

## Research Article

# Computer based learning packages have a role, but care needs to be given as to when they are delivered.

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### Abstract

*It is compulsory for first year biological science students at Queens University Belfast to complete a range of assessed, laboratory-based practicals in various scientific procedures including dissection. This study investigates student performance and attitudes when they have to complete a traditional dissection and a computer based learning (CBL) package (virtual dissection). One group of students had to complete the traditional dissection followed by a brief class test then the virtual dissection and the same test with the questions reordered. The second group of students were subjected to the same conditions the only difference being the order of the practicals, the virtual dissection first, followed by the traditional dissection. Test results showed that students performed better directly following the traditional practical approach in both groups despite pre-exposure to the CBL simulation in the second group. Student comments indicated that they preferred the traditional dissection and that it should not be replaced by the virtual practical. However, they also indicated that they enjoyed the different type of interactivity offered by the CBL package and would like to see both approaches used together to complement one another and reinforce their biological knowledge.*

**Keywords:** Computer based learning, active learning, laboratory practicals, interactivity

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### Introduction

It has been well established that students learn better when they are actively involved rather than being passive recipients of knowledge (Ramsden, 1999). Active engagement and interaction are essential aspects in promoting deep approaches to learning and are essential to achieving quality learning outcomes (Freeman and Blaney, 2005; Ramsden, 2003). The pedagogical theories underlying active learning and its benefits have been well documented and research has shown that greater learning is achieved when students are exposed to active learning methods where knowledge is obtained by sharing, problem solving and creating due to higher levels of active student engagement and when students must utilise higher order thinking tasks such as analysis, synthesis and evaluation (McKinney and Graham Buxton, 1993; Chickering and Gamson, 1987). Several studies have shown that there is a strong correlation between the extent of activity and the efficiency of learning (Biggs, 1999). The modern student cohort is more mixed and varied than ever before, especially regarding preferred learning styles. This study investigates the utility of different approaches to active and interactive learning which may appeal to different learners in order to achieve the same learning outcomes; a computer based learning (CBL) package and a more traditional 'wet' laboratory practical approach.

Laboratory practicals are, by their very essence and design, active learning experiences. When appropriately designed, laboratory practicals can provide a more realistic environment, stimulate group discussion, develop manipulative skills and it can be argued, stimulate a better appreciation of the subject (Peat and Taylor, 2004). The learning that takes place in the laboratory does not just involve laboratory skills; knowledge is gained by performing the

experiment, experiencing the scientific method and the applying theoretical knowledge in a practical context. Laboratory classes also promote a diverse range of generic skills such as time management, organisation, report writing, critical thinking, problem solving, imagination and creativity and evaluation of evidence and help to develop skills in teamwork (Boud *et al.*, 1989; Ramsden, 1999; Hughes, 2001; Hofstein and Momolk-Naaman, 2007). Therefore, academics in the biological sciences have an ideal opportunity to incorporate active and interactive learning techniques into their teaching, as biology teaching traditionally combines the lecture theatre/classroom with the laboratory and/or field (Spicer and Stratford, 2001). However, there are increasing issues in universities regarding laboratory practicals, with a shortage of space, increased student numbers, academic diversity, pressures on staff time, cost, awareness of animal rights and the associated cultural and ethical sensitivities (Hughes, 2001; Peat and Taylor, 2004), all of which have been flagged as potential limitations of laboratory practices. It has also been argued that a sizeable proportion of students do not require the skills they learn from laboratory practicals in their future careers (Hughes 2001), especially the skills acquired in the use of specific scientific equipment (e.g. graduated pipettes) and laboratory-specific technologies (e.g. high specification microscopy) that are unlikely ever to be encountered outside of the laboratory.

