Open learning support for foundation chemistry as taught to health science students

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Abstract: On-line learning support for foundation chemistry was supplied to health science students via Blackboard and interactive web pages. The examples supplied were deliberately numerous, and very gently staged in order of difficulty. Our experience confirmed the advantages of using JavaScript rather than commercial software in the provision of this material. Students appeared to be enthusiastic and extremely grateful for provision of this additional learning material, but it was found that use of the material was mainly by students that were already both conscientious and good attendees. Preliminary indications were that most students, who regularly accessed the material, achieved better examinations results than those who did not although, as yet, we cannot claim these results are statistically significant. [*Chem. Educ. Res. Pract.*, 2006, **7** (3), 185-194]

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Introduction

Many UK further and higher education establishments run foundation year (sometimes called 'access') programmes. These are designed so that mature participants, without the usual formal entrance requirements, can gain the necessary skills and knowledge to proceed to the first year of a degree. Most students who successfully complete Glamorgan's health sciences foundation year go on to BSc (honours) programmes in Nursing or Human Biology. The foundation programme comprises modules devoted to: mathematics, computer literacy, learning strategies, biology and chemistry. These students were previously taught chemistry within a module developed to service the needs of all Applied Science students, a large proportion of whom require at least the equivalent of UK 'A' level Chemistry in order to pursue successfully the chemically related science degree of their choice (e.g. Forensic Science). The Health Science students differ from Applied Science students in all, or some, of the following respects:

- A high proportion are mature females (21+) and have been out of full-time education for a number of years.
- They are less confident with mathematics – indeed, they are less confident with all things that require a 'scientific' perspective (see Stephenson and Percy, 1989 and Hunter et al., 2001).
- They are less likely to recognise that chemistry is relevant to their chosen course and, in order to maintain their interest, references to chemicals that commonly occur in relation to health or medical matters need to be frequent.

With the above observations in mind, a new module entitled 'Chemistry for Health Sciences' was designed specifically to address the needs of these students. The cohort is large (typically 120+) and lecturer contact time is, as is usual for modules within the school, 3 h per week on average. This comprises: 1 h lecture, 1 h tutorial (for the teaching year) and 2 h practical (for half a teaching year). End of module assessment is via a two hour examination, practical work and coursework.

The principal objectives in constructing a 'tailor-made' module for this group were:

- To demonstrate the relevance of chemistry to their daily lives and in the medical professions, thus enhancing their motivation to learn
- To increase their confidence in dealing with scientific and numerical concepts
- To improve the end-of-year results
- And, hopefully, to introduce some enjoyment into the learning process!

Method

'Chemistry for Health Sciences' – structure and content

As with the other foundation chemistry course, all students received a copy of the lecture notes and a practical booklet at the beginning of the teaching year. The university has had a web-based virtual learning environment package (Blackboard[*]) available to both students and lecturers for some time and a 'back-up' copy of these booklets was made available on the Blackboard site. Both booklets covered the essentials of a basic chemistry course: formulae and equations, amount and concentration calculations, atomic structure, bonding, organic chemistry, basic spectroscopy and the periodic table. However, the notes, lectures and practicals were liberally sprinkled with chemical examples that were thought to appeal to these students as relevant.

For example, practical exercises included:

- determining the degrees of unsaturation in different cooking fats and oils;
- finding the citric acid content in Alka-Seltzer tablets;
- finding the content of Vitamin C in a cold remedy preparation by titration;
- testing the pH of common household substances, investigating the pH behaviour of several natural indicators and using a pH meter to monitor the pH change during an acid/base titration;
- determining the percentage of ethanoic acid in commercial vinegar.

Confidence building

In previous years, students from this cohort have requested that they be given more tutorial work so, in addition, end of topic self-study examples, with answers, were also posted on the Blackboard site (see later for a more detailed description of this aspect of the project). These examples were deliberately numerous and very gently staged with the intention that the student, having mastered a particular technique, should receive many positive 'can-do' reinforcements before proceeding to examples demanding the next small incremental level of understanding. This technique (overlearning) is well-known within educational circles (Driskell et al., 1992) as a good mechanism for aiding retention and, we reasoned, it should increase confidence in that the students would be able to confirm the correctness of response to a problem many times. There was no compulsion to do these exercises, but the students had previously demonstrated that they were anxious to 'do well' and we expected a high take-up rate.

