out of ~135) in October 2020 and the increased level of participation in October 2021 (34 out of ~140) can only be considered to give an indication of the impact of the module (a higher response rate would be more appropriate if a statistically robust analysis were to be performed²⁵): all results must be considered preliminary.

Results for both years are plotted in [Figures 1–9](#), but with a couple of notable exceptions (discussed below), the results for the two years are broadly similar. Students were asked for a single word that best summed up their experience, and these are all included in the [Supporting Information](#) for reference, together with all other feedback data.

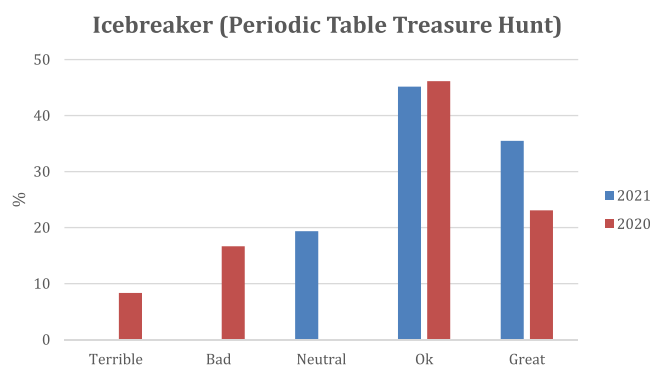


Figure 1. Feedback on the Icebreaker.

a. The Icebreaker

The Icebreaker exercise was a treasure hunt exercise named “In My Element”. In 2020, in the groups of seven students that would become their tutorial and lab groups, students were given a welcome from a member of staff outside in the carpark and then the activity brief, which was to find and photograph as many chemical element symbols as possible from the surroundings (e.g., road signs, advertising billboards, car number plates) in two hours, with points being awarded based on atomic number and bonuses related to completion of

periodic table groups and periods. In 2020 the treasure hunt was restricted to the outdoors only. Student groups were then asked to submit an online spreadsheet complete with photos of their elements. Following this exercise, the student social body, ChemSoc, ran a social event online. In 2021 it was possible to improve the exercise considerably: students could meet in larger groups (so that it was possible to brief three tutorial/lab groups at the same time and spend more time welcoming them to Cardiff), and activities could be inside. Thus, it was possible to add another aspect to the treasure hunt: students could be asked to locate information inside teaching and social buildings (for instance to find teaching laboratories and lecture rooms, indoor sports facilities), and the use of a GPS-enabled app (“Actionbound”²⁴) allowed students to be directed to very specific locations as well as to log their presence at “checkpoints”. The use of the app was coupled with the “In My Element” treasure hunt to build a more comprehensive event where students were directed across the length and breadth of the campus. Students were requested to find as many element symbols as they could and in parallel to find the answers to specific questions (set up in Actionbound, which worked flawlessly).

In both 2020 and 2021 the reception for this exercise was largely very positive (69% and 80%, respectively) and definitely worthwhile (Figure 1). The improvements made in 2021 removed the entire 25% “terrible”/“bad” tail that had been present in the first iteration. There is still some room for improvement, but as a starter event it served the purpose of introducing group members to each other and fostering a working relationship.

b. Meet Your Personal Tutor

The aim of this activity was to facilitate a short (10–15 min) in-person meeting of the new students with their personal tutors, to welcome the students individually to Cardiff, and to provide a human face for support. Such meetings had previously taken place during Semester 1 before the introduction of the “Introduction to University Chemistry” module but had not been formalized in quite the same way. Given the COVID restrictions, relatively impersonal lecture theaters had to be used as venues (to maintain social distancing) and to stick to a rigorous timetable. However, the response from the students was overwhelmingly positive in both years (77% in 2020 and 90% in 2021) (Figure 2).

c. Safety and Lab Introduction

In this session the students were taken into the main synthetic teaching lab and given a safety briefing from the safety officer. An explanation of how the laboratories are run (housekeeping,

such as where to leave coats/bags) was followed by issuing the students with personal protective equipment (PPE) (lab coats, safety glasses, face shields). After this 30 minute in-person lab introduction they were asked to do safety simulations online (approximately 30 min) provided by Learning Science²⁶ and then take an online safety quiz (20 multiple-choice questions). The quiz had to be passed and was worth one-third of the module mark. This session and follow-up quiz were well-received with no negative feedback and only around 15% neutral. A number of students had expressed anxiety about starting in the laboratories (many had had a severely curtailed experience prior to university due to COVID), and it is very reassuring to find that the sessions were appreciated so much (Figure 3).

