

*Research Article***The value of computer based formative assessment in undergraduate biological science teaching**Sarah J. Pitt¹ and Alan Gunn²

¹*School of Biomolecular Sciences and* ²*School of Biological and Earth Sciences,*
Liverpool John Moores University, Byrom Street, Liverpool L3 3AF.

Abstract

The impact of introducing computer-based self-assessment quizzes on examination performance was monitored in 5 modules delivered to undergraduate students in the first, second, and final years at university over a 2-3 year period. The patterns of usage were also monitored to determine the extent to which the quizzes were used and whether there were differences between the students at different stages of their education. Overall, all groups used the CBA package in broadly similar ways, although year 1 students were least likely to access their quiz. Most students used the quizzes during normal 'office hours' between Monday and Friday, but up to 22% of use occurred in the evenings and 3-20% at weekends. Most log-on events were recorded in the weeks immediately prior to an examination. There was a positive relationship between the introduction of the quizzes and mean examination mark; in particular, increases in the proportion of students obtaining good (>60%) marks were observed.

The results suggest that the provision of computer-based self-assessment quizzes is helpful to students and that the opportunity to access them at any time is appreciated. At present, it appears that the more motivated individuals are assisted most by the quizzes. Integration of formative CBA into a programme of learning appears to be beneficial, particularly when used in conjunction with other forms of formative assessment.

Keywords: Self-assessment quiz, performance, Computer based assessment

Introduction

Computer Assisted Learning (CAL) packages are being widely introduced to support undergraduate teaching in British universities (Ward *et al.*, 2001). Technological advances mean that it is now relatively straightforward for teachers who are not computer specialists to provide notes and information to support a series of lectures (e.g. Cann and Pawley, 1999; McEhlone, 1999), interactive tutorials to replace lectures (e.g. Dewhurst *et al.*, 2000; Pinckney *et al.*, 2001) or practicals (e.g. Ryan *et al.*, 2000; Riley *et al.*, 2002) or run Computer Based Assessment (CBA) (Thelwall, 2000). A selection of these can be integrated into a programme of learning, for example through a Virtual Learning Environment (VLE), such as Blackboard (www.blackboard.com) or WebCT (www.webct.com) (Henley and Reid, 2001; Ward *et al.*, 2001).

Assessments which use a multiple choice answer format readily lend themselves to computerisation, using programmes such as Question Mark (www.questionmark.com) to help with design (Thelwall, 2000; Ward *et al.*, 2001). Multiple choice questions are commonly used for paper examinations in biological and biomedical science teaching (Cann and Pawley, 1999) and CBA appears to offer some advantages, the most obvious being saving academic staff time in marking students' answers. Although CBA is currently used in summative assessment, it is not common, due to a number of practical difficulties, including ensuring the integrity of the examination programme before the examination (Thelwall, 2000) and accurate identification of the candidate 'logged in' to each terminal during the test (Ward *et al.*, 2001). However, CBA has found extensive use in diagnostic (at the beginning of a course) and formative (throughout the course) assessment (e.g. Brown and Knight, 1994; Cann and Pawley, 1999; Sly and Rennie, 1999; Pinckney *et al.*, 2001, Steele *et al.*, 2002). These tests are usually designed to help support students with factual learning and familiarising themselves with technical terms and key scientific theories (Ward *et al.*, 2001). However, the immediate feedback and possibility to have control over one's own learning that CBA afford are likely to encourage deeper, conceptual learning as well (Cox and Clark, 1998; Ramsden, 1999). It is not difficult to include illustrations (photographs of patients with particular disease symptoms, microscope slides of stained tissue containing a particular organism, electron micrographs etc) in a computer-based test and they are often clearer than those photocopied onto a question paper. It is possible to design a programme that selects a random set of questions from a larger bank each time the test is accessed (Thelwall, 2000). This increases the 'shelf life' of the test and ensures that a student does not improve performance over time simply by memorising the answers in the correct order.

Students should benefit from formative assessment through the chance to test the limits of their abilities, thus obtaining a realistic picture of how their learning is developing (Ramsden, 1999). A self-administered assessment where others do not know an individual's results is the least intimidating, thus potentially the most helpful, type. Computer-based self-assessment is ideal for formative assessment, since each student can access the package repeatedly, at a time and place suitable to them, which means that they can monitor and thus take control of their own learning. A CBA also has the merit of providing immediate feedback, which is important for student learning (Brown and Knight, 1994; Ramsden, 1999). Case studies suggest that once they are comfortable with the idea of using computer based assessments, students are very positive about them and report that they find the flexibility and autonomy to chart their own progress to be helpful in their learning (e.g. Sambell, *et al.* 1999; Steven and Hesketh, 1999), particularly during examination revision (Steele *et al.*, 2002). There is some evidence that individual students who use CBA for formative assessment, perform well in subsequent summative assessment (e.g. Steven and Hesketh, 1999; Thelwall, 2000; Pinckney, *et al.*, 2001), however, the improvement in marks for the whole group appears to be small (e.g. Henly and Reid, 2001; Pinckney *et al.*, 2001). For example, Henly and Reid (2001) introduced a CAL package, which included formative assessment tests, to support learning in a second

year Metabolic and Nutritional Biochemistry module at Queensland University. On evaluation of student experience of the voluntary self-assessment CBA, they found that the brighter, more highly motivated students accessed the tests more often than the weaker students. Therefore although students who used the computer based formative assessments tended to perform better in the final examination than those who did not, the difference between the two groups could have been partly the willingness of students to use the learning support materials provided for them, rather than the effect of learning through the computer package *per se*.

