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SELF-CHEM: Student Engagement in Learning Through Flipped Chemistry Lectures.

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7 SELF-CHEM: student engagement in learning through flipped chemistry lectures

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Abstract

This project introduces the idea of "flipped lecturing" to a group of second year students. The aim of flipped lecturing is to provide much of the "content delivery" of lecture in advance, so that the lecture hour can be devoted to more in-depth discussion, problem solving, etc. As well as development of the material, a formal evaluation is being conducted.

Fifty-one students from year 2 Chemical Thermodynamics module took part in this study. Students were provided with online lectures in advance of their lectures. Along with each online lecture, students were given a handout to work through as they watched the video. Each week, a quiz was completed before each lecture, which allowed students to check their understanding and provided a grade for their continuous assessment mark.

The evaluation is examining both the students' usage of materials and their engagement in lectures. This involves analysis of access statistics along with an in-class cognitive engagement instrument. The latter is measured by "interrupting" students as they work through a problem and asking four short questions which are drawn from another study (Rotgans and Schmidt 2011), which aimed to examine how students were engaging with the materials in that moment. Results from this study, along with access data, quiz scores, and student comments, aim to build up a profile of how the flipped lecture works for middle stage undergraduate students.

Keywords: cognitive load, flipped lectures, online learning

Introduction

Flipped lectures at university level began to be touted a few years ago and quickly became a popular choice among early-adopter innovators to replace the traditional lecture. The concept of providing material in advance of the class so that more time could be spent on active learning during class is appealing to educators, and the flipped model provides a useful design framework for how one might integrate in-class and online materials. However, despite a lot of attention in the "popular press" of blogs, online journals, and social media, there is scant detail on the effect of flipped lectures on student learning

in the education literature. The study most often referred to is an article published in 2000 in the Journal of Economics Education (Lage, Platt and Treglia 2000). That article describes the implementation of the inverted lecture, along with some evaluation based on student opinions. More recently an article in Chemistry Education Research and Practice describes the implementation in the context of a General Chemistry module, with the implementation consisting of a student survey (Smith 2013).

Recent work by the author reported the effect of providing some material to students in advance of a lecture (Seery and Donnelly 2012). These pre-lecture activities aimed to introduce some core terminology and ideas prior to a lecture with the aim of reducing the in-lecture cognitive load. That research found that introducing some terminology and structure in advance of the lecture improved grades for all students, regardless of the extent of their prior knowledge, and in addition narrowed the gap in these grades to a non-significant difference. While pre-lecture activities differ from flipped lectures in terms of the amount of information provided in advance and the nature of the subsequent lecture hour (Seery 2012), they have similarity in their underlying rationale: providing students with material in advance of the formal teaching time may help reduce the cognitive load as students will have some familiarity with the material when it is being discussed in class.

On the basis of this rationale, the current study aimed to examine the implementation of a flipped classroom model of delivery in place of a more traditional lecture model. The study aimed to address the following questions:

1. Would students engage with the materials in advance of the class?
2. Would students attend lectures for material that had "been delivered"?
3. Would students engage with the more active approaches being taken in lectures?

Details of Implementation

Undergraduate chemistry degrees in Ireland typically consist of four years (stages) with 60 ECTS credits (European Credit Transfer and Accumulation System) per year. After a common science first year, students take modules in chemistry for the remainder of their degree. This module in Physical Chemistry was delivered to 51 students during their second stage (Year 2) in the first semester.

The content consisted of introductory thermodynamics (First Law, Second Law, Solution Chemistry) and made up half of the module (2.5 ECTS). The other half of the module was delivered by another lecturer in the traditional manner. In total in Year 2, students take two modules (2 x 5 ECTS) in Physical Chemistry. The hours of delivery were 9 am and 3 pm on Wednesdays for six weeks over the second half of semester (the final week consists of tutorials). The modular exam for the Semester 1 module is held in January and consists of 50% of the mark. The remainder of the assessment is derived from laboratory (30%) and continuous assessment (20%). Some 10% of the continuous assessment mark is derived from the Thermodynamics half of the module, and is referred to below.

