Teaching Chemistry in Higher Education

A Festschrift in Honour of Professor Tina Overton

Edited by

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A framework to evaluate the transition to undergraduate studies in chemistry

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Every year around half a million students in the UK enter higher education. Around 95,000 enter courses in the physical sciences (HESA, 2018) and around 5,000 of these begin degree courses in the chemical sciences. Similar proportions of students make this same transition in other developed countries. The vast majority of these students will be beginning undergraduate study immediately following their secondary education. The transition between secondary and higher education is a challenging time for students (Smith, 2013). Poorly managed transition can have serious consequences for students potentially leading to underachievement or even non-continuation.

In this chapter, I outline the major differences between chemistry education at a secondary level and in higher education in a framework that can be used by educators in chemistry in both sectors to evaluate how they can smooth this crucial transition using practical steps. Although this chapter is deeply rooted in my experience in chemistry education in England, it has widespread utility beyond the discipline and in education systems in other countries. The differences outlined are applicable to many courses in higher education and particularly to those with an element of laboratory or clinical work. This contribution is developed from my experience as a secondary school teacher for more than 12 years and more recent work as a school teacher fellow, a role where I teach chemistry in both a secondary school and a university.

Influence of Professor Tina Overton
I would not be a chemistry education researcher were it not for Tina’s encouragement when I started out in 2011. Entering the chemistry education community from a school teaching background was initially intimidating. Kind words of encouragement from Tina in person, through social media, and by email gave me the confidence to persevere. The examples she set as someone fighting for parity of esteem against the traditional research landscape have provided me with inspiration.

Introduction

Educational transition points
Transition points between educational phases are challenging for students. There are usually three main transition points in a student’s educational career. The start of primary school marks the transition between informal education in a home or nursery setting and formal, compulsory education. Most students will then make another transition from the smaller primary school setting to larger secondary school settings at some point in their pre-teen years. The final transition occurs when the student leaves compulsory education, either to pursue higher or further education, or enter employment. Each transition point has its own unique challenges and there is evidence that each transition point has a temporary effect on student progress as they adjust to their new educational environment (Galton et al., 1999).

Transition to higher education
Transition between secondary school and higher education is one of the least regulated transition points. At the earlier transition phases, there is some communication between nurseries and schools, and between primary schools and secondary schools. This may be face to face transition meetings or written reports and, in many school systems, student progress is monitored from school entry to school leaving age. A national curriculum may be in place that regulates the content delivered in each phase. In contrast, students leave their secondary education and enter higher education as independent adults. The information that comes with them may be limited to only their exam scores and personal information. In the UK, statistics are gathered each year by the Higher Education Statistics Agency and, of particular interest to the transition process, are those titled non-continuation following year of entry. Across higher education, this drop out rate for students in their first year of study has remained stubbornly static. The percentage of the 2016/17 student cohort in the UK not continuing in higher education following their first year varies widely across institutions; from < 1% to nearly 20% and these statistics are similar in other developed countries. For most students who drop out, leaving has little to do with the inability to meet formal academic requirements (Tinto, 1993). Outside of the non-continuation statistics, it is highly likely that even those students who appear to have made a successful transition and continued in their higher education course will have encountered some difficulties in the transition process.

The field of student transition is under-conceptualised and research in the area is mainly small scale (Briggs et al., 2012). Research tends to be focused on broad themes, neglecting the specific contexts that may cause transition in particular individual subject areas to be especially challenging. The development of a framework to scaffold discussion and intervention around transition to higher education in physical sciences may help alleviate some of the barriers to successful transition for students. Additionally, use of this framework will allow teachers and managers on both sides to ensure good coverage of the issues to be addressed in this important and diverse area.

Design

Secondary and higher education settings for framework development
I have been a secondary school teacher since 2006 working in both community comprehensive schools and a selective fee-paying boys’ school. I have taught students in their pre-university years throughout my career. Since 2015 I have split my teaching week between a fee-paying boys’ school and the School of Chemistry at the University of Manchester where I work primarily with students in the Foundation Year and Years 1 and 2. The University of Manchester is a traditional university with a long tradition in the chemical sciences. Three and four year programmes are offered leading to BSc and MChem degrees in...
chemistry and medicinal chemistry and can be taken with an industrial placement, international study or an integrated foundation year. The typical Year 1 cohort is about 240 students with a mixed cohort of international and home students who mostly enter directly from secondary school.