Undergraduate students would be expected to mature as learners throughout their time at university, to develop interests in particular aspects of their subject and choose courses which reflect that. At year 1, a biological sciences student might not be persuaded of the merit of extra work for a core biochemistry module, being content to pass. However, students taking an optional module in parasitology at year 3 (final year) could be encouraged by enthusiasm for the subject, or desire to achieve a good degree classification, to commit time and effort to additional study. The likelihood of a group of students to undertake voluntary self-directed learning might influence the benefit of formative CBA.

This study investigated the effect of provision of formative self-assessment quizzes on student learning for undergraduates on biological and biomedical science degree programmes at years 1, 2 and 3.

This was achieved by

1. Monitoring the level of use of the quizzes.
2. Comparing student examination performance before and after the introduction of the quizzes.
3. Comparing differences in use and effect of the quizzes with level of study.

Materials and methods

Computer-based self-assessment quizzes were introduced over a two year period for a variety of modules taken by university undergraduates pursuing degrees in biological and biomedical sciences. Each quiz was designed to cover all the subject matter included on a particular module and the questions were designed to mimic the style of those asked in the examinations. Each question was accompanied by an ideal answer, which could be obtained by either clicking on a button or scrolling down the page. The student module handbooks and the quizzes themselves included guidance on how to use a quiz to aid learning. Each CBA package had a counter attached, which recorded the dates and times of log-ons, although due to departmental rules of confidentiality of information, it was not possible to identify individual users. Therefore, the effectiveness of the quizzes was determined indirectly, by analysing the overall performance of the entire student cohort. The percentage of students accessing each quiz and the mean examination mark for each module were calculated on the basis of the number of students sitting the examinations. In 2002-03, the format of the examinations for the year 2 modules Neurobiology and Invertebrate Biology changed from being based

entirely on short answer questions, to a combination of short answer questions and an essay question chosen from a list of options. The weighting of short answer marks to essay marks were 60%: 40% in both cases. Another alteration made in 2002-2003, was the introduction of a data interpretation question worth 25% of the total mark into the year 2 Comparative Physiology examination, which had previously been based entirely on short answers. The data for these assessments has therefore been shown separately. Throughout the study period, the Human Physiology examination remained based on a combination of multiple choice and short answer questions and the Parasitology examination on a combination of short answer questions, an essay question chosen from a list of options and a single compulsory interpretation question. The data for these subjects has therefore remained comparable between the years and, consequently, has not been split into different sub-sections.

In addition to recording the mean examination mark for each module, the proportion of the class failing the examination (i.e. scoring less than 40%) or achieving high pass marks (over 60%) were also recorded. This was done to determine whether the quizzes proved of greatest value to the weaker students or those who were more motivated – in which case a higher proportion might be expected to gain good marks.

Results

Figure 1a shows the percentage of students from each cohort accessing their respective quiz in each week of the semester for the two modules were a CBA package was available in the academic year 2000-2001.

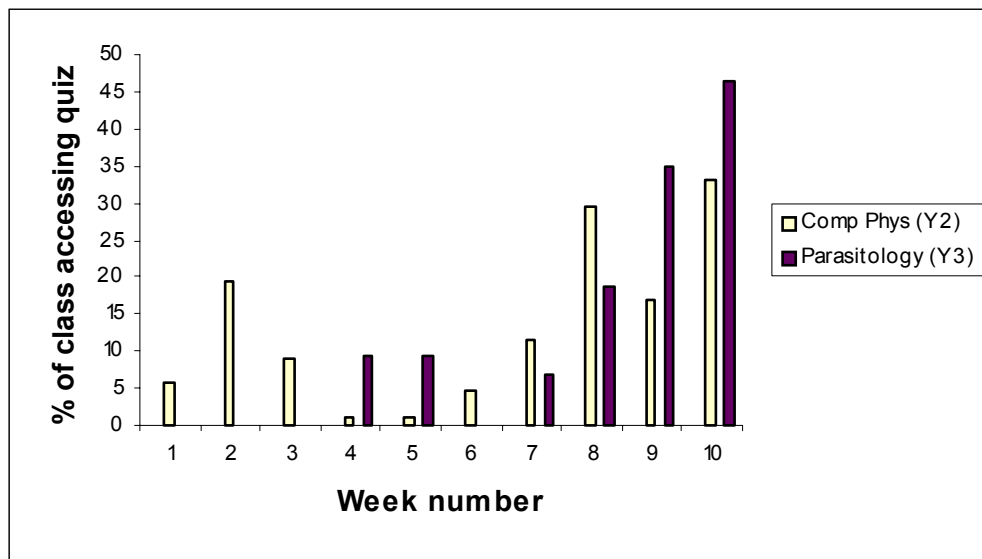


Figure 1a. The percentage of students from Comparative Physiology (Comp. Phys.) and Parasitology accessing their respective self-assessment quiz in each week of the semester in the academic year 2000-01.

