Still pictures, animations or interactivity – What is more effective for elearning?

Alexandra Yeung, Siegbert Schmid and **Adrian George,** School of Chemistry, The University of Sydney, Australia
Michael King, Faculty of Education and Social Work, The University of Sydney, Australia
a.yeung@chem.usyd.edu.au a.george@chem.usyd.edu.au s.schmid@chem.usyd.edu.au
m.king@edfac.usyd.edu.au

Introduction

Over recent years information and communications technology has increasingly been incorporated into teaching activities in higher education. As a consequence best practices for design of multimedia instructional materials and for establishing effective e-learning environments have been investigated. It has been shown that concurrent presentation of text with either animations or pictures can enhance learning (Mayer and Moreno, 1998) and that multimedia materials which include interactive elements may lead to enhanced student engagement (Craincross and Mannion 2001; Littlejohn, Suckling, Campbell and McNicol 2002). Higher quality learning occurs when students are actively and cognitively involved with the learning process, and engagement promotes such involvement (Scott 2001). Design must be based on the needs and interests of the user and the limitations and capabilities of multimedia need to be understood well, before the potential benefits can be realised (Craincross and Mannion 2001). What we believe, as academics, will assist students in their learning, may not necessarily do that. However, evidence addressing the effectiveness of different approaches for promoting engagement with multimedia technology remains limited.

In this context we have started to develop online learning materials for use as pre-laboratory instruction or stand-alone learning modules for first year chemistry students. To inform development at an early stage a study was undertaken to investigate the most effective design of online chemistry modules for enhancing student learning and addressing misconceptions. Initially we have developed three different versions of an online chemistry module:

- one that used still pictures and text only (Static version);
- one that used animations/simulations and text (Animated version); and
- one that used animations/simulations, text and interactivity (Interactive version).

The outcomes of this study are of significant interest for this institution and beyond, since students often use online learning as a supplement to lectures. If one particular method of delivery is more effective than another, then such information is likely to have a significant impact on the design of online materials in the future. Not only can this information help enhance student performance, it can allow the process to be more efficient and cost effective.

The results reported in the following draw on student surveys and participants' assessment results.

Online learning module

A number of design issues were considered when creating the three versions of the online chemistry module used in this investigation. The topic of acids and bases was chosen since past examination performance (Read, George, Masters and King 2004) and anecdotal evidence suggest, that this is a topic that students find difficult, and in which common misconceptions are held. The module focussed on five main aspects that covered areas often associated with student misconceptions:

- the difference between strong and weak acids and bases;
- the difference between concentrated and dilute acids and bases;

- the relative strengths of acids and bases and their conjugates;
- simple calculations of pH involving strong acids and bases; and
- the relationship between pH, Ka, concentration and strength of acids and bases.

Every effort was made to ensure that the content presented was similar in all three different module versions, with the only difference being the design of the module, i.e. layout, type of visuals or type of interactivity. Moreover, animations and interactivity were only included if the additional features added to the presentation of content and ideas. Otherwise animations and interactivity would simply distract students' attention away from what they are intended to learn (Hutchings, Hall, and Colbourn, 1993). Figure 1 gives an example of a corresponding screen from each version of the module.