Personal observations from a dual perspective of working in both higher and secondary education supplemented by a review of the relevant literature informed the identification of framework themes and of measures that can be implemented to smooth transition. Under this framework, transition between secondary and higher education can be considered to fall into four broad themes:

- background factors
- curriculum and assessment
- class and cohort connectedness
- factors related to teaching, learning and feedback

Each of these broad themes can be further broken down as shown in Figure 1.

![Figure 1: A framework for consideration of the transition to undergraduate study in chemical sciences](image)

**Background factors**
Each individual student entering higher education has a set of definable characteristics which may influence how easily they make the transition to higher education. Some may be easily recordable or measurable such as age, ethnicity, gender, and prior achievement profile. Others, such as family circumstances and caring responsibilities may be less defined or not disclosed by students.

Higher education represents a significant personal financial investment for students, especially in systems where tuition fees are payable. In contrast, most students don’t have to pay for their secondary level
education. For those students who have attended fee paying schools, the cost of this is generally met by parental finances, or by bursaries and scholarships. There is no financial implication for the student themselves if they fail or need to repeat a part of their education. Higher education usually requires financial investment by the student directly in the form of tuition fees (where these exist), accommodation and other associated living costs, and books or resources needed for study. Should the student fail, then this financial investment may be lost and a financial penalty is incurred if a student has to repeat a part of their education for any reason. This creates a psychological burden on students (Minsky, 2016).

Most secondary students will live at home with family support for day to day living, such as washing, preparation of meals, and shopping for food. In higher education, students’ living circumstances will vary significantly within a cohort, with some living independently for the first time and increasing numbers choosing to commute from home (Caulton, 2018). Both circumstances present challenges for instructors and students. Newly independent students may have challenges organising their academic commitments alongside the demands of running their own household affairs. Commuting students may find the structures of academic life don’t take account of their commutes by public transport or become isolated as they have additional barriers to integration with students living on campus (Jacoby, 2000; Thomas and Jones, 2017).

Engagement in part-time employment is very varied for students in both stages of education. Some students will work around their secondary school studies, limiting this employment to evenings, weekends and holidays. Many schools and colleges actively discourage part-time employment stating concerns over its impact on attainment. However, employment alongside higher education can be extremely beneficial for future employability and professionalism and go some way to decreasing financial pressures for students. For both groups of students, part-time employment may have a significant impact on their ability to engage with their full-time studies.

**Curriculum and assessment**

The structures surrounding study in secondary and higher education are very different. In the school environment, students will study relatively few subjects. For English students, it is typical to study 3–4 subjects at advanced level (A Level) but there are significant variations across Europe with 5–7 subjects being common. These subjects will be taught by one or two teachers to a regular timetable with the same pattern each week or fortnight. Attendance at school is formally monitored and intervention carried out if it slips below a level that supports progress. This intervention may take a number of forms, eventually resulting in contact with parents/guardians. Classes in schools take place in a small number of rooms on (mostly) one site, reducing the organisational burden on students.

The submission of assignments (homework) generally occurs regularly and informally with students handing in their work directly to their teachers, often during a class. Failure to submit assignments by the deadline incurs no significant penalty unless the assignment forms a component of the final grade. In the UK these assignments are called coursework and are typically marked by the teacher and the marks moderated by the exam board. Coursework has increasingly fallen out of favour in recent years in England due to concerns regarding the validity and reliability of teacher assessment (Johnson, 2013) and the impact of easy sharing of assessment items and responses via the internet leading to concerns regarding plagiarism (Stewart, 2013). It is likely that the students will be given second chances to submit assignments, including deadlines being set deliberately early in order to allow time to intervene before final deadlines are reached.