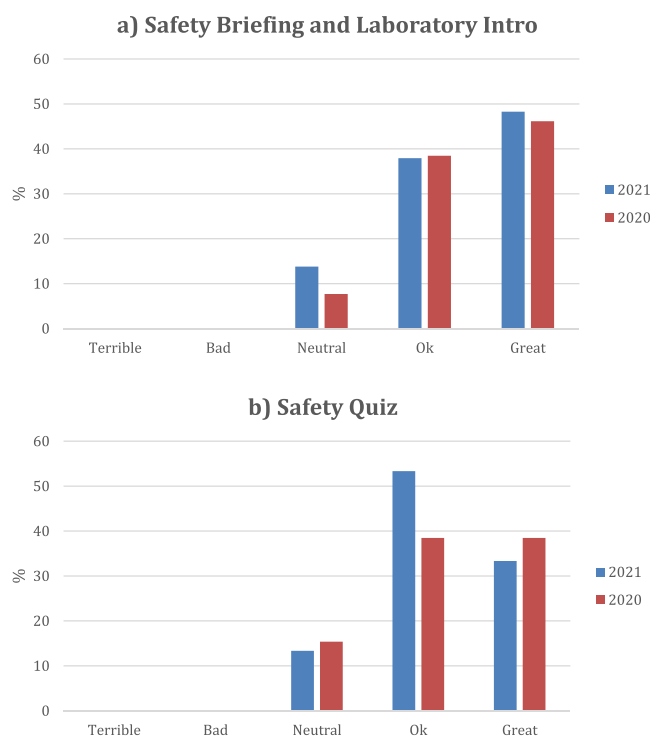


Figure 3. Feedback on (a) the safety briefing and (b) the safety quiz.

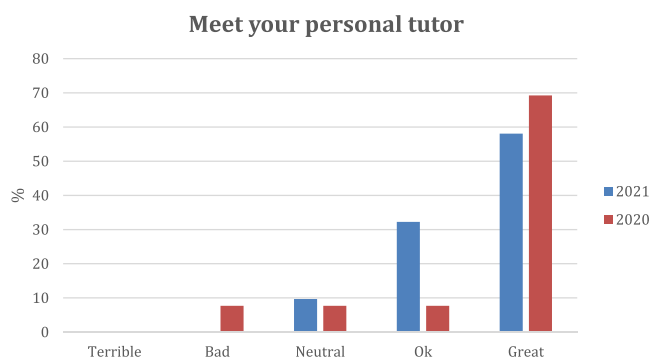


Figure 2. Feedback on the Meet Your Personal Tutor exercise.

d. Laboratory Exercises 1 and 2

The day after the safety briefing, lab work started, with two very simple expository-style experiments,²² each timetabled for two hours. The experiments were designed to allow the students to develop familiarity with the process of doing chemistry in a university teaching lab. Neither lab was assessed, and the emphasis was on working safely, handling glassware, using equipment, and recording data. Thus, the first experiment concerned making up standard solutions and recording UV/vis spectra of an iron complex of aspirin at different concentrations. A calibration graph was to be constructed, and finally, the concentration of an unknown was to be determined by interpolation. The second experiment required the use of standard synthetic apparatus to recrystallize pure aspirin from a mixture of aspirin and sodium chloride.

Both experiments were well-received (68% and 71% positive in 2020, 80% and 92% positive in 2021) even though they were very simple (Figure 4). This reinforces the finding that the simple skills are what students really need in their