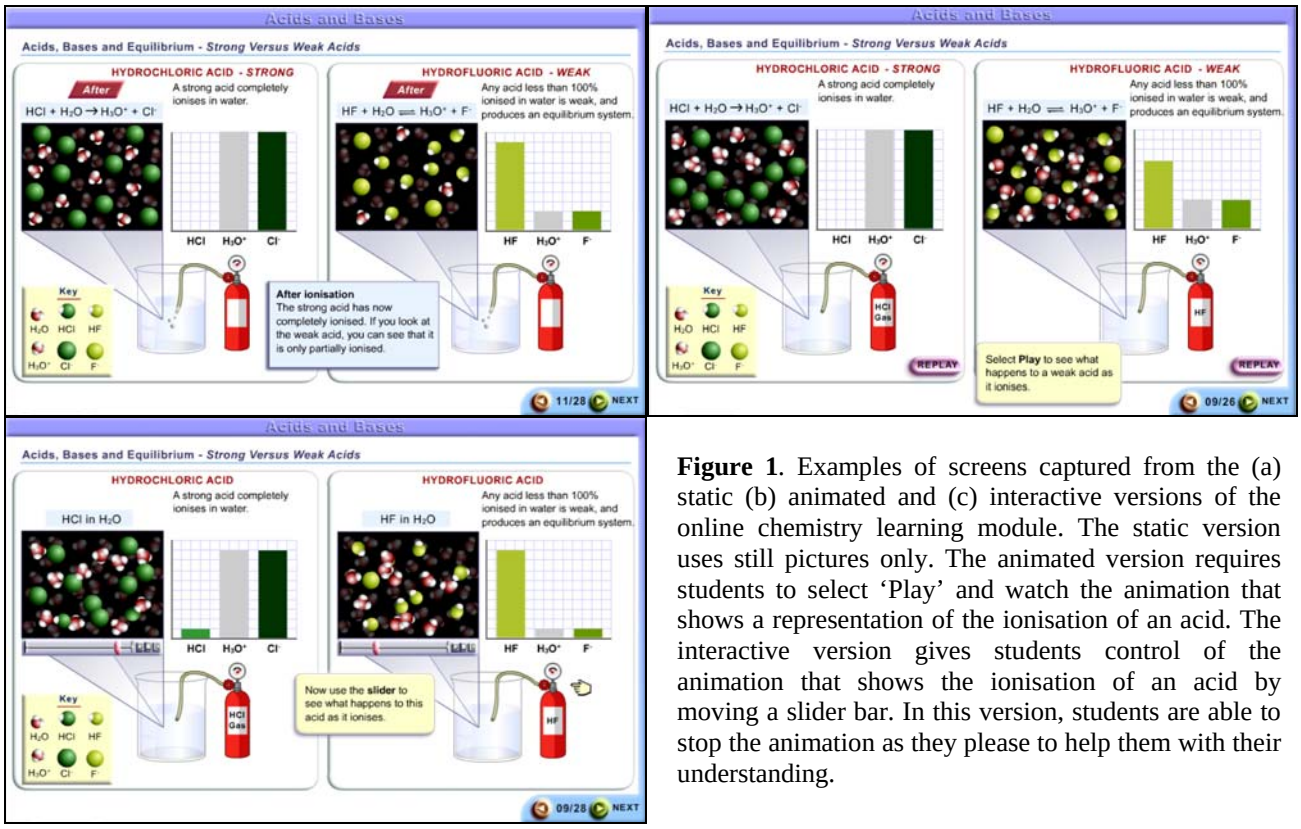

Figure 1. Examples of screens captured from the (a) static (b) animated and (c) interactive versions of the online chemistry learning module. The static version uses still pictures only. The animated version requires students to select 'Play' and watch the animation that shows a representation of the ionisation of an acid. The interactive version gives students control of the animation that shows the ionisation of an acid by moving a slider bar. In this version, students are able to stop the animation as they please to help them with their understanding.

Methodology

Participants

First year chemistry students participated in this study at The University of Sydney in semester 1, 2007. All students were enrolled in either CHEM1102 (Chemistry 1B) or CHEM1611 (Pharmacy). CHEM1102 is the second of two linked first year chemistry units of study offered to students undertaking mainstream science qualifications. CHEM1611 is the first of two linked chemistry units of study offered only to students undertaking qualifications towards a Bachelor of Pharmacy. Both CHEM1102 and CHEM1611 units cover aspects of the topic 'acids and bases' and both units assume that students have satisfactorily completed Higher School Certificate Chemistry.

Study design

Participation in this study was voluntary. Participants from CHEM1102 and CHEM1611 were randomly assigned to three groups. Students completed a pre-test to determine their knowledge prior to working through the module. Each group completed a different version of the online chemistry module, which was delivered via *WebCT*. After completion of the module, students were asked to do

a post-test, which used the same questions as the pre-test. Feedback, answers and marks were only given after students completed the post-test as well.

Marks were recorded for both the pre-test and the post-test associated with the online module. A total of 65 students completed all three aspects of the study (i.e. pre-test, module, post-test) and their results were used in the analysis. The data for students in both CHEM1102 and CHEM1611 were analysed together because the sample was relatively small. Furthermore, all aspects of the module were identical for both units of study, thus combining the results was reasonable.

Student survey
Students were asked to complete an online module rating survey after they finished the online modules in an attempt to determine students' views of the module. Specific questions the survey sought to answer were questions related to students' motivational level, students' perception of the modules helpfulness and user friendliness, and how students use the modules to assist their learning.

Pre- and post-tests
The pre and post-tests sought to test students' understanding of the concepts presented in the module, rather than just the memorisation of facts. The multiple choice questions that were asked ranged from simple low-road transfer questions to more complex conceptual high-road transfer questions relating to the module. Examples include:

- Which of the following is a strong base?
  (a) HNO3
  (b) HCOOH
  (c) H2O
  (d) NH3
  (e) NaOH

- Using the table below, which of the following solutions is the strongest acid?

