COMMUNITY DIRECTIONS

The Flipped Lecture

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Abstract

The drive to flip teaching is a reaction to the limitations of the traditional lecture, which may be efficient at addressing many students but is ineffective at engaging and teaching those students. The term 'flipped lecture' describes the process of requiring students to prepare for a timetabled contact hour through directed but independent study in advance. Consequently the academic is freed from the constraints of having to work through the content and can use a variety of technology-facilitated strategies to maximise engagement, probe understanding and ensure students are able to apply the knowledge effectively.

Introduction

The teaching (and learning) of a discipline as broad and deep as chemistry presents considerable challenges. Despite the nominal autonomy granted by the right to examine their own degrees, the syllabus of those degrees is largely conserved between UK chemistry departments. A UK chemistry degree should adhere to the Quality Assurance Agency (QAA) benchmark statement, while the Royal Society of Chemistry (RSC) is the professional body and publishes criteria against which a degree programme will be assessed before accreditation. Both bodies acknowledge that there are key chemical concepts which a graduate should understand but provide rather little prescription as to what constitutes essential knowledge. In contrast, emphasis is given to the skills that graduates will need in employment, including the ability to work independently and to solve problems.

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Chemistry has a long and distinguished history as a university subject and over time the syllabus has accumulated a very considerable amount of 'content', as it is shown in Appendix D of the Oxford Chemistry undergraduate handbook (Oxford University 2012). The majority of this taught material is still delivered in traditional didactic lectures, even if Bligh outlined the issue in 2000 and examined how lectures might be made more effective learning experiences. Anecdotally, most chemistry lecturers can recount occasions when they suspected that their lecture did not have the desired or expected learning outcome.

The limitations of lectures as teaching and learning events are less surprising given recent evidence showing that brain activity whilst attending lectures is comparable to that registered when watching television (Poh *et al.* 2010). Furthermore, students are remarkably poor judges of how effectively they have learned during a lecture. Their impression appears to be based largely on the 'performance' of the lecturer. It is salutary to reflect how much importance is attached to the results of student evaluations when these are essentially assessments of style over substance (Carpenter *et al.* 2013); at the extreme end of the lecturer-as-performer spectrum is the phenomenon of pseudoteaching (Noschese 2011).

We may, then, conclude that the lecture has serious shortcomings, not least in delivering student engagement. The consensus is that dynamic, interactive learning in which students are presented with opportunities to solve problems is more effective than students functioning as receivers of didactic transmission. Interacting might be with the 'lecturer' or between peers. The most popular current approach is to provide lecture support wherever possible by workshop and tutorial sessions, where the student is challenged to synthesise and apply their knowledge. However, our institutions rarely have the resources to increase contact time to the point where each lecture has a complementary session.

The difficulty is that the type of teaching we would like to do takes time; time required to work through the monolithic body of content. It would appear unrealistic to contemplate any chemistry department approximately halving the material delivered on its degree programmes to make way for the desired interactivity. So just how do we make better use of the existing timetable, move from lectures towards something more tutorial-like and ensure students' own self-directed study time becomes more purposeful? The answer, in its various guises, is flipped teaching.

Flipped teaching

The term 'flipped classroom' is normally attributed to Bergman & Sams (2012). The flipped classroom/lecture theatre is a philosophy that places the student and not the lecturer at the centre of the learning process. There is no one way to flip teaching, however. The common thread is that students are required to prepare in advance to facilitate informed use of the contact session. As such the approach has much in common with seminars in the humanities even if it has only recently found traction in the physical sciences. There are a now a number of high-profile pockets of flipped teaching within UK physical sciences but the way in which students are invited to prepare varies considerably.

Facilitating flipping with screencasting

At the University of East Anglia (UEA) we were granted HEA funding to examine the impact of providing our first year lectures as a screencast archive to our students (Read & Lancaster 2012). Following this seed funding many staff proceeded to provide all their lectures in screencast format across the four years of the MChem degree. Our approach was to record live undergraduate lectures using the Camtasia™ software on laptop PCs and broadcast quality microphones. The alternative is especially to record screencasts in an office or studio environment Access to the screencasts was provided through our virtual learning environment (VLE).

Screencast provision proved extremely popular with our students, who could decide whether and when to view them. Typically they were of greatest initial value to students for whom English was not their first language. Most accesses occurred during the period immediately before the examinations, implying that they were finding application in revision. The problem with screencasts is that while they may replicate the didactic element of a lecture, they lack interactivity. In part we have addressed this pedagogical deficiency through the Chemistry Vignettes project, in which the Camtasia™ tools have been employed to introduce interactivity.