The 12 hours traditionally delivered to students were re-configured into five weekly screencasts, prepared especially for this purpose. Details on design considerations for these screencasts are available (Seery 2010). Students were asked to watch the screencast before Wednesday of each week. Screencasts were typically 10–15 minutes long. While watching the screencast, students completed worksheets where they had to write out explanations and try questions.[7] In addition, they were referred to the textbook at various points and asked to work through worked examples and other questions to check their understanding in their own time. Once they had completed the screencast and worked on their questions, they completed a pre-lecture quiz. The questions in the quiz were devised by the author such that they followed on from the worked examples students were asked to work through. Each student completed similar questions, although the values in each question were different. The quiz had to be completed prior to the lecture, and after this time, students could review their answers and the correct answers. The sum of the pre-lecture quiz marks was used to compute the continuous assessment mark (10%) that was drawn from this component of the module. On the whole, the entire pre-class work required approximately 45 minutes to one hour of work from students.

The cognitive load considerations underlying the approach were used to design the lecture hour. As there were two lectures per day following on from an associated screencast, it was decided to use these two hours to progressively develop students' understanding and problem solving as related to the material under consideration. Therefore, the first hour consisted of revisiting some core concepts in the introductory 10 minutes of the lecture, followed by a series of problem sets, the design of which followed directly from the pre-lecture quiz. Students worked on these in small groups, typically groups of three. The purpose of this first hour was to get students talking about the topics under consideration and working on algorithmic style problems. This was to ensure that they had the knowledge and confidence to use the core equations and approaches in each of the topics. In the second lecture hour, the students were given more advanced problems to work through, again in groups. These often had missing data or data that need to be estimated, and/or brought together related topics. The aim here was that students would be able to move on to applying the core knowledge in each topic to a thermodynamics problem. The author circulated the lecture hall dealing with queries and prompting questions. Finally, after the lecture, some worked example videos were placed on the virtual learning environment, which covered the approach to some of the main problems if students wished to revisit them at their own pace.

Observations from Implementation

As mentioned in the introduction, this pilot study was interested in three main questions. These are considered in turn below.

Would students engage with the materials in advance of the class?

Screencasts and pre-lecture quizzes were made available for the week preceding each lecture, giving students seven days to complete the work required in advance of the lecture. As these students are quite busy with course work (four chemistry practical reports per week to prepare, continuous assessment from other modules), there was a concern that even though intentions might be good, students would not engage with the preparatory material.

Analysis of the access data for each screencast shows that overall, 92% of students watched the screencast at least once each week (Figure 7.1). These included three students who never logged in to watch videos or who never came to lectures, and in Weeks 1, 3, and 5, an additional three students. When the latter group of students were asked why they did not watch the video, the typical answer was that they had forgotten. Students who did not watch a video were automatically sent an email reminding them to do so the following week, which may explain the periodic nature of the data.

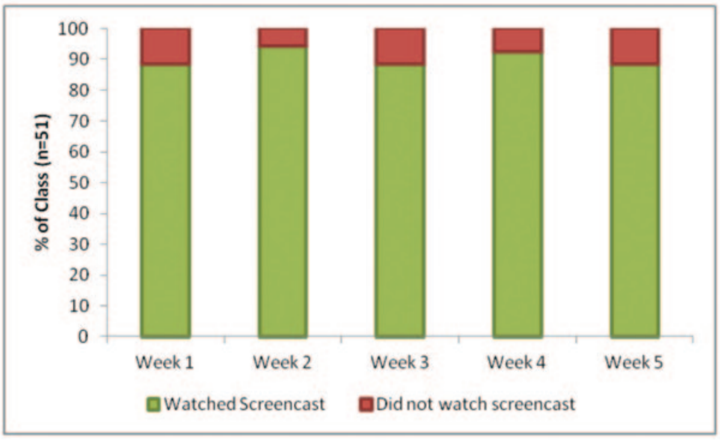

Figure 7.1: Proportion of students who watched and did not watch weekly screencast

7 Permission was obtained from the textbook publisher to reuse images in the screencasts and handouts.

The day that students watched was also recorded, and it was found that most students watched on the day before the lecture, in the evening time (Figure 7.2). There are some indications that as the weeks went by, the time of day moved to earlier in the evening, which suggest students began to build it into their regime on a Tuesday evening.