Acid	Concentration (M)	pH
HA	0.10	3.4
HB	0.010	3.4
HC	0.050	4.6
HD	0.080	3.7

  (a) HA
  (b) HB
  (c) HC
  (d) HD
  (e) It is not possible to tell from these data

Results

Student survey
The student survey had a number of questions for students to answer on a 5 point scale and some free format questions.
Figure 2 shows the distribution of survey responses for a few selected questions. A larger proportion of students who completed the animated and interactive versions of the module find the explanations easier to follow, the material more engaging and interesting than students who completed the static version of the module. Moreover, a larger proportion of students who completed the animated version of the module responded by saying that the module was helpful for their learning. Students

who completed the static version were the only students who did not find the module engaging or interesting at all. Additionally, a larger proportion of these students found the explanations in the module difficult to follow.

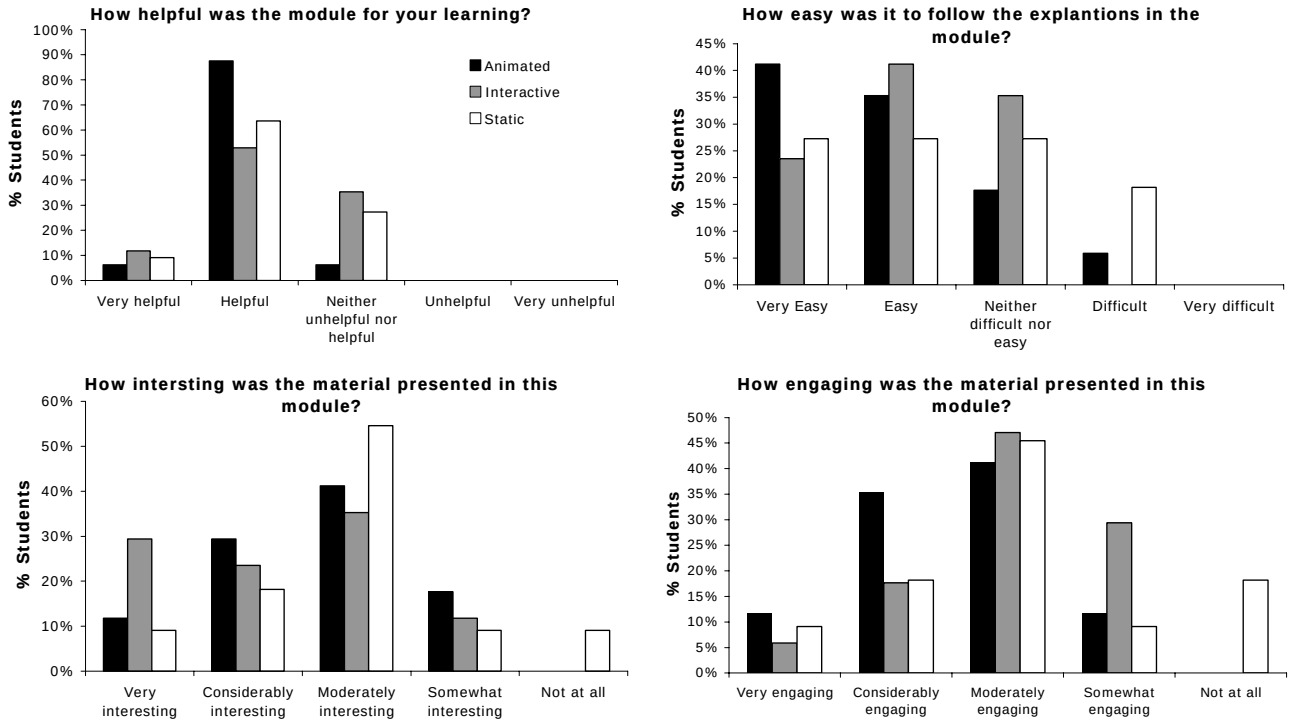

Figure 2. Student responses for the module rating survey for each version of the module

Chi-square analyses were conducted to determine whether there were statistical differences in the distribution of survey responses for students who completed different versions of the module. However, due to the small number of responses (45), the differences between the three groups (see above) did not reach statistical significance.

In addition the free format questions were analysed to see whether differences were evident for responses from students who were assigned to different versions of the module.

Students who completed either the animated or interactive versions had positive comments about the module, e.g.:

- 'Use of animations and videos help with understanding'
- 'I like them! I like the interactivity of online modules, especially animations, which help to shape my understanding of the concerned topics'
- 'It's colourful, animated and interesting!' and 'Far more interesting and motivating'
- 'Allows me to learn at my own pace, allows me to learn in a comfortable environment - in my own comfort zone'

Students who completed the static version only had negative comments or did not answer the free response questions about the module. Some of their comments include:

- 'Perhaps less text or text more spread out'
- 'It's quite strenuous to look at the screen and learn ... It makes my eyes really tired ... but the online activities should be more interactive'

Academic performance

One-way ANOVA was conducted to determine whether there was any difference in performance in the pre-test and post-test for the module. Subjects were divided into treatment groups depending on which version of the module they completed: static version, animated version, or interactive version. It was found that there was no statistically significant difference in academic performance between the treatment groups for the pre-test [$F_{2,75}=0.257$, $p=0.774$] (Figure 3a). Post-hoc comparisons using Tukey HSD confirmed that there were no significant differences between the treatment groups.

