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Pre-lecture Resources to Reduce In-lecture Cognitive Load

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Abstract

In order to reduce an observed gap in Year 1 performance between students who had and had not completed chemistry at Leaving Certificate in a first year chemistry group, an intervention based on cognitive load theory was implemented. Students completed ten pre-lecture resources before associated lectures. The resources took no longer than five minutes to complete and aimed to introduce students to the core terminology of the lecture. Resources were designed with the principles of cognitive load theory and multimedia resources in mind. They were administered through the DIT Webcourses virtual learning environment and students obtained feedback on a short quiz and a mark in the gradebook after completing each resource quiz. The resources were integrated into the lecture activity, increasing in-class discussion. After implementing the resources, the performance in a mid-semester exam and the end of year exam was examined. For the first time, students' prior knowledge was not a predictor of performance in these exams. The work resulted in dissemination at several national and international conferences, an accepted journal publication and a Teaching and Learning award.

Key Words: cognitive load, eLearning, first year experience, pre-lecture resources

Introduction

Introductory chemistry for those without a background in the subject has a high cognitive load (Sirhan, Gray and Johnstone, 1999). New learners in chemistry are very quickly exposed to a large amount of new terminology which they need to understand and interrelate (Johnstone, 2009). As the chemistry syllabus builds progressively, learners need to continually call on recently acquired knowledge and integrate that into ever increasing layers and representations of the subject as they progressively develop their understanding and begin to relate these terms at representational, atomic and macro levels (Johnstone, Sleet and Vianna, 1994).

In this fast pace, it is easy for learners to slip. A lecture which builds on a previous lecture is all very well, but if learners did not have time to understand those concepts which are being built upon, they fall behind. This was observed in a previous study by the author. A longitudinal analysis over several years found that students who had prior knowledge of chemistry at Leaving Certificate level tended to do better in their Year 1 performance (semester and end of module exams) than those who had no prior knowledge (Seery, 2009). However, there was no association between Leaving Certificate chemistry and marks in later years. This led to the hypothesis that a consideration of the teaching of material in Year 1 in the context of cognitive load theory may be a suitable grounding for an intervention to assist these learners.

Outline of the Project

Cognitive load theory is a model for instructional design based on an understanding of how we acquire, process and retain new information. It proposes that a successful use of the model will result in more effectual learning, and the retaining of information in the long term memory, which can be recalled when required in a given context. The theory distinguishes three types of cognitive load (Ayres and Paas, 2009; Sweller, 2008):

1. **Intrinsic load** is caused by the complexity of the material. This depends on the level of expertise of the learner – in other words it depends on the learner's understanding of the subject.

2. **Extraneous load** depends on the quality or nature of the instructional materials. Poor materials or those that require a large amount of working memory to process will increase the load and leave little capacity for learning.
3. **Germane load** is the mental effort required for learning. Because of the limited capacity of the working memory, germane load (the extent of learning) is dependent on the extent of the extraneous load, and also on the material and expertise of the learner – the intrinsic load. An expert on a topic is able to draw from prior knowledge, and release working memory capacity for germane load processing.

The consideration of cognitive load theory for the purposes of multimedia learning was summarised succinctly by Mayer. Mayer's model is shown in Figure 8. 1 below (Clarke and Mayer, 2008):

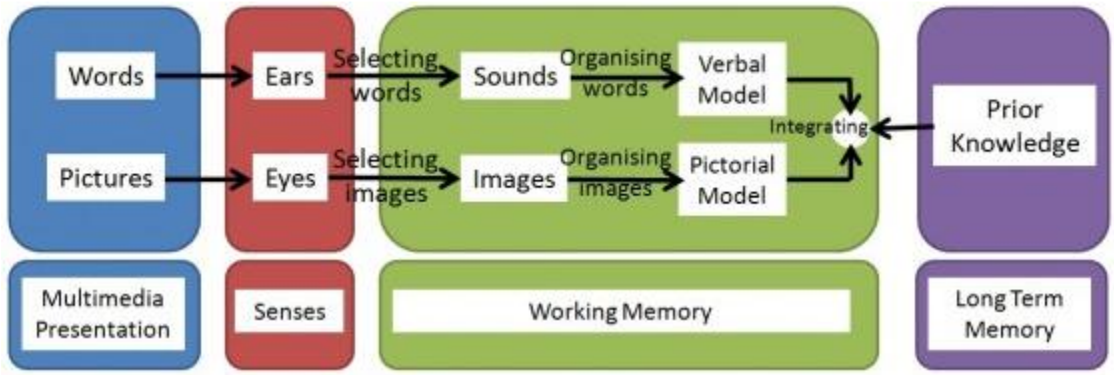

Figure 8.1: Cognitive Theory and Multimedia Learning (Clarke and Mayer, 2008; Mayer, 2005)

Information is presented to users in the form of words and pictures (there are other channels too, but these are the most pertinent to eLearning). The user senses these and the working memory processes some information at any time. If this material can be related to existing prior knowledge, it is integrated with it, and effective learning occurs – the new experiences and information are stored in the long-term memory.