[*] see www.blackboard.com

On line tutorial material

We looked for means of delivering extensive practice material that would not, in the long term, involve an increasing burden on the teaching staff. The delivery of paper based material (multiple problems all different) has been discussed elsewhere (Hall, 1998) and provides the basis for individualized course work. While this does also provide a mechanism for additional tutorial work, feedback requires a substantial input from teacher. We therefore investigated the possibility of on-line delivery of such material, which can offer interaction, feedback and support without significantly increasing student-instructor contact time (Cole and Todd, 2003). It was decided to undertake this work ourselves rather than involve professional computing support. This would allow us to maintain control of content and delivery timescale. It would also put us in a better position to explain the use of the material to students and to make adjustments in the light of their comments. In addition, given the modest computing background of the cohort, we wished to make the material as technically straightforward as possible – for example, it was considered that the requirement to download 'browser plug-ins' could be a significant turn-off for the students. Early student feedback certainly underlined the importance of off-campus access.

All Glamorgan students have access to Blackboard, the university's chosen virtual learning environment. This has proved useful for gathering student-use data and for delivering text (back-up copies of lecture notes, for example) but we have found the system somewhat restrictive for delivery of more interactive material. Blackboard was thus used as a portal through which students accessed a website. Interaction on the web pages was by means of JavaScript, a simple programming language able to operate within the HTML environment of a web page. JavaScript is widely used by professional web developers, but is simple enough to be used by non-specialists such as ourselves. We have now been offering on-line, formative self-assessment work to our B.Sc. students for many years and have not yet found a commercial assessment package able to offer the same flexibility as a JavaScript activated web page, nor even as an Excel spreadsheet incorporating macros.

Previous authors have discussed the use of commercial packages for delivery of on line 'quizzes' (Bunce et al., 2006) and examples are available on line – (see, for example, Lowry, 2005) and the European Chemistry Thematic Network. These, however, are dominated by a relatively simple structure; generally multiple choice questions and the provision of limited feedback – the answers are provided immediately and help is not 'staged'. Also, the exercises are tied into commercial templates. JavaScript allows us far greater flexibility in terms of question type, style and response structure. At first sight it might appear that this makes question and response provision more difficult than with Questionmark, WebCt, etc. However, once the initial learning time had been invested this has not proved to be the case, particularly since so many textbooks are available for programmers from novice to expert (Negrino and Smith, 2003).