Figures 1b and 1c gives the same information for 2001-2002 and 2002-2003 respectively, when students on 3 further modules were given a self

assessment quiz to use. Each quiz was introduced as soon as it was completed which accounts for the varying starting times for record of usage.

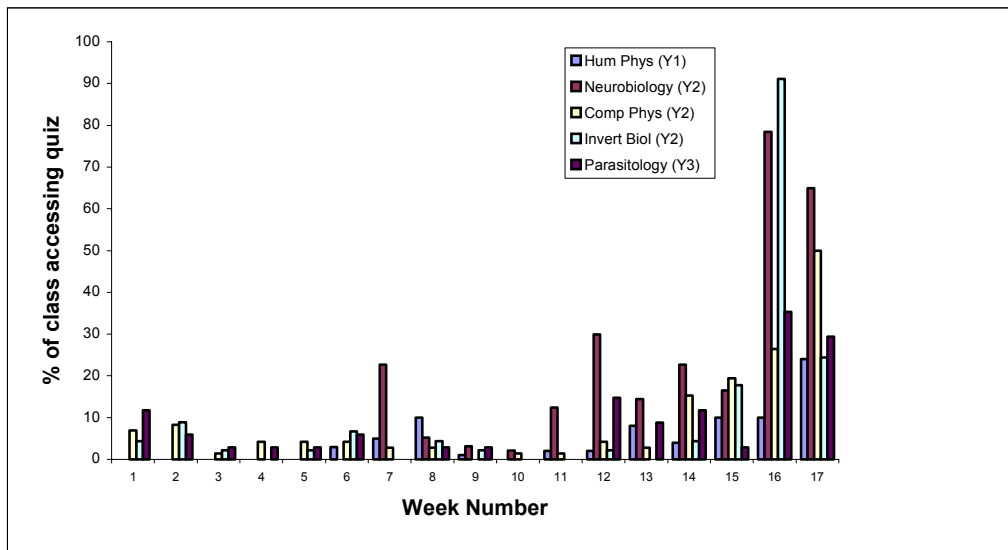


Figure 1b. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz in each week of the semester in the academic year 2001-02.

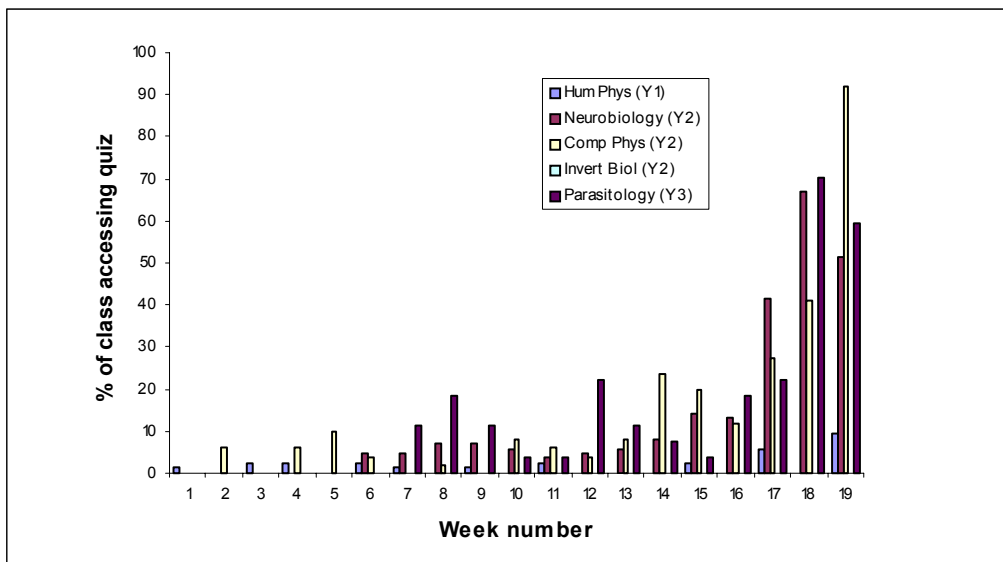


Figure 1c. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz in each week of the semester in the academic year 2002-03.

Furthermore, the modules did not all take place in the same semester and consequently there were differences in the length of the time between the start of lectures and the date of the examination. Students invariably ceased to use a quiz on the day of the examination and therefore, to make comparisons between modules easier, the data was adjusted so that the last

week in Figures 1a-c represents the week in which the examination took place. Figures 2a and 2b indicate the usage of the quizzes by day of the week in 2001-02 and 2002-03, while Figures 3a and 3b summarise the data about the times of day that each group of students accessed the quizzes.