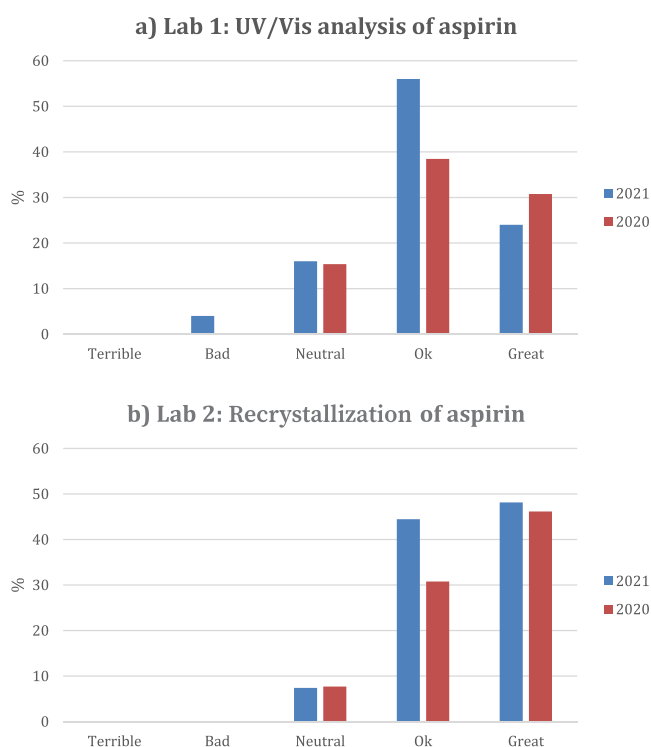


Figure 4. Feedback on the laboratory experiments: (a) Lab 1; (b) Lab 2.

transition to University-level science¹ and that the need to give the students confidence is of paramount importance.

e. Study Skills

There are many differences between the styles of learning and teaching in a secondary school and a university setting.²⁷ Cardiff students in previous years had highlighted that a number of incoming students often felt ill-prepared for university. Their concerns around the increased focus on independent learning at university had been vocalized at staff–student panels over the years, and it was hoped to address this, and other aspects, in a pair of sessions on learning skills. The sessions were delivered twice each year (one-half of the year had laboratories on a first day and study skills the next, and the other half had study skills on the first day and laboratories the next) and were 45 minutes long.

The first session focused on teaching methods: lectures, tutorials, workshops, and synchronous online and asynchronous online delivery. The emphasis here was to explain to the students what they should expect, how to prepare for any sessions, and how to get the most out of the teaching. The second session focused on information retrieval and data upload: accessing information from the library and Cardiff's VLE (Blackboard) and then uploading assignments were explained and demonstrated.

Both sessions were similarly well-received (Figure 5), with less than 5% negative feedback, and their reception is gratifying. While the content can and will be tweaked, broadly speaking the objectives of these sessions were achieved. Interestingly, there was very little difference in the reception of these sessions in 2020 and 2021, even though the sessions in 2020 were delivered online over Zoom and those in 2021 were delivered in person in a lecture theater. Following both sessions, an explanatory session on the degree structure at Cardiff (B.Sc. vs M.Chem. and how to change stream), the