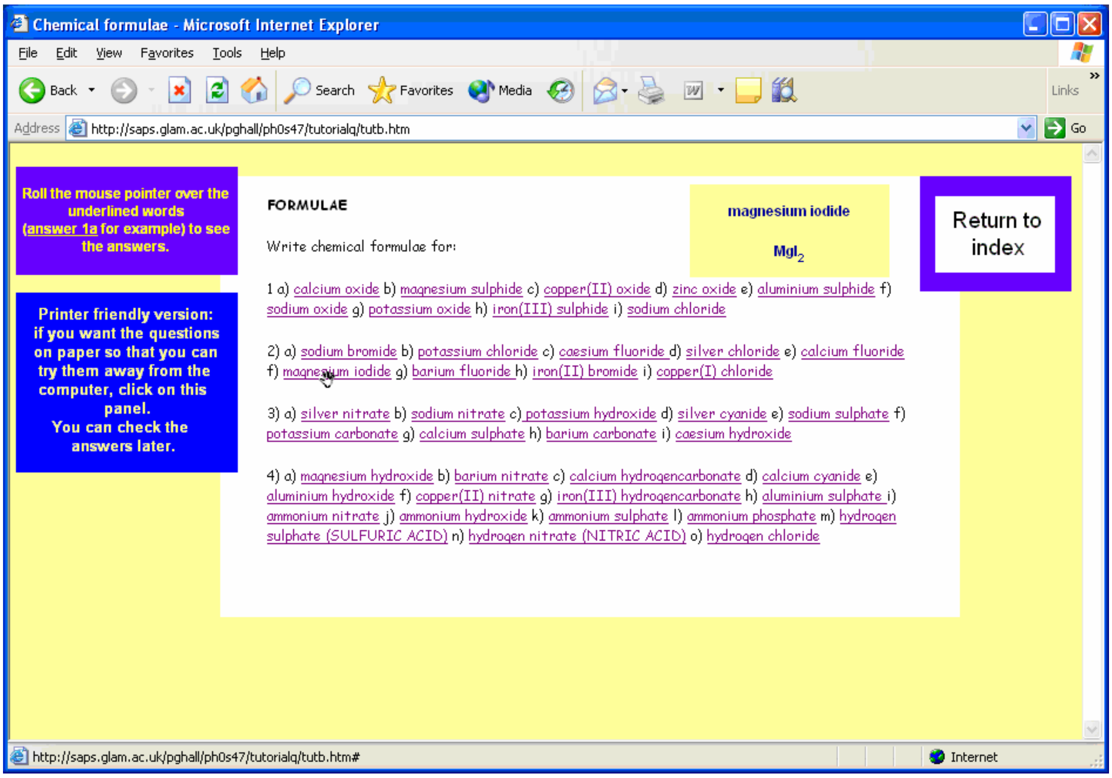
We duplicated one section of work using the commercial package, Authorware, and this only strengthened our commitment to JavaScript web-page development. Not only was the latter more flexible, it was also easier to work with and easier for the students to use. At the other extreme, we investigated the use of Java applets on the web pages. This, however, proved to be very time consuming and introduced a number of technical problems that have been identified elsewhere (Reid, 2004).

It should be stressed that our emphasis has been on providing material to aid students' learning rather than providing assessment material – particularly not summative assessment. We would be happy if others made use of our material and have designed some of it with this in mind. An individual item of our work can be incorporated as a known size pop-up window into the web page of other teachers/lecturers (Hall, 2005). The material can be used directly by others or be copied and modified – an important difference between our work and that of others.

In other subject areas (language teaching, for example) there are authors (Morrison) and organizations (Virginia Commonwealth University) who encourage the use of script languages to introduce interaction in on-line teaching material so, in the hope of persuading others to provide chemistry support in this way, we describe briefly how we set about this provision.

The material was developed along two lines. The first, the simplest from a programming point of view, involved limited interaction. The students were provided with problems based on paper materials given to them in tutorials. Interaction was limited to ‘pop-up’ answers and some pop-up support. This allowed us to provide a wide range of material available from day one. An example is shown in Figure 1. The pop-up nature of the answers prevents the students from printing these. Our past experience suggests that some students equate printing off the answers to having done the problems.

Figure 1. The most basic interaction, a pop-up response: rolling the mouse pointer over the question provides the answer (yellow box).



The second line of development involved a more interactive range of material. This provided more help and support for the students (see Figures 2 and 3). Feedback on student answers was immediate and a number of common errors were identified and commented on. As our experience developed, a certain amount of ‘entertainment’ was introduced into the material to encourage the students to return.

Figure 2. Interaction becomes more sophisticated: here students fill in the blanks to complete the periodic table. The software checks the answer and, if requested, shuffles the spaces to provide a new problem.