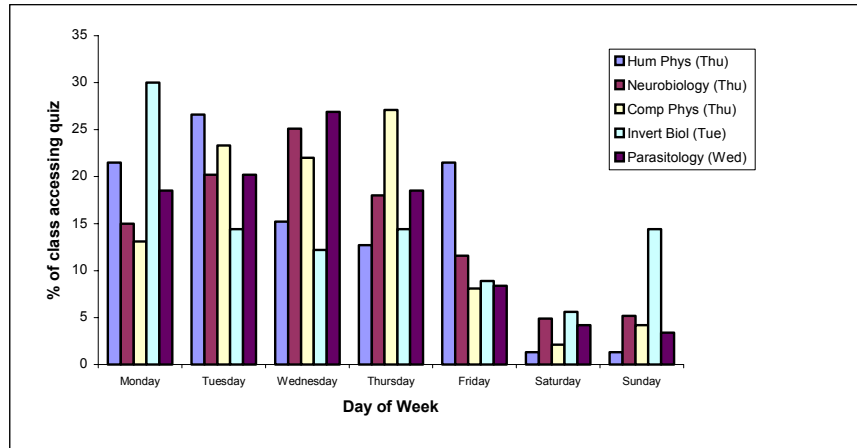


Figure 2a. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz according to the day of the week in the academic year 2001-02.

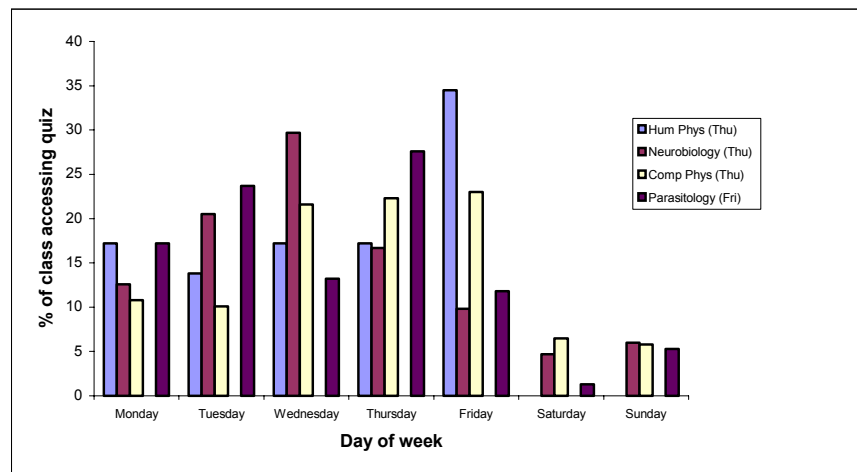


Figure 2b. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz according to the day of the week in the academic year 2002-03.

The results show that, for each module, once introduced, the quizzes were used fairly consistently by small numbers of students in each cohort and by larger numbers in the weeks leading up to the examination (Figures 1a and 1b). The majority of log-on events occurred on weekdays (Figures 2a and 2b) and between 0900 hours and 1800 hours (Figures 3a and 3b) but some students from each cohort used their quiz in the evenings or at weekends.

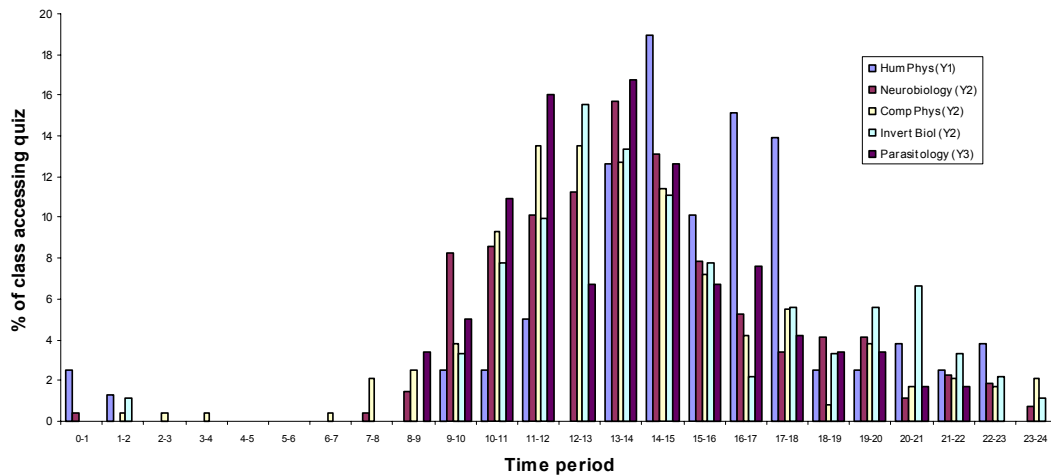


Figure 3a. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz according to the time of day in the academic year 2001-02.