In higher education, at the degree title level, students may be studying a single subject. However, even
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For students studying the single subject of chemistry, the way the course is split into modular structures may make it appear to be a combination of numerous disciplines, some of which may seem disparate. For example, a module in quantum mechanics will be a very different experience to one in organic chemistry, or one in practical chemistry. Added to this, within many undergraduate programmes, a number of course credits are taken in option courses. Option courses are not considered core to the programme and choices may be very closely related to core chemistry — for example biochemistry; or may extend outside of traditional course boundaries, such as a course in a foreign language. It is likely there will be many instructors per module with contributions to teaching made by lecturers, tutors, graduate teaching assistants (demonstrators), and peer tutors. Formal monitoring of attendance may only be in place for a small proportion of the timetabled classes, most commonly laboratory classes and tutorials. There may be some intervention strategies in place for low attendance, but they are likely to only be triggered after many weeks which may mean a significant impact on student achievement will have already occurred.

Undergraduate teaching takes place in several different rooms on different sites across campus, and these may change several times during the timetable for a module. Assignments are handed in through formal structures and rarely handed directly to the instructor. This submission may be electronically through a virtual learning environment or physically to a teaching office, or perhaps even to a postbox at the office rather than submission to a member of staff. Failure to submit assignments by the deadline is likely to incur a significant penalty which ranges from deduction of marks to refusal to mark and a fail or zero grade. Second chances are rarer in higher education.

**Syllabus, support resources, and assessment**

In secondary education the syllabus is fixed, usually by an external body such as an exam board with influence from national government and various stakeholders such as representatives from higher education and employers. These are publicly available and accessible to a range of audiences from the learners themselves to their teachers and parents, the general public and employers. This is in complete contrast to the situation in higher education where flexible syllabuses are designed within the institution. Whilst there may be some degree of regulation of content, often linked to degree accreditation by a learned society or professional body such as the Royal Society of Chemistry, syllabuses will vary from institution to institution. A syllabus document with learning objectives and outcomes is usually publicly available, perhaps on the institution’s website or internal systems but they may seem opaque to novice readers.

Secondary students are spoilt for choice with support resources. National syllabuses are well resourced with both commercially published resources such as revision guides and also web-based content from educators in the field on sites such as YouTube. In higher education there are fewer resources available and resources such as textbooks are likely to be written for a general audience and not tailored for the syllabus. Web based resources may be difficult to find at the correct level.

Assessment in sciences in secondary education is primarily through terminal examinations. The English GCSE and A Level examinations are each planned to assess two years of work. Assessment models in higher education are incredibly varied including aspects of in course assessment, laboratory assessments, and examinations. Many past papers are available to secondary students and these are widely used for examination preparation. These past papers are published alongside their mark schemes. Relatively few past papers are available to undergraduates and, when they are available, mark schemes may not be provided, or indeed may not exist in any formal way (Turner, 2012).

Large differences are evident in the design of assessments. Public examinations taken at the end of
secondary education are highly regulated with rules dictating many aspects of assessment design from the overall length of examinations to the proportions of different assessment objectives such as recall, application, and analysis in the papers. Examination papers in sciences are designed with accessibility factors in mind including accessible font, plenty of white space to improve readability, no repetition within questions, and standard question types and layouts. Command-led questions form the greatest proportion of question types with those command words clearly defined for candidates in syllabus information. There are agreed command words for particular question types. For example the standard command for drawing a curly arrow mechanism for A Level students chemistry is outcome. Secondary school examination papers in England are designed with the question section followed immediately by the space for the answer, giving candidates vital clues about the expected length of the answer and its format — for example, a written answer or a drawing. Answer line prompts may be present to further guide the candidate. The examination rubric is simple as all questions in an examination are to be answered, meaning there is no question choice. The difficulty of the questions in a paper is considered and an overall ramping effect is generally seen with earlier questions designed to be easier to build the candidates’ confidence. Mark schemes are standardised and revisited following the examination taking account of candidates’ responses. Once complete, the examinations are marked by specially trained examiners who are regularly monitored to check their accuracy in applying the mark scheme. Increasingly this marking is done on screen, reducing errors in addition of marks.