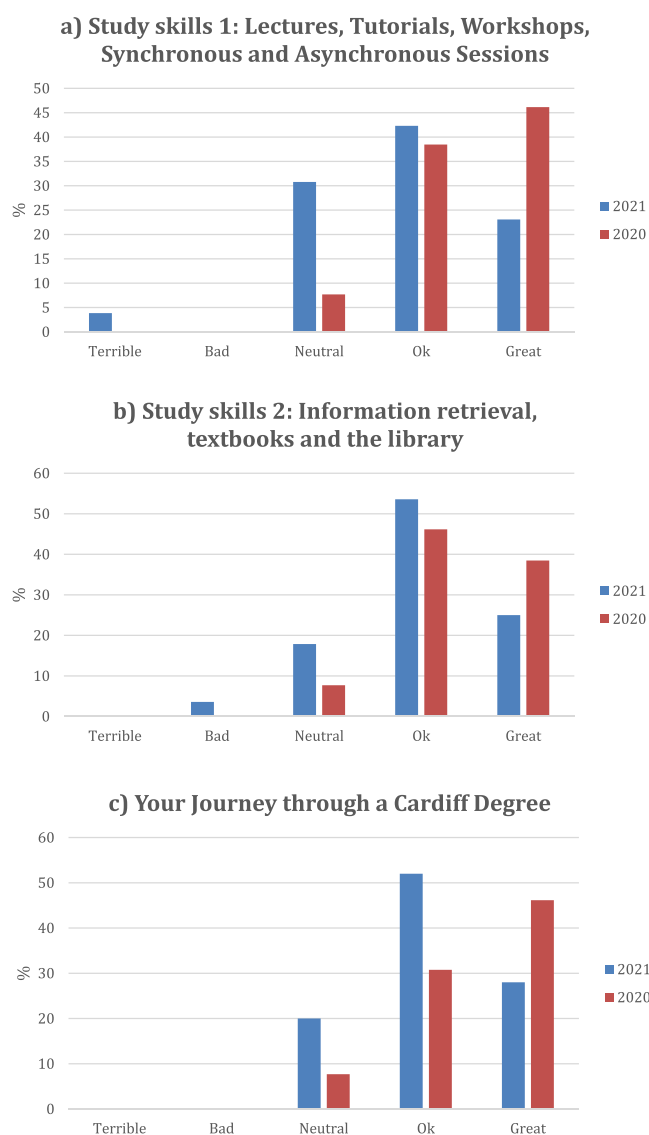


Figure 5. Feedback on the study skills sessions: (a) Study Skills 1; (b) Study Skills 2; (c) Your Journey through a Cardiff Degree.

opportunities for placements (both industrial and overseas), and optional modules, entitled “Your Journey through a Cardiff Degree” was delivered. This session was clearly much appreciated, and it is intended to enhance it with additional information about external options (e.g., the “languages for all”) available.

f. Maths Skills

The varied range of maths skills that students have when they begin a chemistry degree is a perennial problem: typically, 60% of the intake at Cardiff has an A-Level in maths (which includes differential calculus) whereas 40% of the intake has no post-16 maths qualification. Some of those with A-Level maths are extremely confident in their ability, whereas some are much more unsure. For chemistry students at Cardiff, there is a compulsory 10-credit maths module in year 1 that starts immediately after the “Introduction to University Chemistry” module, taught in-house by the Chemistry Department. Those students with A-Level maths should find it relatively simple, as the course content does not go beyond the A-Level syllabus. The content is clearly signposted, and students are encouraged to attend sessions that cover material they feel they need more

assistance with. However, in previous years, the students did not always seem aware of their limitations, so it was felt necessary to bring some maths into the new introductory module with an assessment point so that staff could advise students where to best concentrate their subsequent effort.

In the introductory module, three one-hour maths sessions were devised to cover very basic maths skills and signpost the students to where they might need to participate in the later maths module. Thus, the first session was on nomenclature and units, the second on basic algebra, and the third on chemical calculations. In both years all three sessions were delivered to the full-year group on Zoom by the same instructor and included many worked examples. Following the sessions there was an online multiple-choice test covering the material (20 marks, worth one-third of the module mark). Though the material delivered was essentially identical in 2020 and 2021, there was a significant difference in how it was received (Figure 6). In fact, there was a larger difference in

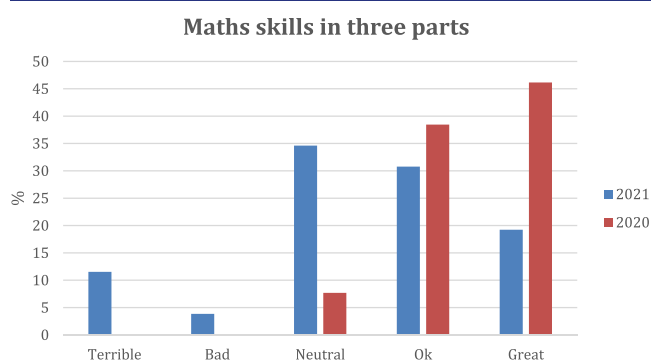


Figure 6. Feedback on the maths exercises.

how this aspect of the module was received between the two years than any other aspect of the module. In 2020 the maths material was extremely well received (84% positive), whereas in 2021 it was considerably less well received (50% positive), with comments like “repetitive” cropping up. This aspect was perplexing, and the initial thought was that the two intakes might have different proportions with and without A-Level maths. However, an analysis of intake qualifications showed this not to be significant (39% vs 42%) (Table 3), though it did point to a significant difference in the proportion of the intake with the top (A/A*) grades: 12% in 2020 but 22% in 2021. It is perhaps this difference that resulted in the differing experiences in the two years: for those students with a good level of maths competence, the introductory module maths is just too simple. However, it would appear that the majority did

Table 3. A-Level Maths Grades by Intake Year

Grade	2020		2021	
	Number	Percent	Number	Percent
A*	3	2.2	10	7.2
A	13	9.6	20	14.4
B	29	21.5	18	12.9
C	26	19.3	23	16.5
D	9	6.7	7	5.0
E	2	1.5	1	0.7
Other	1	0.7	2	1.4
Total maths	53	39.3	58	41.7
Cohort	135		139	

appreciate this aspect of the module, and it is intended to keep it in the syllabus for the time being, though the content will be looked at carefully in the future.

g. Laboratory Experiment Demonstration and Report Writing

This aspect of the module consisted of three interlinked activities. There was an initial session (45 min) via Zoom on the information that should be collected during an experiment, how to record that data, and finally how to write it up as a report.