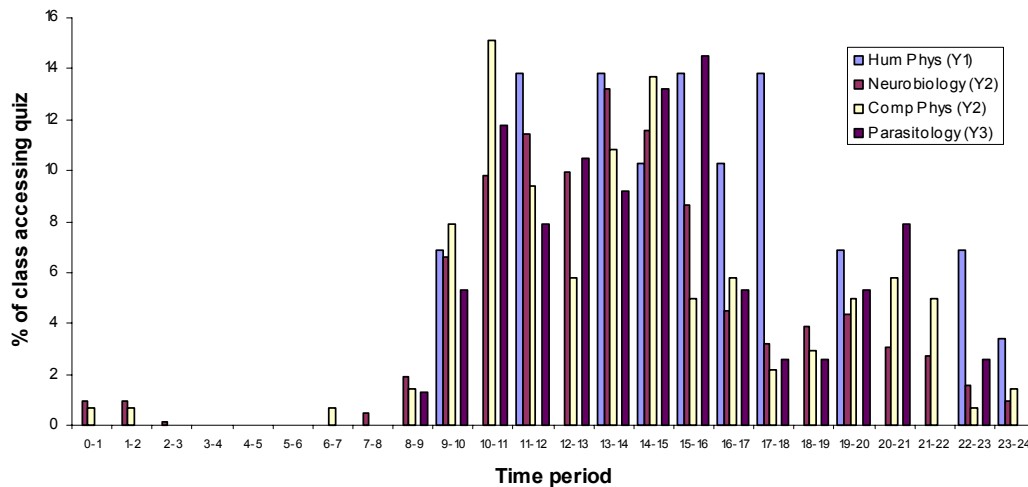


Figure 3b. The percentage of students from Human Physiology (Hum. Phys.), Comparative Physiology (Comp. Phys.) Invertebrate Biology (Inv. Biol.) and Parasitology accessing their respective self-assessment quiz according to the time of day in the academic year 2002-03.

The year 1 Human Physiology students used their quiz least frequently. In the year that the CBA package was introduced for this module (2001-02) small numbers of students used the quiz from the moment it came 'on-line', but the highest number of 'log-ons' took place in the final 3 weeks before the examination and these only involved 24% of students taking the examination (Figure 1b). During the second year the quiz was operational, usage rates declined by about half (Figure 1c), possibly because there was a new module leader, who did not constantly encourage the students to use it. A few students used the quiz during the weekends and outside normal working hours. However, following the introduction of the quiz, the percentage of students failing the examination decreased in comparison with the previous

three years (Table 1), an increased proportion of students achieved good passes and the overall mean mark improved slightly.

Table 1: Examination performance on Human Physiology (Year 1) before and after the introduction of the self-assessment quiz.

Academic Year	Number of students	Mean Examination Mark (%)	%Fail (<40%)	%Good Pass (>60%)	Total % Use of Quiz*
1998-99	109	51.2	23.8	29.3	N/A
1999-00	92	50.0	22.9	41.3	N/A
2000-01	83	51.3	27.8	27.7	N/A
2001-02	100	55.5	18.0	45.0	79
2002-03	86	54.1	19.8	38.5	30.2

* N/A = not applicable to that academic year, as quiz not yet available
Numbers in bold represent data collected after the introduction of the computer-based self-assessment quiz.

The quizzes for the three year 2 modules were not used equally, which was quite surprising, as many of the students in the study were taking two or all three of them. The quiz provided to support the Neurobiology module received a high rate of use throughout the teaching time, the patterns of which were similar in both years of operation. In 2002-03, the initial examination was aborted after 4 minutes owing to a fire alarm and rescheduled for 8 weeks later. During this intervening period, the quiz received 'hits' equivalent to 82% of the class (unpublished data). This indicates that a significant proportion of the class continued to use the quiz as part of their revision strategy. Throughout the semester, the rates of usage for the Neurobiology package tended to be higher than for the other quizzes although it was still heavily concentrated in the last three weeks before the examination. In both academic years, approximately 5% of students accessed the quiz on a Saturday or Sunday (Figures 2a and 2b) and 14-16% of log-ons were in the evenings after 6pm (Figures 3a and 3b).

Table 2 Examination performance on Neurobiology (Year 2) before and after the introduction of the self-assessment quiz.

Academic Year	Number of students	Mean Examination Mark (%)	%Fail (<40%)	%Good Pass (>60%)	Total % Use of Quiz
1998-99		NR			
1999-00	113	44.1	44.3	16.8	
2000-01	110	41.0	51.8	17.3	
2001-02	98	41.8	54.1	22.4	272.3
2002-03*	128	47.7	35.1	28.9	238.5
2002-03 SAQ	128	47.3	43.0	33.8	
2002-03 Essay	128	48.4	29.7	36.1	

NR = module not run in that academic year. Numbers in bold represent data collected after the introduction of the computer-based self-assessment quiz.

* = Data for overall examination performance

As Table 2 shows, the mean examination performance in Neurobiology did not change between 2000-01 and 2001-02, when the quiz was introduced. However, the proportion of students gaining good marks did increase and there was a further improvement the following year (Table 2).

The pattern of usage of the quiz for the Comparative Physiology module was sporadic, greatly increasing in the 4-6 weeks before the examination. In 2000-01 and 2001-02, the maximum number of students logging-on in a single week only equated to 50% of those sitting the examination (Figure 1b).