When we became aware of the growing interest in flipped teaching in the USA, we recognised that our screencast archive were a near ideal resource to prepare students for it; indeed we realised that we could present to any sceptical students both the recorded lecture experience and the live flipped teaching. The UEA model of lecture flipping therefore encourages students to watch a lecture recording in their own time and at their own pace before attending the flipped teaching session.

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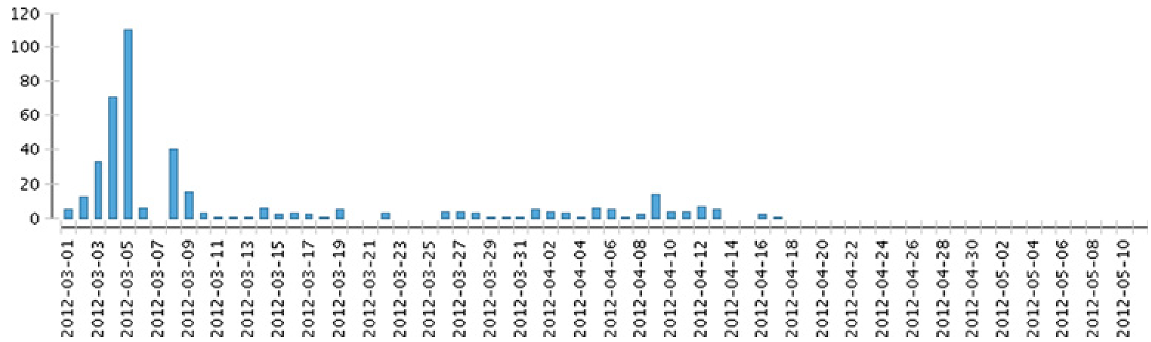

Figure 1 Blackboard™ access statistics for the screencast 'Main Group Organometallic Chemistry'.

Figure 1 illustrates a 'just-in-time' approach to preparation for the flipped session by the approximately 80 students on our second year Inorganic Chemistry module. This initial trial involved three hour-long sessions, two on the afternoon of Monday, 5 March and one on Friday, 9 March.

Executing the flip

The flipped session should be student-led wherever possible. Ideally, students send their queries to the academic in advance, allowing them to consider their interaction strategy. However, experience has taught us that students are initially not particularly forthcoming in providing direction for teaching sessions even when they have familiarised themselves with the topic in advance. As a consequence, the academic's preparation for a flipped session will typically involve the design of a series of questions or group exercises to probe the understanding and application of the concepts to be considered.

Traditionally, questions from the lecturer are effectively rhetorical for the vast majority of the class and genuine interaction is restricted to a small subset of students who raise their hands and volunteer answers. In a flipped session the objective should always be to engage all the students. And it is here that techniques such as mass polling, made possible through clickers and smartphone technologies, can be invaluable as shown in Figure 2 (Bruff 2009).

Chemistry is a very visual subject and there will be many instances where the required skill cannot be properly exercised or evaluated through a keypad or even in a short passage of text. At UEA we have had considerable success with personal whiteboards, on which students can draw their responses. If the whiteboards are then held up, only the academic can see the sketches, removing the student concern of being seen to be wrong by their peers (fig 3).

Incorporating peer instruction

Where the vast majority of students demonstrated clear understanding, the session progressed to the next question or task. But what should the academic leading a flipped session do when, as is

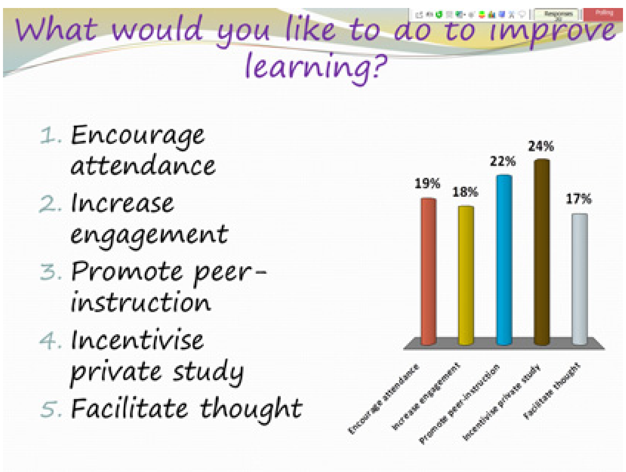

Figure 2 Example of polling using TurningPoint™.