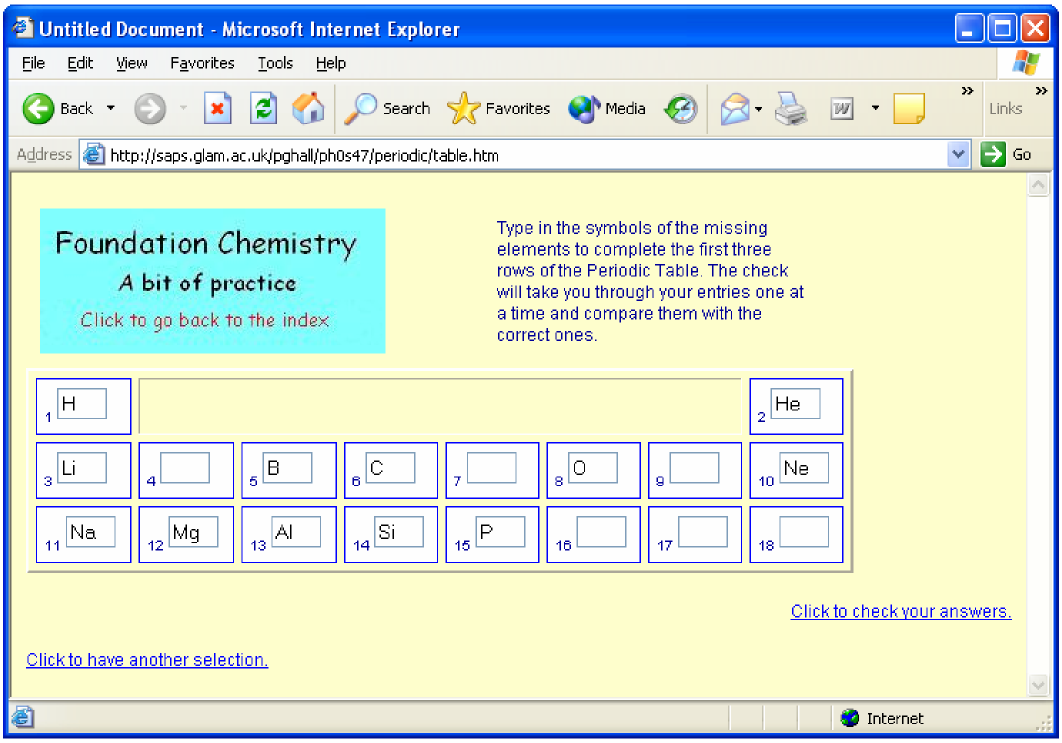
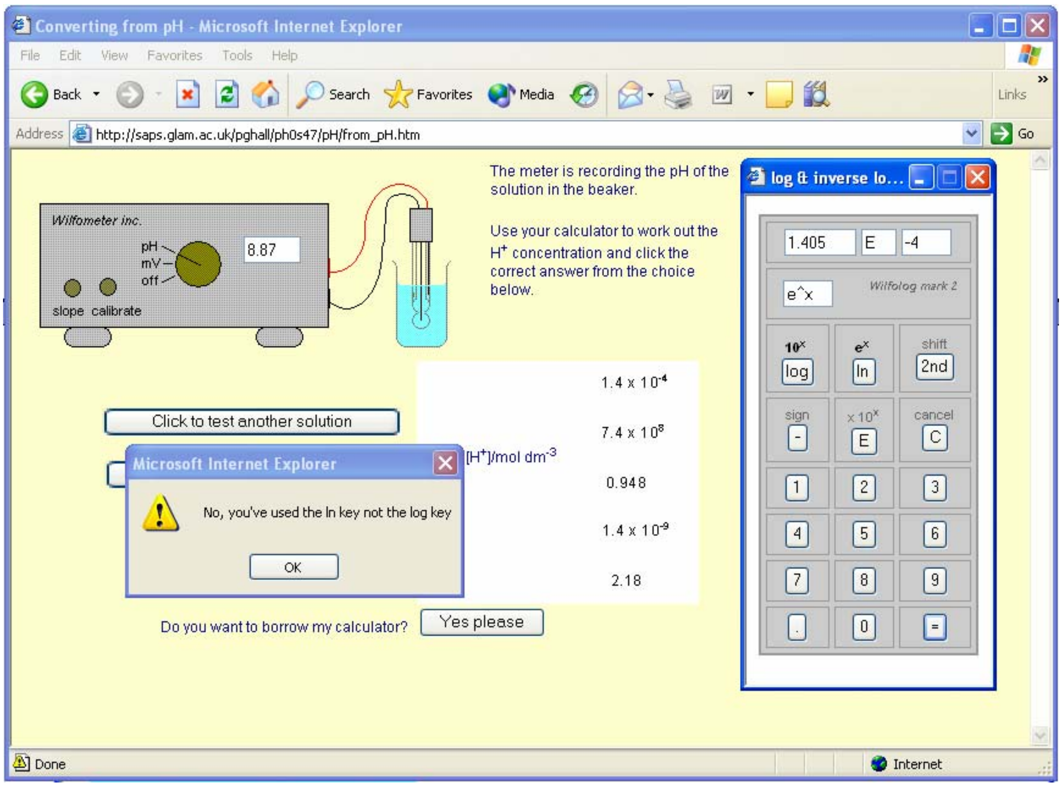