This session was immediately followed by a livestreamed synthetic experiment, which the students were expected to watch (and participate in via the chat functionality of Zoom) and record observations and data in their own notebooks. The final part of the exercise was to write up the experimental from their observations/data and to submit a report online.

The experiment chosen to livestream was a synthetic one: the synthesis of ferrocene. This reaction was chosen for a number of reasons: the simplicity of the reagents and reaction, the visibly obvious transformation, the time scale of the experiment (<3 h), the ease of purification (sublimation), and the fact that the type of compound being made (a d-block organometallic compound) would be totally new to the students (and would hopefully provide a suitable sense of wonder in the audience).

The initial session was similarly well received in both years (62% and 68% positive), though with a large “neutral” contingent (Figure 7).

The synthetic procedure successfully gave good (>50%) yields of pure ferrocene in both years. However, student reception of the livestreaming was substantially different in the two years. In 2020, the technology was a struggle, with both the audio and visual components of the stream being poor—none of the feedback was “great”, at best it was “ok”, and nearly a quarter (23%) of respondents rated it “terrible”. In this first iteration a single mobile phone which gave poor sound and vision quality and an appalling recording was used. The poor quality of the livestream was in part caused by the need to keep all demonstrators far apart (including the person operating the camera recording equipment). In addition to this, the quality of the recording was adversely affected by the fact that the default Zoom recording option was a gallery view, with the “action” only occupying one twentieth of the screen.

In the second iteration in 2021, the livestream was set up as a Zoom webinar, which forced the recording on the main camera and made this video stream full-screen. Together with increased lab capacity allowing more flexibility of recording, it was possible to successfully use wireless Bluetooth headphones with integrated microphone and an iPad camera to properly capture the audio/visual aspects of the experiment, with one member of staff giving a running commentary. Through the chat functionality of Zoom, it was possible to respond in real time to student queries. It is gratifying to see that the feedback for 2021 is equally spread across “neutral”, “ok”, and “great” with the complete loss of the “terrible” responses (Figure 7).

The third part of this part of this exercise was an assignment to write the experiment up as a report and to submit it online, with one-third of the formal credit for the module coming from this aspect. Reports were marked and annotated extensively before being returned to the students, though it should be noted that this had not taken place when the module feedback