However, in 2002-03, this rose to 92% with 41.2% accessing the quiz on the day of the examination. Use at weekends rose from 6% in 2001/02 to 12% in 2002/03 (Figures 2a and 2b); similarly an increase in log-ons to the quiz in the evenings was recorded in the second year of its running (Figures 3a and 3b). The examination marks are presented in Table 3 and indicate a consistent improvement in the percentage of students achieving good marks in short answer questions following the introduction of the quiz. However, in the year 2002-03, the extremely poor performance in the interpretation question caused a reduction in overall examination performance. There was no correlation (Pearson Correlation = 0.195, N = 51, P = 0.169) between performance in the short answer questions and the interpretation question, which indicates that different skills being assessed in these two tasks and that, as expected, the quiz had not helped those who used it with interpretation skills.

Table 3. Examination performance on Comparative Physiology (Year 2) before and after the introduction of the self-assessment quiz.

Academic Year	Number of students	Mean Examination Mark (%)	% Fail (<40%)	% Good Pass (>60%)	Total % Use of Quiz
1998-99	71	48.9	30.9	21.1	
1999-00	65	55.8	13.9	38.4	
2000-01	88	46.8	34.4	26.4	131.7
2001-02	72	53.6	23.7	34.7	155.7
2002-03*	51	48.2	31.4	25.9	268.6
2002-03 SAQ	51	56.0	21.6	43.4	
2002-03 Interp.	51	24.6	90.2	2.0	

Numbers in bold represent data collected after the introduction of the computer-based self-assessment quiz.

* = Data for overall examination performance. SAQ = Short answer questions. Interp. = Interpretation question

In 2001-02, very few students studying Invertebrate Biology accessed their quiz during the semester, although over 90% of them used it in the week before the examination (Figure 1b). Over 20% of recorded access to the quiz for Invertebrate Biology occurred in the evenings (Figures 3a and 3b), which was much greater than for the other two year 2 modules. Unfortunately, during 2002-03, the tracker on this quiz malfunctioned and all the data was lost. However, anecdotal evidence suggested that the students were using the quiz

to a similar extent to the one for Comparative Physiology. The examination results indicated that the introduction of the quiz did lead to an improvement in examination performance (Table 4).

Table 4. Examination performance on Invertebrate Biology (Year 2) before and after the introduction of the self-assessment quiz.

Academic Year	Number of students	Mean Examination Mark (%)	% Fail (<40%)	% Good Pass (>60%)	Total % Use of Quiz
1998-99	58	47.5	32.7	24.1	
1999-00	47	48.6	34	34.1	
2000-01	60	38.4	65	16.7	
2001-02	45	49.5	33.3	24.4	170.9
2002-03*	50	50.7	20.0	28.0	Not available
2002-03 SAQ	50	49.6	26.0	34.0	
2002-03 Essay	50	52.5	16.0	34.0	

Numbers in bold represent data collected after the introduction of the computer-based self-assessment quiz. NR = module not run in that academic year.

* = Data for overall examination performance. SAQ = Short answer questions

For the year 3 Parasitology module, small numbers of students used the quiz throughout the semester with a concentration occurring in the last two weeks before the examination.

Table 5 Examination performance on Parasitology (Year 3) before and after the introduction of the self-assessment quiz.

Academic Year	Number of students	Mean Examination Mark (%)	% Fail (<40%)	% Good Pass (>60%)	Total % Use of Quiz
1998-99		NR			
1999-00	24	56.2	4.2	45.8	
2000-01	43	48.5	18.7	18.7	125.6
2001-02	35	53.1	8.7	25.7	141
2002-03	27	50.3	11.1	14.8	262.9

NR = module not run in that academic year. Numbers in bold represent data collected after the introduction of the computer-based self-assessment quiz.

All three cohorts of students tended to favour logging-on in the middle of the working week and during 'office hours'. The numbers of students using the quiz appeared to improve in the 2002-03 year compared to the previous two. It is not clear why this should be, although these students would have been familiar with the quizzes from the previous academic year and the group may have discussed the benefits to their revision programme and decided to use the Parasitology quiz *en masse* immediately prior to the examination (Figures 1a -c). The examination results were variable between years making it difficult to assess the impact of the quizzes on performance (Table 5).

Discussion

This study has illustrated the value of CBA packages in supporting student learning. Previous work (e.g. Thelwall, 2000; Henly and Reid, 2001; Steele *et al.*, 2002) suggests that students can find computer-based self-assessment quizzes extremely helpful in monitoring their individual progress through a taught course and providing focus for their private study.

The patterns of use of the CBA packages were similar among all the groups of students investigated here. Although the majority of 'log-on' events were recorded during the working day (9am to 6pm) and mid-week, there was considerable activity outside these times. For example, the quiz for the Invertebrate Biology in 2001/02 was accessed on Sundays by 14% of the class (Figure 2a); 1-8% of students in all groups were logged on during the time periods between 6pm and midnight (Figures 3a and 3b) and a few students did use the quiz in the early hours of the morning. This implies that students were taking advantage of the opportunity to work in their own time and at their own pace, which is one of the expected benefits of CBA (Thelwall, 2000). A survey of students in the School of Biomolecular Sciences revealed that the majority of them undertook some form of paid employment during the term (S.Pitt, unpublished data). Provision of access to the quizzes at any time therefore fits in with irregular study times and gives equal opportunity for part time students to use them.