As previously discussed, while assessments that bear credit in higher education are varied, examinations remain a significant feature of the assessment landscape at this level, particularly for large first year cohorts. Examination papers set in higher education are subject to quite different regulation to those in schools. At an institution level, assessment is heavily regulated. However this regulation is at a surface level and doesn’t delve deeply into the details of the papers. Papers are set by academics themselves with various checking procedures in place. These checking procedures vary through a hierarchy from informal systems such as colleagues checking a paper through to internal committees and eventually, external examiners. External examiners are experienced higher education teachers who offer an independent assessment of academic standards and the quality of assessment to the appointing institution (HEA, 2015).

The typical examination format for undergraduate assessment is a booklet of questions with instructions to answer the questions in one or more separate answer books. The front of the examination paper usually shows the rubric for answers. This may be complex, with compulsory and optional questions with associated instructions. As a result, each year a minority of candidates are likely to fail to follow the rubric, answering too many or too few questions or in the wrong number of answer booklets. The design of examination papers may not take into account other accessibility factors as the font is likely to be chosen by the institution or just be the one historically used rather than chosen specifically for readability. Sans serif type face such as Verdana, Calibri, or Arial are considered the most accessible, and 11pt Arial font is used by the major English exam board AQA. Ramping of difficulty may be apparent within questions with earlier parts of questions being set for confidence building. It may not be apparent across the whole paper. Questions may be direct, or command-led (Figure 2) with little standardisation of command words.

**Cohort and class connectedness**
Fostering a positive climate and sense of community for students in educational settings has been linked with retention and academic success (Dwyer et al., 2004). There are many factors that influence how connected students feel to their cohort and class including group dynamics, peer-student relationships and student-instructor relationships and pastoral support.
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Group dynamics
A class of students is a temporary group of individuals which “consists of friendships, peer interactions, relationships, tensions, and overall dynamics that can be positive, negative or even neutral” (Mamas, 2018). These groupings may stay together for significant periods of time, perhaps whole school years; or for much shorter time periods including one off groupings for a specific learning session. Tuckman (1965) observed that groups go through five stages of development: forming, storming, norming, performing, and adjourning. These stages may be cyclical and there is no recognised usual time for each stage. Some groups may be stuck in one stage for a significant period of time.

In schools, teaching groups are relatively static in terms of numbers and make up (Turner, 2017). Students are likely to sit in the same place in the classroom with the same peers in each teaching session. Classes are usually small enough for students to quickly gain an understanding of the others in the group and their own role and contribution to the group. Typically, a secondary school advanced chemistry class contains between 10 and 35 students. Some school teaching groups also have historical connectedness when a group of students go through their whole secondary school together. All these factors mean students may feel a sense of community at school relatively quickly.

In undergraduate teaching, groups vary significantly both in size and construction. Small group teaching may mean as few as two students with a tutor such as in supervisions at Oxford and Cambridge colleges although groups of 4–8 are more common. For example, at the University of Manchester, a typical first year student in chemistry will have tutorials with six students, workshops with 20-40 students, peer assisted study sessions with 15 students, whole cohort lectures with >200 students and optional unit lectures taken in other departments with >400 students. That is a lot of different groups for a student who has been used to just one to adjust to. Additionally, group dynamics may also impact upon assessment as universities increasingly use group projects and assessments in their programmes (Gibbs and Laga, 2009).

Instructor-student relationships and pastoral support
The relationship between instructors and students is a key component of student success in education and can be crucial in developing students’ academic self-concept and enhancing their achievement (Konaraju et al., 2010).

In secondary education, teachers tend to develop significant relationships with students during the teaching period. This is a consequence of regular, frequent contact with relatively small classes over a significant period, sometimes up to five years. In contrast, in higher education the strength of relationships formed with students can be highly variable. Some instructors such as personal guidance tutors may

DIRECT: What is the meaning of the term Hamiltonian operator?
COMMAND LED: Define the term Hamiltonian operator

DIRECT: How many possible isomers are there of C₅H₁₂?
COMMAND LED: State the number of possible isomers of C₅H₁₂.

DIRECT: Why does E/Z isomerism occur in but-2-ene?
COMMAND LED: Explain the origin of E/Z isomerism in but-2-ene.

Figure 2: illustration of direct and command led questions
develop significant relationships with students. However, it is likely that others will not know the names or faces of their students due to large cohorts in groups in lectures, and the nature and duration of teaching at this level. Academics leading teaching activities may have little understanding of students’ prior learning experiences and curriculum (Turner, 2013).