Figure 3. Help and support become more sophisticated: the student can access a calculator and the software can identify many common errors. The next problem is taken at random from a large array so that the student is presented with a new problem every time.



Results

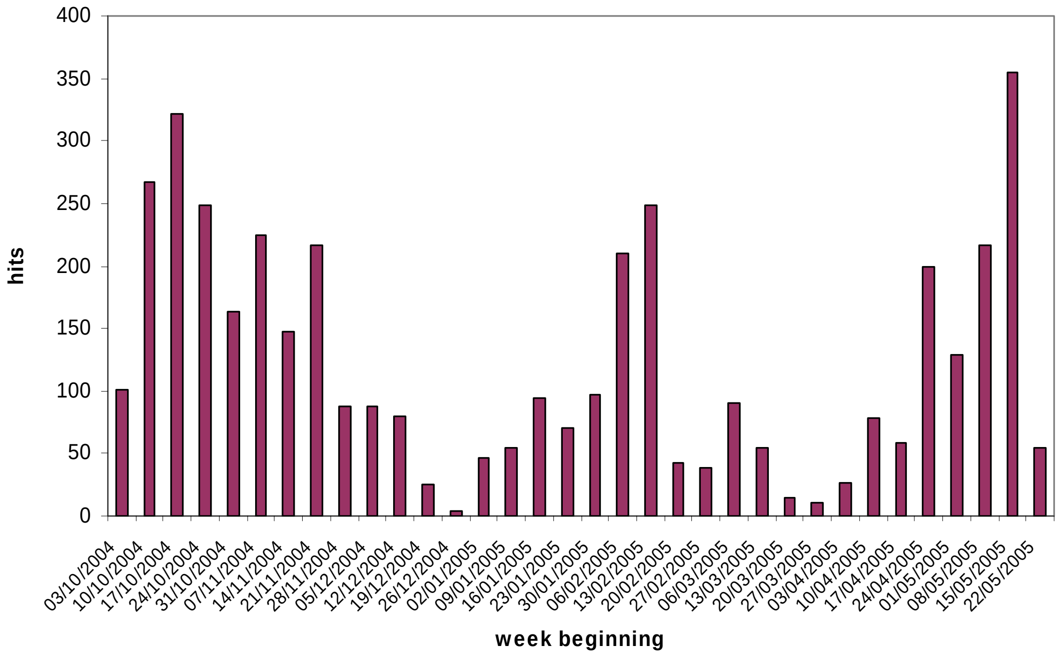
Monitoring of use

Our primary aim was to respond to student demand and provide the material rather than to undertake 'educational research'. To investigate the effect of this material on the students, however, two processes were used to provide quantitative information. One was the maintenance of an attendance register by the lecturer, and the other was the logging of use by Blackboard. It should be pointed out that the latter data were limited since once the students accessed the web material; they were no longer logged by Blackboard. In addition, a small but increasing number of students accessed the web site directly because it was simpler than access via Blackboard. This was primarily a teaching project, not a research project, so we were not prepared to halt free access to the web site.