With the Internet becoming one of the foremost instruments in the search for information, information technology becoming ever more prominent in daily life and the experiences of today's student population with computers, it is important for academic staff to be aware of the possible uses of computer technology in their teaching (Gunn and Pitt, 2003; Ward *et al.*, 2001). The use of computer based learning (CBL) programs in undergraduate teaching have been used and reported across a range of biological disciplines, such as virtual dissections in mammalian biology and veterinary science (Franklin *et al.*, 2001; Kongrso *et al.*, 2008; Philip *et al.*, 2000), virtual learning environments in first year biological science courses (Peat *et al.*, 2002) and computer simulations in marine biology and ecology (Spicer and Stratford, 2001; Ergazaki and Zogza, 2008). It has also been argued that students who learn from simulated experiments might lack laboratory-specific skills but have a different skills set, and so are not necessarily less skilled with respect to their needs (Hughes 2001). Downie and Meadows (1995) suggested that when students were offered alternative learning aids to dissection such as models and charts there were no significant differences in written exam results compared to students who completed the associated dissection.

These factors coupled with difficulties with using animal cadavers for dissection, such as economics, increasing awareness of animal rights and associated ethical and cultural issues (Kongsro *et al.*, 2008; Franklin *et al.*, 2001), have led some universities to re-evaluate some existing and more traditional student laboratory practices. One of the alternatives being suggested is the use of CBL packages such as virtual dissections.

Modern communication technologies offer enormous potential to challenge established styles of learning (Matterson, 2005), to introduce a degree of interactivity into subject themes where previously there may be a reluctance to do so, or it was felt that it was contextually difficult, and appeal to the widening range of learning styles of students. A wide range of instructional strategies must be used to engage different learning styles and encourage learning through hands-on activities (Dale Tunnicliffe and Ueckert, 2007). The future of science teaching is to use the resources in the best possible mix for the discipline and one of the issues for the future will be how we assess the effectiveness of the mix of learning opportunities (Franklin and Peat, 2001).

However, it should be noted, that when using CBL packages one must provide an enhanced learning experience. Simply putting notes on the web does not improve student learning.

Rather, the material presented must have a sound pedagogical underpinning, be easy to navigate, interactive, reflective and well thought out to enhance student learning and promote the development of active learners rather than passive recipients (Badge *et al.*, 2005; Evans *et al.*, 2004; Ramsden, 1999).

With these sentiments in mind the main aims of this study were to examine by means of a short class test whether exposure to a CBL dissection package before or after participating in a traditional dissection affected student understanding of the topic, and to evaluate students' attitudes towards a virtual dissection of a squid delivered as a CBL package. We were also interested in whether students felt that the CBL package could replace the 'wet practical' or whether they preferred a combination of the two, and if so, did it matter which order they were timetabled, and whether or not there was any gender differences in their perceptions.

## Methods

A Biological Diversity module is offered in Level 1 at Queen's University Belfast as part of the biological science degree pathway. To complete this module, students are required to fulfil a number of laboratory-based practical sessions. One of these practical sessions is the dissection of a squid. Due to large student numbers (104), they were arranged into two groups alphabetically.

### Group 1

For the purposes of this investigation the first group of students (Student Group 1) was taken through the 'wet' practical (the dissection of a squid) by the lecturer. Students completed their own dissections and observational drawings on the external and internal structures of the squid. They were then asked to complete a brief, anonymous class test on squid features and anatomy (52 returns). On completion of the test, students had to work their way through the relevant topics of a virtual squid dissection in Froguts® (Froguts Inc., [www.froguts.com](http://www.froguts.com)) CBL package. Once this was completed, students were asked to complete the same class test, the only difference being that the questions were in a different order (50 returns).

### Group 2

Students in the second group (Student Group 2) were subjected to the same conditions; however the order of the practicals was switched. Students in this group completed the relevant topics of the virtual squid dissection in Froguts® first. They were then asked to complete the same class test as the previous group (45 returns). Students then had to complete the wet practical with the same set of conditions as the previous group and complete a quiz as above (43 returns).

## Questionnaires

At the end of each practical session when all students had completed both virtual and wet practicals and the two tests, they were asked to complete a questionnaire in which they had to score a number of statements on a scale of 1–5 (where 1 = strongly agree to 5 = strongly disagree) (See appendix). There was also a section where students could volunteer what they liked best about the CBL package, what they liked least about it and any other comments they wanted to include. In total 95 questionnaires were returned from both groups of students.

## Data analysis

Student's t-tests were performed on the class test results using GraphPad Prism version 4.0 (GraphPad Software, San Diego California USA, [www.graphpad.com](http://www.graphpad.com)).