A key feature of secondary education is the pastoral care and guidance that forms part of the organisation of schools. There is frequent contact (daily, several times a week) with a pastoral tutor. At its highest frequency, a tutor may see students several times a day for registration periods meaning they are able to form strong relationships and informally monitor students. Tutors in schools have regular training in areas like child protection, protecting students from radicalisation (Home Office, 2015) and adolescent mental health. Pastoral tutors are also likely to be available for a significant proportion of the teaching week as they are employed full or part-time and teach on the same site as students.

In higher education, there is significant variation in pastoral care. Pastoral care may be carried out by a number of staff in the institution including student support professionals, peer mentors, and academic staff. It is good practice for every student to have a personal tutor — a member of academic staff who takes an overview of a small group of students’ progress and experience. Contact with a pastoral or personal tutor is likely to be infrequent, perhaps as little as once a semester. Additionally, pastoral tutors may have little or no training for this aspect of their wider academic role, with their efficacy often depending on their own innate interpersonal skills and desire to do the job well. It is likely that pastoral tutors will be only intermittently available due to teaching, meeting, and conference commitments. Some pastoral work will be high quality and higher education institutes have a wide range of support services available however the lack of a strong relationship with a tutor may mean a student may not feel comfortable in making a disclosure to a staff member and thus accessing support services.

Factors related to teaching, learning and feedback

Teaching in higher education has the potential to be more varied than that in schools. Across any given year at the University of Manchester, chemistry students will encounter lectures, workshops, tutorials, facilitated group work, flipped teaching, laboratory instruction, and peer facilitated study. Despite this available variety, the main mode of delivering chemistry content is through large group lectures with direct instruction. Whatever the type of class scheduled, the mode of delivery is likely to be the same for the whole session as there is little variety within sessions. Learning in higher education is increasingly supported by virtual learning environments, providing everything from a repository for educational resources and flipped content to discussion forums and group learning spaces.

In schools, teaching the smaller class size means that the mode of delivery can be very varied although individual teachers may have fixed styles which limit the experience of their students. In a secondary school class, lessons may include aspects of direct instruction, active learning and enquiry. A key feature of this stage of education is regular homework exercises. These are set to engage students in regular practice of key concepts and provide formative assessment of students’ understanding of concepts covered in class. Past paper questions feature heavily in the homework exercises set by teachers at this level (Husband, 2016; Ofsted, 2011). Homework is set regularly, completed and handed in to teachers who then mark it and deliver feedback. The feedback given on the work is personal, delivered in context of a personal relationship between teacher and student. It may also be given alongside a grade or score or comment only based marking may be used. Secondary students may be encouraged to engage with feedback, redoing pieces of work or taking retests until a particular score is achieved. Secondary students receive a large volume of feedback, even within individual lessons and this feedback is multimodal; verbal, audio, and written feedback may all feature.
In higher education, there may not be any regular homework type exercises which provide formative assessment opportunities. Most exercises form part of a coursework element of a module and therefore feedback received is often accompanied by a grade. Formative pieces, such as tutorial exercises may or may not be marked or returned to students. Where feedback is given it is usually written and as such, engagement with any feedback given may be limited.

One of the most striking differences between chemistry courses in secondary and higher education is in the environment for practical work. School students will carry out practical work relatively infrequently depending on a number of factors associated with their school or college and their teachers. Practical work could be as infrequent as 12 tasks across a two year programme of study or more regularly, perhaps once a fortnight (Cadwalader, 2018). Experiments are carried out in the same school laboratories that are used for regular theory teaching. This practical work is often done in pairs to reduce the costs associated with consumables and waste disposal. In higher education, practical work is carried out in a specialist laboratory designed specifically for that purpose and is frequent — usually at least weekly — and often carried out individually.

For secondary students, some of the equipment used in practical work will be unfamiliar but most will have been used in their prior education. This equipment is likely to be specifically provided by teachers or technicians for each practical session. New undergraduates encounter far more new equipment and instrumentation more regularly in their laboratory work. The equipment used is likely to be part of a larger stock of equipment in the laboratory and students have the additional responsibility of finding the appropriate equipment prior to starting work.