The first year students were least likely to use their quiz, with higher proportions of the second and third year students accessing their respective packages. The results showed that the students on one of the year 2 modules, Neurobiology, used their quiz most. This suggests that they found the package useful as an aid to learning and understanding a challenging subject. All the quizzes were set up to provide the student with immediate feedback once they had submitted an answer to the computer. This has been shown to be a key to deeper learning (Ramsden, 1999) and is expected that the students in this study were helped to greater awareness of the facts and fuller understanding of the concepts through their use of the CBA provided for them. The high proportion of the 2002/03 Parasitology group using the quiz suggests that they had gained an appreciation of this support for their learning while taking one or more of the second year modules mentioned in this study and had become more confident in using CBA.

It was interesting that although students had been introduced to the appropriate quiz at the beginning of the module and reminded to use it for on-going formative assessment, it appears that most of them waited until the few weeks preceding the examination to try it. The authors expected that more students would use the package for their module during the term, to help reinforce and deepen the understanding of lecture material (Cox and Clark, 1998; Croft *et al.*, 2001). Informal conversations with students suggested that many of them viewed the quizzes as means to 'test' themselves on knowledge, which they did not feel they would have until they had done revision towards the end of the module (S.Pitt, pers. obs.). Since the CBA packages have so far only been developed for a few modules within the Schools of Biomolecular and Biological and Earth Sciences, it is possible that

students viewed their use as a low priority. It also appears that the change of module leader for Human Physiology in 2002-03, to a staff member who had not been involved in the development of the quiz, adversely affected the rate of usage of the quiz for this module (A.Gunn, pers. obs.). This highlights the need to integrate computer based assessment and computer assisted learning more fully into the teaching at a university-wide level (Zakrzewski and Steven, 2003), so that students are more aware of the potential for these tools to promote deep and independent learning and staff are encouraged and supported to develop appropriate packages.

Although they were designed to be used 'on-line', some students attempted to print off paper copies of the quizzes and several complained of the difficulty this caused them. Apart from indicating that records of quiz use may be underestimated owing to some students working from paper copies rather than computer screens, this observation also shows that computer based learning and pencil and paper study are often seen as separate, rather than complimentary skills.

The introduction of the CBA package did appear to have a positive influence on examination marks for each module, although as other authors have found, the case for a direct, uncausal link is not clear (e.g. Thelwall, 2000). The outcome was most marked in the level 1 Human Physiology module. Following the introduction of the quiz in 2001-02, there was an improvement in examination results, with a decrease in the proportion of students failing and an increase in the proportion gaining good marks (Table 1). A similar pattern of results was repeated in 2002-03, although it must be noted that a comparatively small proportion of students taking the module used the quiz. This implies that the students who did use the package may have them helpful for learning facts and understanding concepts as previous authors have found (e.g. Cox and Clark, 1998).

For the other modules investigated here, improvements in mean examination mark, reductions in percentage failing the module and increases in the numbers of students performing well were also observed. The results from the year 2 Neurobiology module are particularly interesting. The mean mark was greater after the introduction of the quiz and in subsequent years and the percentage of students achieving a mark over 60% increased. Data from 2002/03 showed a significant positive correlation between performance on short answer questions and the essay question (Pearson Correlation = 0.391, N = 128, P < 0.001). The mean examination results for year 2 Invertebrate Biology fluctuated from year to year, but after the quiz became available, there was a clear increase in the percentage of students achieving good marks and a decrease those failing the examination (Table 4). Again there was a significant positive correlation between performance on short answer questions (Pearson Correlation = 0.585, N = 50, P < 0.001) and the essay question. This finding supports the idea that CBA when designed and used suitably can encourage a students' learning to move from surface factual recall to deeper understanding (Cox and Clark, 1998). Students tend to find the subject matter in the Neurobiology module challenging (A.Gunn, pers. obs.) and the high number of hits to the relevant quiz and the improvement in

marks suggest that many found it useful. However, the percentage of students failing the examination was consistently much higher than for the other modules under investigation and only fell below 30% for the essay section of the 2002-03 examination. This suggests that while the students whose work was of a satisfactory standard were aided by the quiz to achieve higher marks, students who were already performing less well were not. This may be because they did not respond to the style of the quiz or because they did not access it as often as some of their colleagues. Henly and Reid (2001) found that students who were already achieving assessment marks which placed them in the bottom 10% of the class in a (year 2) module, were less likely to access voluntary, formative assessment quizzes than the students in the top 10%.

The results from the year 3 Parasitology module are particularly variable (Table 5). The first cohort of students to take this module (1999-00) did exceptionally well without the CBA, which means that it is hard to assess its initial impact. Students appeared to have used the quiz more frequently in 2002-03 compared to the previous two years, but there was an increase in failure rate for the examination and decrease in the percentage of students achieving marks over 60% in that year. A range of other computer based materials have been used to support learning in this module (Gunn and Pitt, 2003) and data collection will be continued to allow a long-term evaluation of their effectiveness.