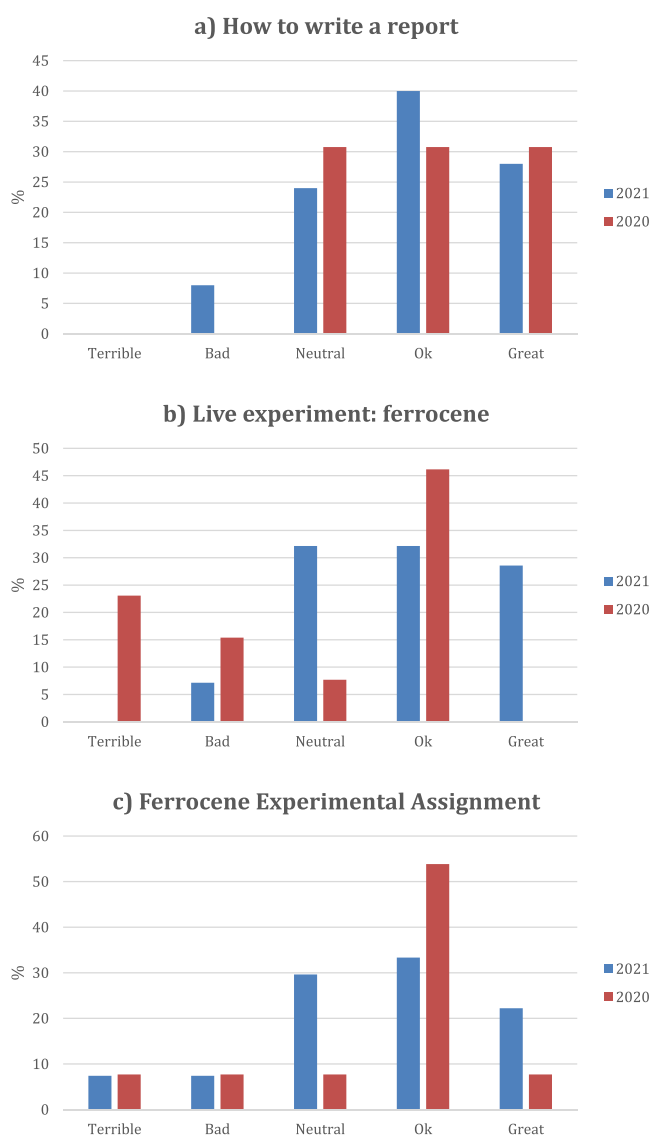


Figure 7. Feedback on the live experiment exercise: (a) How to write a report; (b) live experiment; (c) experimental assignment.

was sought. The feedback on this aspect of the exercise is on the positive side of neutral.

h. Final Challenge

The final exercise was designed to be a creative event that the students would undertake in the same tutorial/lab groups that they had been assigned at the beginning of the module and would remain in for the rest of the academic year. Thus, it was envisaged as more of a team bonding event than an academic exercise. The brief given to the students was to use the elements “collected” in the initial Icebreaker to create a presentation in less than three hours, to present it in 3 minutes in the most creative and engaging way possible to the entire cohort, and then to construct a sentence from the collected elements (see Table 4).

Given the COVID restrictions, this entire exercise, including the final presentation to the whole year, was conducted online. Zoom was used in both 2020 and 2021, with the individual groups assigned breakout rooms and the instructors dropping in and out of them to offer guidance.

Table 4. Final Challenge

Guidelines for presentation	<p>Your presentation can be on any topic that is somehow related to the elements. Be creative! For example, you might:</p> <ul style="list-style-type: none"> ○ tell an adventure story about how you collected your elements; ○ give a David Attenborough talk, e.g., “Capturing the most elusive element”; ○ animate your photos in time to a chemistry-themed song; ○ give six team members 30 s each to talk about their favorite element; etc. <p>Your presentation can be in any format your team chooses, for example, a song, a movie, a slide show, etc. You only have 3 minutes to present, so choose wisely!</p> <p>Your sentence should include as many elements as possible. You are allowed to use additional letters to complete your words if needed (e.g., <i>Breaking Bad</i>), but these will be taken into account when scoring (i.e., fewer additional letters = better score).</p> <p>All team members must be involved in this activity, but not all need to present/speak—play to your team members’ strengths.</p> <p>You have approximately 2.5 hours to create your presentation and sentence and to upload them to Learning Central. Make every second count!</p>
Judging	The ChemSoc will be judging the presentations, and their decisions are final.
Categories	<ul style="list-style-type: none"> ★ Overall winner—the most engaging presentation. ★ Funniest presentation. ★ Most imaginative and unique presentation. ★ Best sentence made using your collected elements.

The variety in the type of presentations given was incredible and included video, poetry, rap, song, and a film trailer. Though the majority of groups (12 out of 14 in 2020, 13 out of 16 in 2021) really entered into the spirit of the exercise, a minority did not (2 out of 14 in 2020, 3 out of 16 in 2021), and this is reflected in the feedback (Figure 8).

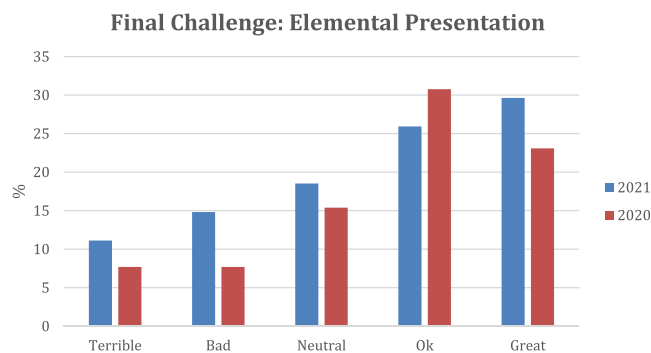


Figure 8. Feedback on the Final Challenge.