Approaches to health and safety are very different. In schools, responsibility for health and safety in practical work lies with the teacher and the institution’s management. The student carries little or no personal liability. Risk assessments for each practical session are done by teaching and technical staff and not routinely shared with students beyond highlighting the main risks. Where risk assessments are done by students, this is usually to fulfil an academic requirement rather than to genuinely assess the risks of a procedure. This contrasts with laboratory work in higher education where responsibility for the health and safety in practical work lies with the student following training from an instructor and with support from technicians. Students routinely carry out risk assessments relating to the experiments they are carrying out, initially with support but later independently, and this is often a requirement of beginning work on each experiment in the laboratory. At the end of a laboratory session, students are expected to decontaminate and clean their own equipment, returning it to the appropriate place. In schools, decontamination and washing of equipment is carried out by teaching staff or technicians.

A Framework to Evaluate Transition

The themes identified highlight the differences between secondary and higher education and these were used to formulate a framework (Table 1). The framework is presented in a format showing the steps that can be taken by educators in both sectors to ease the transition. It is intended that this can be used in both schools and HEIs to promote discussion to evaluate what measures are in place and what areas may need some attention. Of course every detail within the broad themes identified will not be applicable to all of the students entering our undergraduate chemistry courses. Within any large cohort there will be a large variation in prior experience. As mentioned earlier, this framework is based on my experience as a chemistry educator in England. Although some practices may be specific to this system, many of these differences should be quite minor and the framework should be applicable in other countries.
<table>
<thead>
<tr>
<th>School actions</th>
<th>Transition themes</th>
<th>Higher Education Institution actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop an enrichment/pastoral curriculum that includes sessions on independent living, study-life balance, and financial education.</td>
<td><strong>Background factors</strong></td>
<td>Identify variety in cohorts of students (for example, students with family responsibilities, with part-time jobs) and track to check progression is in line with the overall cohort. Projects such as Jisc (2019) learning analytics provide tools to facilitate this and many universities have their own systems.</td>
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**Curriculum and assessment**

| Consider some aspects of centralised assignment submission. Evaluate institutional attitude towards deadlines and second chances and the consequences for learning behaviour. | **Curriculum structures** | Sample a number of student timetables to evaluate the impact of timetabling of internal and external modules on workload and organisation requirements. |
| Encourage students to interact with the published syllabus, with activities such as using learning objectives to predict the kinds of questions that can be asked on a particular concept. | **Syllabus** | Evaluate the transparency of learning outcomes for each module including clarity of language used to communicate them. Consider working with students to develop syllabus materials. This could be through formal students-as-partners (for example University of Reading, 2019) or team projects, or informally through staff-student committees. |
| Signposting to a support resource that aligns with those used in higher education, for example, a general chemistry textbook. Encourage students to use more than one source when working on a topic. | **Support resources** | Provide support in the use of general texts, such as guided reading lists. Evaluate multimedia resources by external providers that may enhance independent learning of topic areas. A collection of resources is collated by the Royal Society of Chemistry (RSC Learn Chemistry). |
| Plan assignments to expose students to a range of questions and paper styles including those where answers are written on paper separate to the questions. | **Assessment** | Evaluate the balance of formative (non-credit-bearing) and summative assessment across programmes. Consider the use of exemplar materials to increase assessment literacy. |

**Teaching, learning and feedback**

| Consider how timetabling could be used creatively to provide opportunities for students to experience different teaching styles, such as large group lectures and 1:1 sessions, alongside their regular class style. | **Teaching styles** | Allow time initially for students to get it wrong and learn from their mistakes. Introduce students to the organisation of sessions shown in an online timetable and encourage staff to use online calendar tools to schedule sessions with students. Encourage participation in large group teaching sessions, such as through the use of electronic voting systems (Gibbons and Laga, 2017; Lancaster and Arico, 2018; Wijtmans et al., 2014). Consider incorporating starter activities at the start of lectures to make good use of the available time when students are arriving into the teaching session (Smith, 2013). |
Table 1 (continued): Framework devised to evaluate transition to undergraduate study for students in chemical sciences