The first encouraging point to arise from the limited data was that student use of the material did not seem to be dropping off as the year progressed (Figure 4). As would be expected, the initial Blackboard count was relatively high as students enrolled themselves onto the module on Blackboard and found out what all the buttons did. Although there was no requirement whatsoever on students to enrol on Blackboard, about 70% did so. This is similar to the take up reported by Lowry (2005) for on-line material delivered to what appears to be a comparable student group in terms of age and background. It is, however, much lower than the take up we obtained when first experimenting with on-line tutorial material with first year BSc students.

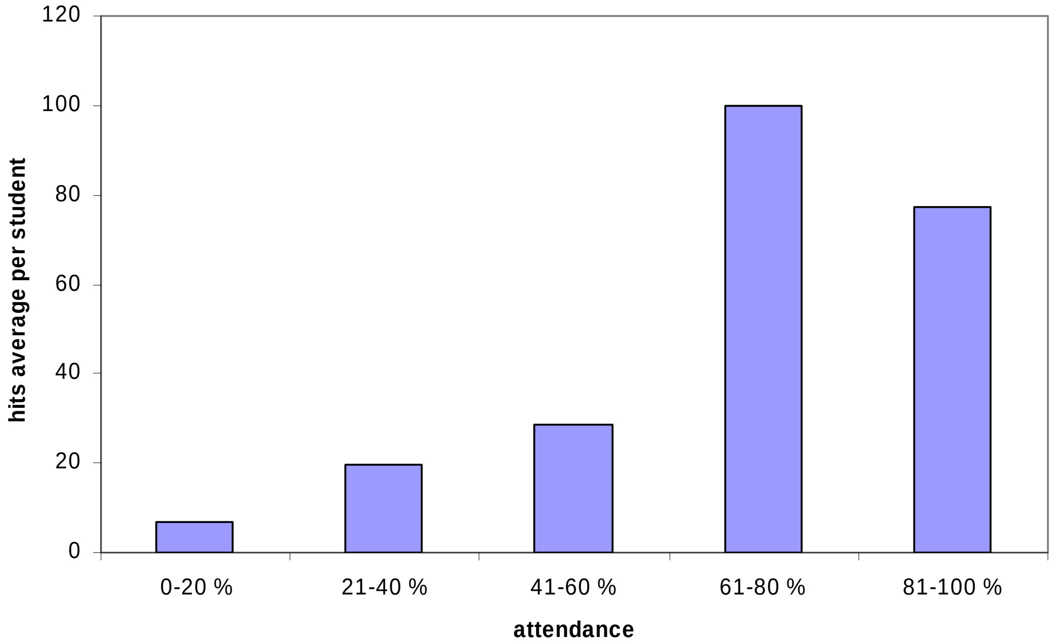
Initially, the web site was not available off-campus, but following considerable student pressure we were able to persuade the university to make the site available to the outside world. The results show that students made use of the material seven days a week and at all hours of the day and night – though the most favoured access time was not 11 p.m. to 1 a.m. as reported by Freasier et al., (2003).

Figure 4. Hits counted by Blackboard on a weekly basis. Note that the lulls correspond to the student vacation periods: December 18th-January 9th and March 19th-April 10th.



The second feature to appear quite clearly was the correlation between attendance at lectures and use of the on-line material (Figure 5).

Figure 5. The relationship between student attendance at lectures and hits counted by Blackboard: 0-20 % 14 students, 21-40 % 21, 41-60 % 25, 61-80 % 27, 81-100 % 15.