Project Implementation

This project aimed to reduce the cognitive load of novice learners in chemistry by providing online pre-lecture resources which they could interact with before coming to the lecture. Ten resources designed in the context of the principles of multimedia design were developed and integrated into the students' VLE, *webcourses.dit.ie*. In designing the resources, the core terminology that would arise in each lecture would be presented. For example, in a lecture that might involve 20 new terms, 6–7 were chosen as core, and incorporated into the pre-lecture resource. It was not the aim of the pre-lecture resource to cover all material in the lecture, rather to introduce the students to the core terms required to begin to approach these terms.

The resources were no longer than five minutes long and had a quiz at the end. The quiz provided an opportunity for students to check their understanding of the core concepts underlining each lecture, and students received both answer-specific feedback (to help address any misconceptions) along with a grade for their quiz in the Gradebook. The grade for all ten resources was worth 1.5% of the module mark. Students completed two quizzes per week for the first four weeks of Semester 1, with an additional two later in the semester.

In the lecture, the resources were purposefully integrated. At the very least, they were referred to, and built on in presenting new material in lectures. In some cases, students were asked in the pre-lecture resource to prepare some material for contribution to the lecture. In the latter case, some useful discussion in the lecture replaced a teacher-centred approach. This approach will be used more in the future.

Evaluation

A concern before rolling out these resources was that students would not use them. In fact, students were very keen to use them, with access rates typically over 85%. Problems initially were technical – for example library computers could not play the Flash formats in which the resources were produced. After the first week, the students settled quickly into a routine. Lectures were held on Mondays and Thursdays, and the most common day to access was Sunday afternoons and Wednesday evenings. 65% of students spent between 2 and 20 minutes on the resources. An analysis of semester test marks found that the large difference between students who had not completed chemistry and those who had – present for every one of the last six years of the module – had reduced to the extent that there was no significant difference between the groups. Similarly the gap between examination marks between the two groups disappeared completely. The literature on prior knowledge is full of examples of how prior knowledge is a sole predictor of future achievement (Dochy, Segers and Buehl, 1999), so these results are pleasantly surprising in this context.

Discussion and Lessons Learned

The model described here technically does not change the lecture style. However, because students were arriving at the lecture with some familiarity with the lecture concepts, and often with pre-assigned activities, lectures could move to a more discussion based format. This has been found with other students involving pre-lecture resources (Collard, Girardot and Deutsch, 2002; Narloch, Garbin and Turnage, 2006).

It was considered important to purposefully integrate the pre-lecture resources into the lectures to attribute them a sense of value among students. This ranged from mentioning the resources right through the pre-assigned activity, to be developed in lectures. It was found in the latter case that the level of pre-preparation students had done was impressive, and allowed the lectures to integrate a high level of discussion in developing the content and ideas under consideration. Lectures in this case became very active learning environments, and the discussion element is considered to be a fundamental part of the enhancement of learning.

An output of the work that was not considered was that of the first year experience. Students in first year are in a new environment and unsure of their standing there, leading to uncertainty in their new environment (Yorke and Longden, 2004). Feedback from quizzes and discussions in lectures can provide students with a sense of their progress in the very early stages of Semester 1, before more formal aspects of continuous assessment take place.

It was a concern that "buy-in" from students would not take place. The level of usage and engagement was very high. This may be due to various factors, for example a (small) assessment component, the placing of value on the resources by the lecturer, and possibly the fact that new first years are more open to ideas of what happens at third level. An advantage of seizing this openness early on is that these kinds of activities can encourage students to develop a sense of agency in their own learning (Nicol, 2007; Nicol, 2009).

Recommendations

As a result of the work from this project, the following recommendations can be made:

1. Lectures should use purposeful resources to support first year material, meaningfully integrated with lectures and other learning activities. The use of technology enhances the

reproducibility of these and after initial development, automates a lot of the work regarding recording of usage and marks.

2. Lecturers should be encouraged to develop in-class discussion, both peer–peer and peer–tutor. This can be facilitated by clickers.
3. Informal feedback early in the year is important to give students a sense of their standing in the new learning environment.

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