<table>
<thead>
<tr>
<th>School actions</th>
<th>Transition themes</th>
<th>Higher Education Institution actions</th>
</tr>
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<tbody>
<tr>
<td>Provide opportunities for students to receive whole group feedback and construct their own next steps.</td>
<td>Feedback</td>
<td>Signpost feedback opportunities for students and evaluate the clarity of the feedback for language used and applicability for novice chemists.</td>
</tr>
<tr>
<td>Evaluate the practical work done with pre-university students for both frequency and purpose. Consider a cycle of skill acquisition followed by application of the skill to a problem-based task.</td>
<td>Laboratory work</td>
<td>Evaluate introductory practical chemistry courses for purpose. Consider the balance of skill acquisition, problem solving, and alignment with taught chemistry courses. Consider a cycle of skill acquisition followed by application of the skill to a problem-based task or a competency-based curriculum in the initial years (Goedhart, 2015).</td>
</tr>
<tr>
<td>Provide opportunities for students to mix academically with students outside their class grouping for example by merging classes for some activities in school or providing opportunities for whole cohorts to visit universities or workplaces.</td>
<td>Group dynamics</td>
<td>Consider how groupings can be organised to find a balance between supportive peer groups and challenging students to move beyond their comfort zone. Monitor and evaluate the composition of groups in order to provide some stability of individuals for some classes.</td>
</tr>
<tr>
<td>Provide opportunities for students to interact with peers outside of their immediate friendship group. Consider implementing seating plans or planned groupings of students.</td>
<td>Student-peer interactions</td>
<td>Consider crossover of some groupings including those in laboratory groups and tutorial groups to allow groups to gain stability. Provide opportunities for students to interact outside of formal academic sessions, such as by facilitating social interactions such as cohort meals and trips and supporting student societies.</td>
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<tr>
<td>Invite guest speakers to present lectures or classes on particular concepts. These could be other teachers from the school or college or external speakers, such as from universities or learned societies.</td>
<td>Student-instructor interactions</td>
<td>Identify opportunities for instructors to develop their skills in communicating with novice learners. This could include both online and face-to-face training sessions, or visits to schools (Turner, 2014). Consider allocating the most student-focused members of staff to Year 1 courses (Westlake, 2008).</td>
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<tr>
<td>Encourage students to research student support mechanisms in their general research prior to choosing HEIs for their applications.</td>
<td>Pastoral support</td>
<td>Develop opportunities for personal tutors to share expertise and experience. Signpost training opportunities for academic advisors. Implement peer assisted study schemes and where schemes already exist, evaluate their effectiveness.</td>
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Implications and Adaptable

The framework proposed is based on my experience of teaching chemistry in both secondary and higher education over several years and an overview of the chemistry education landscape. This experience spans different types of schools and a large university setting which draws its intake from a range of school and college settings. The framework should therefore be readily adaptable to other schools and higher education institutions.

Your context
The prompts below outline key aspects to be considered by those exploring the use of this framework to evaluate what they are already doing to address the school to university transition and what else they might implement.

For educators in schools
- What role do you think schools and colleges play in the transition to higher education?
- How can you make small and sustainable changes that will smooth the transition between secondary school and higher education for students who leave your school to pursue higher education in the sciences?

For educators in universities
- What do you know about the composition of your own typical student cohort and their educational background at secondary level?
- What measures are already in place to ease transition to undergraduate study?
- How can you make small and sustainable changes that will smooth the transition between secondary school and higher education for your typical cohort and for identifiable groups (such as those students with caring responsibilities, those with non-standard entry qualifications) within the wider cohort?

Conclusions

Transition between school and university in chemical sciences is a complex issue and one where there is no quick fix. The proposed framework provides guidance for both schools and higher education institutions to evaluate their contribution to the transition between school and undergraduate study in chemical sciences and other subject areas with common features such as experimental or clinical work. It is intended to provide a stimulus for discussion with educators at all levels together with examples of practical actions that could be implemented.

This work is being followed up with various studies trialling and evaluating activities that schools can implement to ease transition to undergraduate study as well as pedagogical studies around the mastery of key skills in chemistry, most notably the balancing of chemical equations.

References


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