Academic staff who want to support their students by providing computer based self assessment should find the development programmes 'user friendly' (Steven and Hesketh, 1999; Thelwall, 2000), but writing the questions and designing the package is still time consuming. The teacher needs to be clear about why they are doing it and what they hope to achieve. Students seem to view formative CBA as a useful tool to help them assess their learning, identify areas which need further work (Thelwall, 2000; Steele, *et al.* 2002) and support their private study. However, as the results presented here and elsewhere (e.g. Henly and Reid, 2001) demonstrate, a significant minority of students will not use the materials if it is not compulsory. At present CBA and CAL packages appear to be good ways of supporting the more able and highly motivated students. As academic staff become more accustomed to using them in their teaching and more practised in writing suitable questions, patterns of usage by learners might change. However, this type of formative assessment is most useful if seen as complementary to other methods of assessment (Thelwall, 2000).

Communicating author Sarah J Pitt, School of Biomolecular Sciences, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF. Tel 0151 231 2209, Fax 0151 207 3224, e-mail S.Pitt@livjm.ac.uk

Acknowledgements: We would like to thank Jim McCloskey for his assistance in preparing the quizzes used in this investigation. We are grateful to the anonymous reviewers of the first draft of this paper for their helpful and constructive comments.

References

- Brown, S. and Knight, P. (1994) *Assessing Learners in Higher Education*. London, UK: Kogan Page.
- Cann, A.J. and Pawley, E. (1999) Automated online tutorials: new formats for assessment on the WWW. In: *SEDA Staff Educational and Development Series: Computer Assisted Assessment*, eds. Brown, S. Race, P. and Bull, J., pp.39-45. London, UK: Kogan Page.
- Cox, K. and Clark, D. (1998). The use of formative quizzes for deep learning. *Computers and Education*, **30**, 157-167
- Dewhurst, D.G., Macleod, H.A. and Norris, T.A.M. (2000) Independent student learning aided by computers: an acceptable alternative to lectures? *Computers and Education*, **35**, 223-241.
- Gunn, A. and Pitt, S.J. (2003) The effectiveness of computer-based teaching packages in supporting student learning of parasitology. *LTSN Bioscience education e-journal*, **1**, 1-7 (<http://bio.ltsn.ac.uk/journal/vol1/beej-1-7.htm>)
- Henly, D. C. and Reid, A.E. (2001) Use of the web to provide learning support for a large metabolism and nutrition class. *Biochemistry and Molecular Biology Education*, **29**, 229-233
- McEhlon, M. (1999) Creating web-based learning environments for teaching and learning about ecology. *Life Sciences Educational Computing*, **10**, 10-12.
- Pinckey, R.D., Mealy, M.J., Thomas, C.B and MacWilliams, P.S. (2001) Impact of a computer-based auto-tutorial program on parasitology test scores of four consecutive classes of veterinary medical students. *Journal of Veterinary Medical Education*, **28**, 136-139.
- Ramsden, P. (1999) *Learning to Teach in Higher Education*. London, UK: Routledge
- Riley, R. S., Ben-Ezra, J.M., Massey, D. and Cousar, J. (2002) The virtual blood film. *Clinics in Laboratory Medicine*, **22**, 317-345
- Ryan, M. Mulholland, C.W. and Gilmore, W.S. (2000) Applications of computer-aided learning in biomedical sciences: considerations in design and evaluation. *British Journal of Biomedical Science*, **57**, 28 -34.
- Sambell, K., Sambell, A. and Sexton, G. (1999) Student perceptions of the learning benefits of computer-assisted assessment: a case study in electronic engineering. In: *SEDA Staff Educational and Development Series: Computer Assisted Assessment*, eds. Brown, S. Race, P. and Bull, J., pp.179-191. London, UK: Kogan Page.

- Sly, L. and Rennie, L.J. (1999) Computer managed learning as an aid to formative assessment in higher education. In: *SEDA Staff Educational and Development Series: Computer Assisted Assessment*, eds. Brown, S. Race, P. and Bull, J. pp. 113-120. London, UK: Kogan Page.
- Steele, D.J., Palensky, J.E.J., Lynch, T.G., Lacy, N.L. and Duffy, S.W. (2002) Learning preferences, computer attitudes and student evaluation of computerised instruction. *Medical Education*, **36**, 225-232
- Steven, C. and Hesketh, I. (1999) Increasing learner responsibility and support with the aid of adaptive formative assessment using QM designer software. In: *SEDA Staff Educational and Development Series: Computer Assisted Assessment*, eds. Brown, S. Race, P. and Bull, J., pp. 103-112. London, UK: Kogan Page.
- Thelwall, M. (2000). Computer-based assessment: a versatile educational tool. *Computers and Education*, **34**, 37-49.
- Ward, J.P.T., Gordon, J., Field, M.J. and Lehmann, H.P. (2001) Communication and information technology in medical education. *Lancet*, **357**, 792-796.
- Zakrewski, S. and Steven, C. (2003). Computer-based Assessment: quality assurance issues, the hub of the wheel. *Assessment and Evaluation in Higher Education*, **28**, 609-623.