This exercise was considered very worthwhile, but perhaps the online nature was responsible for lack of engagement of some students. Serious consideration of how to adapt this exercise to a fully in-person event for 2022 is being given. The observation that there is very often a considerable degree of familiarity and friendship within the groups throughout the subsequent academic year gives a sense that this aspect of the module has clearly been a success.

i. Chemistry in the Media

This was a voluntary one-hour online session that ran only in 2021; a prerecorded lecture was available in 2020, but no students engaged with it. The point of this session was simply to provide a bit of light relief and to look at how chemists and chemistry are portrayed in the media and identify interesting chemical non-sequiturs in popular entertainment (e.g., in a

Bond film). In 2021, even though it was flagged as noncompulsory, attendance was very good (>85% of the class), and participation was satisfactory. The feedback suggests that it was worthwhile but perhaps could be enhanced (Figure 9).

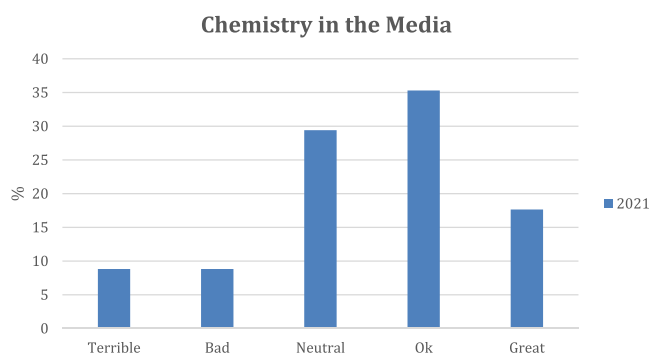


Figure 9. Feedback on the voluntary session.

SUMMARY OF THE ASSESSMENT AND SUGGESTIONS FOR IMPROVEMENTS

Clearly there are lots of positives in the feedback, with nothing really standing out as not working. Given that students were unaware of their final grade for the module at the point that assessment was sought, the good average grades received by the class cannot have positively influenced their perception of the teaching.

The categorical ordinal data were backed up with appropriate words (see the Supporting Information), and generally the feedback was gratifying given the rather trying circumstances under which the module had been delivered. It would appear that the content in the two iterations of the module that ran is appropriate and that nothing should be removed. When asked in the surveys what aspects of the module they thought worked well, the students indicated two aspects of the module that stood out. First, the students liked the laboratory sessions and felt that they set them up for their laboratory module, especially as the majority of students had had limited laboratory experience during their A-Levels, mainly due to COVID. This reinforces the view that the basic skills are what students really need in their transition to University level science and that the need to give the students confidence is of paramount importance.¹ Second, the students appreciated the opportunity to get to know their cohort and make friends before lectures started, with at least one student commenting that this eased their anxiety. Thus, the intention to address the “belonging” aspect of the student experience appears to have been successful, at least in part.

Three of the responding students (out of the total of 46 who participated in the surveys) wrote additional commentary questioning the value of the introductory module, suggesting that it be truncated to only 1 week. This only goes to emphasize the diverse backgrounds of the students: some are already confident, some less so. Thus, paradoxically, this “bad” feedback actually demonstrates the necessity of the new module. Other constructive criticisms were also supplied: a number of students commented that they wanted more stops on the treasure hunt to help them find “good study spots” and “cafes”. Another student added suggestions of topics that could

be added to the maths lectures, including mole and yield calculations.

Plans for delivery in October 2022 have yet to be finalized, but currently suggestions include sessions on the use of software (Microsoft Office, especially Excel, and ChemDraw) plus additional laboratory sessions.

CONCLUSION

As identified in the literature, there is a need to formalize and recognize the student transition to University. A new “Introduction to University Chemistry” module at the Cardiff University School of Chemistry was devised and structured with feedback from students and two external advisors. So far it has run in the first two weeks of the semester in academic years 2020/21 and 2021/22. Students were surveyed on all of the different aspects of the module, and generally the feedback was positive, showing that the module has helped the students settle into university life. There are still aspects of the module that need to be improved and more that can be added, and this module will continue to be developed over the coming years.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at <https://pubs.acs.org/doi/10.1021/acs.jchemed.2c00654>.

External advisors’ comments and student questionnaires (PDF, DOCX)

Complete sets of responses (XLSX)

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Notes

Statement of ethics: The research adhered to ethical standards and guidelines as required by Cardiff University. Consent from all participants was obtained, and all analysis was performed using nonidentifiable data.

The authors declare no competing financial interest.

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