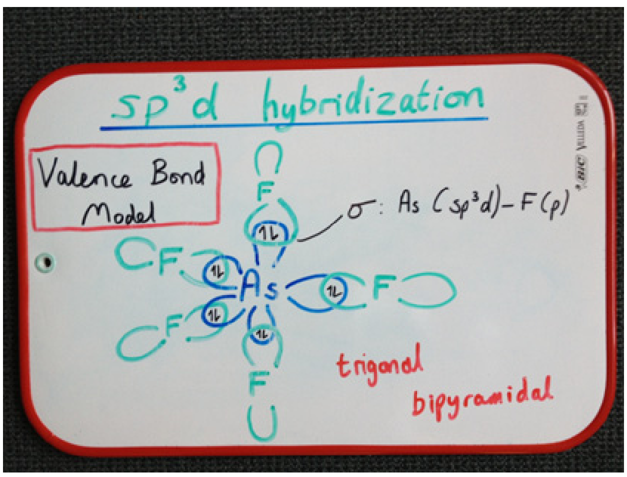

Figure 3 Diagrammatic answer on a personal whiteboard.

inevitable, the process reveals a misconception? Clearly, there is little point repeating the initial (screencast) explanation and the temptation will be to explain again using a complementary approach. Here, we and others have had noteworthy success through peer instruction. In the event that students are divided between two equally popular responses, only one of which is correct, ask the students to find someone with whom they disagree and allow them a couple of minutes to try to convince each other of the right selection. Then, without offering further explanation, simply poll again. In our experience the effect is invariably positive, sometimes dramatically so.

Evaluation of lecture flipping

Over the last decade of introducing teaching innovations to chemistry at UEA, lecture flipping has proven to be by far the best-received change to teaching practice. Not only do the students describe lecture flipping in very positive terms, but they are prepared to explain exactly how the process improves upon the conventional lecture. Table 1 presents comments from our original trial, in which three sessions were flipped. The extension of the practice to further sessions in Years 1 and 2 of the degree programme has met with equal student enthusiasm.

The gradual introduction of flipped teaching and the absence of an instrument directly addressing the part of the course that has been flipped have to date precluded the rigorous quantitative assessment of the practice in chemistry at UEA. However, Bates & Galloway (2012) have been able to provide quantitative evidence for improved learning outcomes from the introduction of related practices to an entire module in physics at Edinburgh.

Table 1 Student evaluation comments for CHE-2C32 Inorganic Chemistry 2011-12

A lot of the descriptive chemistry was very dry and essentially boring. It is hard to teach this kind of material but the 'flipped lectures' seemed to combat this.
I think the 'flipped' lectures run by Dr Lancaster were a really good idea and I felt more engaged in the module.
I appreciated Dr Lancaster's efforts to make the lectures interesting and engaging in a modern way. The 'flipped' lectures were very successful.
I really enjoyed the flipped lectures and find that revising that material is much easier.
The flipped-lectures are a definite step in the right direction, away from archaic lectures with little or no mental stimulus, towards a more interactive learning experience that maximises learning outcome!
They were good fun as it was nice to have interaction with the lecturer as opposed to just being talked at, it was also nice having knowledge of what you were talking about as we had already gone through the material!
I think the flipped lectures were a really good idea because it was a more interactive way to engage students into learning, rather than the repetitive routine of having to listen to the lecturer work through a PowerPoint presentation for an hour.

Conclusions and future direction of the community

Flipped teaching is a relatively new term for a teaching practice that has always been prevalent in HE disciplines with a tradition of few but intense contact hours. In chemistry, and indeed in all disciplines wedded to a monolithic body of content, lecture flipping is an opportunity for a step change in peer and learning facilitator interaction, a chance to get beyond simply exposing students to information so that all of our precious contact hours can be spent ensuring understanding and accomplished application. There are many ways in which students can be encouraged to prepare for the enriched contact time, from the reading of textbooks to the viewing of pre-recorded lectures. No two flipped sessions will be the same. The learning facilitator will have formulated a series of questions and activities but they need to be prepared to relinquish control over the session and to be taken in the direction dictated by the needs of the students. Through peer instruction in the flipped environment the lecturer has an incredibly powerful tool to help students come to terms with their misconceptions.

Flipping the lecture can only be recommended for teaching staff convinced by the potential of interactivity and engagement and with the confidence (and perhaps experience) to relinquish some control. Taking an existing lecture course and flipping it will require an initial investment of effort. However, those lecturers who already have an interactive style will find the preparation of a flipped session straightforward. True engagement of large classes, in which every student can interact equally, probably does require facilitating technology such as clickers or smartphone applications, but here too variety is likely to be one of the keys to success.

For the student, flipping lectures promotes independent learning and allows much greater attention to the problem solving and higher order skills than would otherwise be possible. Thus lecture flipping can be argued not just to improve conceptual understanding but to address the other learning objectives outlined in the subject benchmarks.

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