## Results

### Class test results

The results from both tests indicate that: (i) the wet practical enhances learning, (ii) pre-exposure to questions does not enhance learning / performance and (iii) the wet-based practical was more successful in enabling the students to answer the class test than the virtual approach upon first exposure to the test.

### Group 1

#### Class Test 1 (following wet practical) versus Test 2 (following CBL program)

Both males and females individually and as a group, scored significantly higher ( $p < 0.001$ ) in class test 1 (Table 1). The average marks for females and males were 9.6 and 14.3 percentage points higher in Test 1 when compared to Test 2 respectively. Average group marks were reduced by 12.1 percentage points in Test 2 despite pre-exposure to the questions during class Test 1 (Table 1).

**Table 1** Mean scores in non assessed tests from both student groups completed following both dissection approaches.

	Group 1		<i>p</i>	Group 2		<i>p</i>
	Mean Score for Test 1 (%) $\pm$ SD	Mean Score for Test 2 (%) $\pm$ SD		Mean Score for Test 1 (%) $\pm$ SD	Mean Score for Test 2 (%) $\pm$ SD	
<b>Female</b>	80.9 $\pm$ 10.6	71.3 $\pm$ 11.3	<0.001	50.9 $\pm$ 18.7	81.4 $\pm$ 13	<0.001
<b>Male</b>	80 $\pm$ 12.6	65.7 $\pm$ 14.9	<0.001	40.9 $\pm$ 14.9	80.9 $\pm$ 15.3	<0.001
<b>Combined</b>	80.8 $\pm$ 11.3	68.7 $\pm$ 12.9	<0.001	47.1 $\pm$ 18.7	81.2 $\pm$ 14	<0.001

### Group 2

#### Class Test 1 (following the CBL program) versus Test 2 (following the wet practical)

Both males and females individually and as a group did significantly better ( $p < 0.001$ ) in Test 2 (directly following the wet practical see Table 1). The mean female score increased by 30.5 percentage points in Test 2 (directly following the wet practical). The mean score for males improved by 40.0 percentage points in test 2 (directly following the wet practical), whilst the combined mean score increased by 34.1 percentage points in Test 2 (directly following the wet practical).

#### Differences in performance between the two groups upon first exposure to class test

There was a very highly significant difference ( $p < 0.001$ ) in the performance of Group 1 (wet-dry) and Group 2 (dry-wet) students upon their first exposure to the test. The average mark of Group 1 students was 33.7 percentage points higher than those of Group 2 (Table 1) indicating that the wet-practical approach was significantly more successful in enabling the students to recall the information required for the test.

#### Differences in performance between the two groups upon second exposure to class test

The wet-based practical was more successful in enabling the students to score highly in Test 2 than the virtual approach upon second exposure to the test. There was a very highly significant difference ( $p < 0.001$ ) in the performance of Group 1 (wet-dry) and Group 2 (dry-wet) students

upon their second exposure to the test. The average mark of Group 2 students was 12.5 percentage points higher than those of Group 1 (Table 1).

### Gender Differences

There was no indication of gender-related differences in performance in either practical-based delivery of teaching or virtual-based delivery. There was no significant difference between the performance of males and females in either Test 1 ( $p = 0.8325$ ) or Test 2 ( $p = 0.1648$ ) for Group 1 or Group 2 (Test 1,  $p = 0.1371$ ; Test 2,  $p = 0.8584$ ) (data not shown).

**Table 2** Student perceptions of the CBL package Froguts®

Statement	Percentage of total student responses who (n=95);		
	Agreed or strongly agreed with the statement (actual counts)	Neither agreed or disagreed (actual counts)	Disagreed or strongly disagreed with the statement (actual counts)
Froguts® was easy to use	80.0 (76)	10.5 (10)	9.5 (8)
Froguts® was relevant to the course material	88.4 (85)	3.2 (3)	8.4 (8)
Froguts® stimulated my enthusiasm for the practical and squid anatomy	61.1 (58)	23.2 (22)	15.8 (15)
Froguts® helped my understanding of squid anatomy	83.2 (79)	10.5 (10)	6.3 (6)
I would like to see virtual practicals replace wet practicals	9.5 (9)	13.7 (13)	76.8 (73)
Wet practicals are better than virtual practicals	66.3 (63)	22.1 (21)	11.6 (11)
I would like to have a combination of both where possible	67.4 (64)	20 (19)	12.6 (12)
I enjoyed the Froguts® CBL package	65.3 (62)	17.9 (17)	19.9 (16)
I would like to have a virtual practical before the wet practical	72.6 (69)	12.6 (12)	14.7 (14)
It doesn't matter what order the virtual practical comes	18.9 (18)	23.2 (22)	57.9 (55)