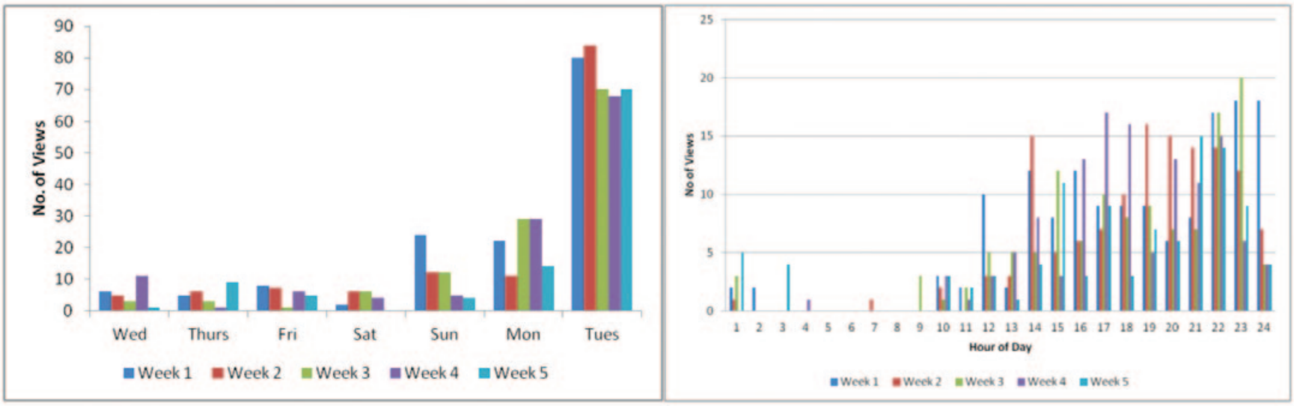

Figure 7.2: Access data showing days of the week (left) and time of the day (right)

In addition to watching the screencasts, students were required to complete a pre-lecture quiz. All students who watched the screencast completed the quiz. Those that did not also did not complete the quiz, which helps to verify "forgetfulness" as the reason for non-viewing. The overall average on the quiz for all quizzes was 69%, excluding those that did not attempt (DNA) (Figure 7.3).

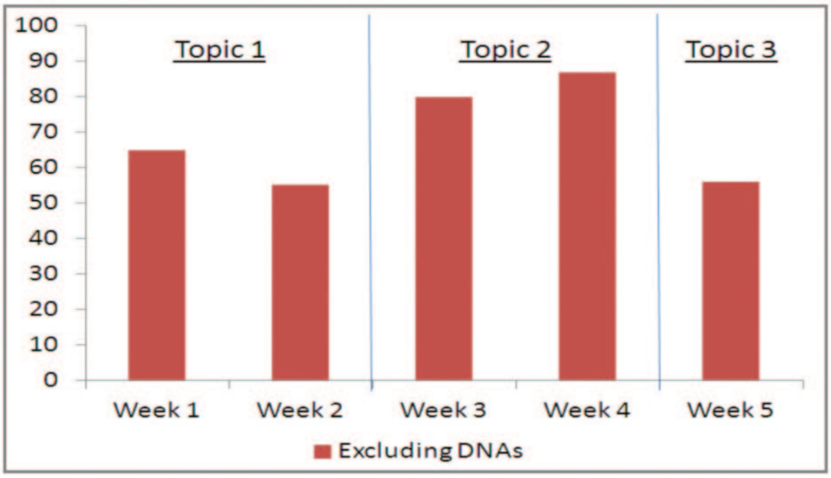

Figure 7.3: Scores achieved in weekly quizzes

Note: Topic 1: 1st Law, Topic 2: 2nd Law, Topic 3: Solution Thermodynamics

Would students attend lectures for material that had "been delivered"?