To determine the effect of different versions of the module on academic performance, the difference between a student's pre-test and post-test marks was determined. This 'gain' gave an indication of the benefit students may have received from the module. Subsequently, one-way ANOVA was conducted to determine whether there was a difference in academic performance between students who completed the different versions of the module. It was found that there was no statistically significant difference in gain for the treatment groups [$F_{2,62}=0.876$, $p=0.422$] (Figure 3b). Post-hoc comparisons using Tukey HSD confirmed that there were no significant differences between treatment groups.

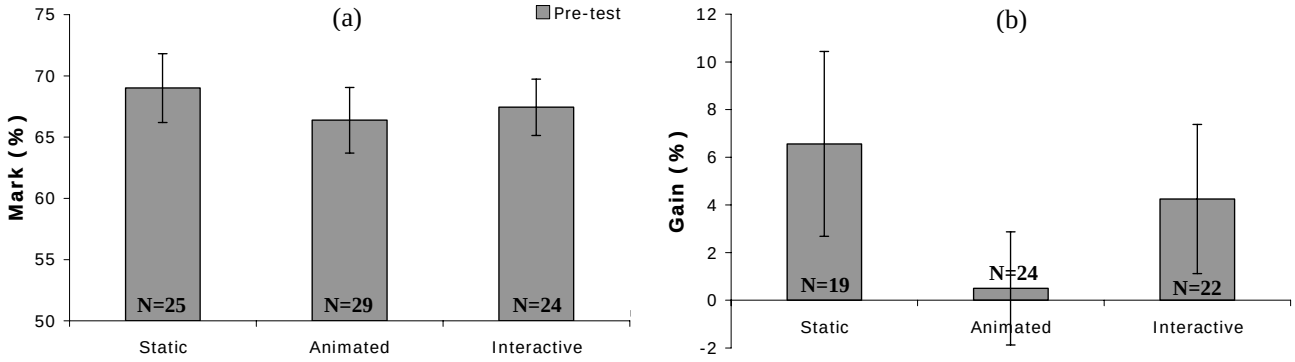

Figure 3. (a) Mean marks for the pre-test for each version of the module and (b) Mean gain for students who completed each version of the module.

Discussion

This study provides strong evidence that there are differences in student rating for different versions of the online learning module. Those who completed the interactive and animated version overall had much more positive responses in the module rating survey compared to those who completed the static version. Student comments in the free response section of the module rating survey also indicated that students who completed the animated and interactive version had a very positive experience compared to negative or no comments from students who completed the static version. However, due to the small sample size and students having been split into three groups the differences in distribution of responses did not reach statistical significance. While it is clear that the static version was not preferred the situation is less clear for the differences between the animated and interactive versions of the module. No clear trend could be determined from this study.

The preference for and higher engagement with the animated and interactive versions of the module compared with the static version does not seem to translate into improved academic performance. Surprisingly, when looking at the mean gain for students who completed the different versions, it appears that those who completed the static version gained more from doing the module compared with the other two versions. Again due to the small number of participants in this study differences in the academic performance of students who completed the three different versions of the module did not reach statistical significance. The result, however, conflicts with results from the module rating survey, as one would expect that students who are more engaged will perform better (Scott 2001). Since this is not the case it may require further study on a larger sample to determine

whether this result was an artefact of the small sample size or can be confirmed. In turn this will then allow a better indication of the effect of each version of the module on student performance and better inform us of the design of online chemistry learning modules.

Conclusion

The aim of this study was to determine the most effective format of an online chemistry module to enhance student learning. This study has shown that students have a preference for and are more engaged with the animated and interactive versions of the online chemistry learning module that we have designed, compared with the static version. However, differences in student rating for the interactive and animated version could not be determined with certainty. For this reason, further research on a larger sample is required to determine whether any differences between the animated and interactive versions exist. In depth interviews and focus groups can be conducted and may provide more detailed data on students' authentic experiences of the module and better determine the effects of the different versions on student performance.

Surprisingly, students who completed the static version of the module had a greater mean gain between the pre and post-tests of the module, although one would expect more engaged students to do better. This warrants further research using a large sample, as the sample size of this study was relatively small and results did not reach statistical significance. Consequently, we will be better informed about the design of online chemistry modules to effectively enhance student learning and engagement.

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