### Questionnaire Results

It can be seen from Table 2 that a percentage of students agreed that the CBL package was enjoyable (65.3%), easy to use (80.0%), relevant to the course (88.4%), stimulated their

enthusiasm for the subject (66.1%) and helped their understanding of the subject (83.2%). Students indicated their approval on the usefulness of the CBL package by writing;

*"Froguts provided information on squid anatomy that was not previously known"*

*"it was fun and easy to use"*

*"it was interesting and helpful in explaining the practical"*

*"a lot of interaction and interactive learning activity"*

*"after reading the information there was interactive bits which helped further my understanding of the squid"*

A number of students also highlighted that the CBL package gave them a chance to see gender differences in the squid which was not the case in the traditional wet practical as they only received one specimen each.

When the students were asked whether they would like to see virtual CBL dissection programmes replace the traditional 'wet practical' 76.8% indicated that they would not. When asked which method they preferred 66.3% believed that the traditional wet method was better (Table 2).

*"not the same as the real thing"*

*"need to be able to see it in real life"*

*"wet practicals are better"*

*"might not learn as much this way compared to if you did a wet practical"*

*virtual dissections do "not require as much understanding as wet practical, therefore is a less effective learning experience"*

Despite the overall preference for the traditional dissection, 64 students also indicated that they would like to have a combination of both a virtual dissection and a traditional dissection where possible (Table 2).

*"would be good to have both"*

*"both wet and virtual practicals worked well together"*

*"you get more information and better time management with virtual, however, it is important to see the real thing and identify parts as everything isn't exact, like in the virtual"*

*"Froguts® was extremely helpful in providing the basics needed to carry out the practical with full understanding"*

*"learnt more on virtual practical whilst the wet practical was more interesting"*

When students were asked about whether or not the order in which they completed the virtual practical mattered to their overall learning experience, 69 (Table 2) felt that if they had to complete both a virtual aspect to a practical and a traditional 'wet practical' then the CBL element should come first.

*“virtual better before the practical as you will then know what you are looking for”*

*“no point in having CBL after as you don’t learn what you need for the practical, virtual practical then wet”*

*“helped with the actual wet practical and had a few interesting facts about squid lifestyle”*

*“it helped me understand the dissection of the squid before going into the wet practical”*

*“Froguts® was extremely helpful in providing the basics needed to carry out the wet practical with full understanding”*

*“would like to have a Froguts session before all dissections”*

Questionnaire results did not show any gender preference in responses when analysed separately.

In the interest of impartiality students were asked to volunteer any negative opinions on the CBL package. These included;

*“some parts very juvenile”*

*“not very exciting”*

*“a bit boring”*

*“writing changed to quickly”*

*“might not learn as much this way compared to if you did a wet practical”*

*“Froguts was bit slow”(x5)*

The majority of negative student responses corresponded to dissatisfaction in the speed of delivery of the programme and format, rather than objections to the concept of CBL *per se*.

## **Discussion**

Hughes (2001) reported that when laboratory reports from students who had completed a virtual practical were compared with those who had completed a traditional laboratory-based practical, the virtual group performed better due to the consistent high quality data that a virtual practical can offer as opposed to the inherent problems (lack of reproducibility and consistency) that can often occur in undergraduate laboratory practicals. The same report also draws attention to the fact that no difference was noted in the understanding of theoretical principles between the groups. Downie and Meadows (1995) reported that examination performance showed no difference when students were offered an alternative to dissection by employing other learning material such as models and charts. In contrast, the current investigation found a very highly significant difference ( $p < 0.001$ ) between the performance of students who had taken the wet practical (Group 1, Test 1: average score 80%) compared to students who had taken the virtual practical (Group 2, Test 1: average score 47%). Interestingly the average for Group 2 increased dramatically to 81% (Test 2) after completing the wet practical. Enhanced performance in Test 2 may be due to previous exposure to the questions during Test 1, although there is no indication of this occurring in Group 1, and therefore it is plausible that Group 2’s enhanced performance can be attributed to elements within the wet-based practical approach. Equally as interesting the mean score for Group 1 students went down after exposure to the virtual practical (81% to 69%). Students appear to respond better to the more hands-on approach than the traditional