Having completed the online work in advance of the lecture, the next concern was that students might feel that they had "covered" the content, and therefore had no need to attend the lectures. As with the concerns about watching the screencasts, these fears were mostly without basis. The attendance at each lecture was logged and overall, the attendance was good. Attendance for the first four weeks was above 70% for morning lectures and 80% for afternoon lectures. Attendance in Weeks 4 and 5 were lower, and this is probably due to a combination of it being close to the end of semester, as well as an increasing amount of coursework being due. Nevertheless, attendance for this module was above the average attendance for other lecturers who recorded attendance that semester.

Would students engage with the more active approaches being taken in lectures?

One of the core aims of considering flipped lectures is that students engage with material during the lecture in a more meaningful way. As well as the traditional means of considering engagement as shown above, it was decided to use an instrument to measure students' cognitive engagement as they were working through some material in a lecture. This was achieved by using the survey developed by Rotgans and Schmidt (2011)8. This survey asks students to consider, in a particular moment, four aspects of engagement: (i) whether they were engaged with the task at hand, (ii) whether they are putting in effort, (iii) whether they wished to continue working, and (iv) how deeply involved they were in the activity.

Mid-way through one of the afternoon lectures, students were interrupted while they were working on a problem during class time. They were handed out a sheet of paper which contained a table listing "Statement 1" through "Statement 4" in the left hand column and a five-scale Likert response across the top, running from "Not true at all for me" on the left to "Very true for me" on the right (Table 7.1). Students were then shown each of the four statements in turn and asked to rate whether that statement was true or not for them (i.e. students did not see the statement until it was displayed on the screen). Then the sheets were collected and the students resumed work. The entire exercise took approximately five minutes.

	Not true at all for me	**Not true for me**	**Neutral**	**True for me**	**Very true for me**
Statement 1: I was engaged with task at hand					
Statement 2: I put in a lot of effort					
Statement 3: I wish we could continue with the work for a while					
Statement 4: I was so involved I forgot everything around me					

Table 7.1: Cognitive engagement instrument based on Rotgans and Schmidt (2011)[8]

Note: The text of the statement was not on the student form.

In order to explore the students responses to the four statements, the difference between each student's response and the "neutral" response was calculated, where each of the five statements were scored 1–5 with neutral being 3. The results of this analysis are shown in Figure 7.4.

The analysis shows that students agreed, to decreasing extents, with statements 1–3. This suggests that the students were actively engaged with the work to hand (Statement 1), were applying mental effort while doing so (Statement 2), and at least did not mind continuing to work on the problem (Statement 3). Strong disagreement with Statement 4 ("I was so involved I forgot everything around me") is probably to be expected given that students were actively encouraged to discuss and work through problems with their neighbours.

Figure 7.4: Responses to cognitive engagement instrument for each of the four statements

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Discussion

The implementation of the flipped lecture method was approached with some trepidation. Fears that students would, in the context of a busy academic week, not have time to prioritise the work required to engage in the material prior to lectures, or not attend lectures themselves resulted in this pilot study monitoring pre-lecture work, attendance, and in-class activity. As can be seen from the data, the students taking the module embraced the flipped model whole-heartedly. They engaged with the material prior to the lecture, attended the lectures, and worked well on assigned tasks during the lecture. In this regard, the implementation was considered to be successful.

Conclusions

The implementation of a flipped lecture model in a mid-stage undergraduate chemistry module was piloted over the duration of half a semester. The design of the implementation was grounded in cognitive load theory. Students engaged with the module and its online materials, and worked well in class on active learning components there. The implementation has thrown some light on some issues surrounding flipped lectures, as well as some thoughts that may be useful in the delivery of online material in the future.

Recommendations to DIT

1. Flipped lectures are a potentially beneficial way to help students structure their approach to a module.
2. The module requires some preparative work, especially in the development of screencasts and other learning materials. A media suite (sound room, screencasting software, etc.) available on each campus would be hugely beneficial in producing these. Group offices are too noisy.
3. Students like the regular use of quizzes as a means of checking their understanding and targeting where they need to study. This should be promoted for appropriate modules.

Proposed Future Work

The project will be re-run in the following academic year, with a further analysis of what students do in the lecture and how discussions there inform their understanding.

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