'wet' practical offered, perhaps due to a more apparent 'wow' factor or perceived relevance helping to maintain motivation and attention. Unfortunately student motivation was beyond the scope of this study, however, anecdotal evidence, based on observations by teaching staff suggested that students in Group1 (wet-virtual) appeared to lose focus and become bored more quickly with the CBL dissection package, something which may explain their subsequent drop in test score.

Despite variation in factual recall and possible motivation issues this investigation suggests that students believe that virtual biology and e-learning have a place in education. The overwhelming majority of students in the current study believed that the CBL package was relevant (88.4%), helped their understanding of the subject (83.2%) and was enjoyable (65.3%). Of the students who returned the questionnaires 67.4% highlighted they would like a combination of both learning scenarios and 72.6% would like the opportunity to sit a virtual practical before the 'real' thing. Although the exposure of students to the CBL package prior to them completing the 'wet' dissection did not significantly enhance their test scores, when compared to students completing the CBL package after the 'wet' dissection (Group 2, Test 2) it is worth noting teaching staff and laboratory demonstrators reported an increase in the number of higher-level questions that were asked during the 'wet' practical in Group 2 (i.e. those students who had already experienced the CBL package). This may indicate an increased keenness to learn, a greater understanding of the squid anatomy, or perhaps a greater familiarity, less fear or more confidence with the material or that students were more comfortable with the material.

Previous studies have highlighted that students enjoy well designed pedagogic CBL packages, find them easy to use, feel that they stimulate subject enthusiasm, when used in the right context are relevant, are valuable learning methods which can enhance their experiences in the subject, can offer an effective mechanism to prepare for the 'real thing', are useful for revision and allow and encourage the development of an independent learning approach (Philip *et al.*, 2000; Spicer and Stratford, 2001; Franklin *et al.*, 2001; Peat and Taylor, 2004). However, the same studies have strongly and unanimously highlighted that laboratory activities such as dissections and field courses are highly valued and are perceived as crucial learning experiences by students. This was also the case in this current study, although the students clearly enjoyed the virtual dissection (65.3%) and saw its relevance (88.4%) there was a marked preference for the wet practical (66.3%) with only 9 students (9.5%) indicating they would like to see the virtual dissection replacing the real one.

It has been argued that laboratory based practical classes utilising animal tissue are central to bio-degree courses. and that whilst some CBL learning programs may meet the learning objectives there is a substantial body of evidence to suggest that these alone are inadequate for the teaching of some generic and specific laboratory skills and should only be used as an educational resource for background support rather than mainstream function (Dewhurst, 2007; Dantas and Kemm, 2001). Similar views are expressed in the Quality Assurance Agency's benchmark statement for biosciences (2002) which states "all honours degree students are expected to have some personal experience of the approach, practice and evaluation of scientific research" and that practical skills are not only essential for a successful biology graduate, they are also central to the practice of research biologists as they provide experience with equipment, organisms and chemicals (Ballie and Hazel; Lederberg, 1995) and promote important creative and critical generic skills such as report writing, data handling, interpretation skills and the ability to evaluate evidence. This study re-emphasises the need for well defined and planned learning outcomes rather than the use of one method over another just for the sake of using it.

In summary, despite these data indicating that the Froguts® package did not enhance student test performance, it has revealed that offering students the option of a CBL package prior to a wet practical (dissection) is preferred by students. They enjoyed the Froguts® package and felt that the combination of both approaches complemented their understanding and learning. As a consequence of this study, Froguts® has been made available for student access on campus prior to the scheduled squid dissection practical and for the duration of the academic year.

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Appendix to be created as PDF