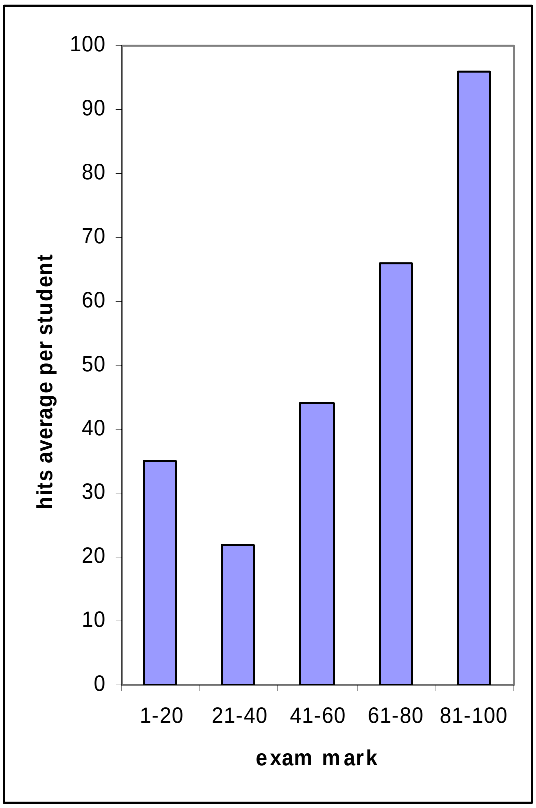


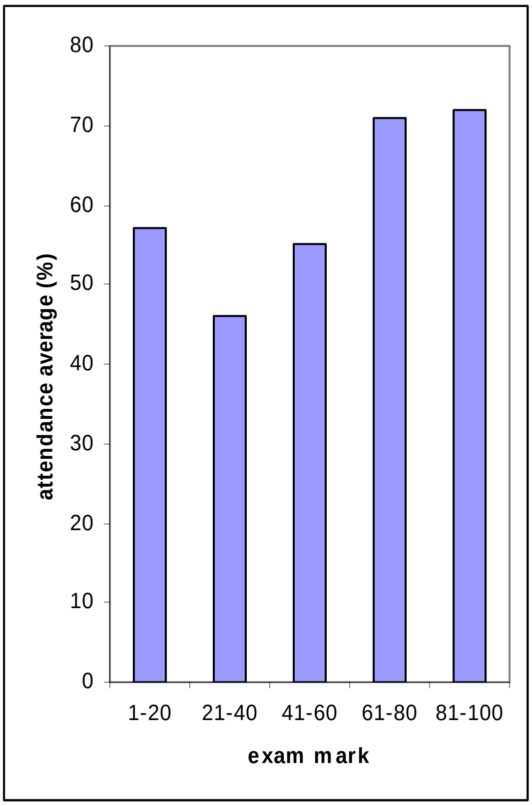
Another feature of the data, not shown by averaging as in Figure 5, was that whilst there were many students who had a high lecture attendance who did not access Blackboard, the reverse was not seen. There was not one poor attendee with a high hits count on Blackboard.

End of year examination

The data in Figure 4 show a one week spike (week beginning 15/02/2005) immediately prior to the exam. In the main, this is attributable to those who had been, in previous weeks, moderate users. There are few new users at this late stage of the year and those who had been heavy users no longer dominate the 'hits' count.

Figure 6. Attendance and ‘hits’ records as a function of exam mark.





Once the examination had been completed, we were able to investigate the attendance and ‘hits’ records as a function of exam mark. A summary of the results is shown in Figure 6 where, once again, the relationship between attendance and ‘hits’ is apparent. Also apparent, though not shown on the charts, is the effect that one individual can have on the figures. One student (out of 14) in the 1-20 mark range was both a good attendee and the second biggest user of the Blackboard/web material. Neglecting this one result reduces the 1-20 column of the ‘hits’ chart to 20 %.

Our view is that the link between ‘hits’ and exam mark is a result of both being a measure of conscientiousness and study skills. It is not therefore possible for us to say that use of the on-line tutorials improved exam performance since Blackboard use was so closely correlated with lecture attendance. We can state, however, that the exam average went up by 6 marks (out of 100) following the introduction of the on-line material. The exams for the two years were very similar but since no two student cohorts are the same, we cannot claim that this is significant.

Student feedback

We requested comments and criticisms through Blackboard and a number of students posted replies [their spelling and grammar have been corrected. Editor]. In the main, comments were extremely supportive, for example:

“Just to let you know that all the links are now working from home. The stuff on Blackboard is brilliant… “,

“THE STUFF IN THE LINK WAS A GREAT HELP TO A FEW OF US, SO CHEERS”, and

“Thanks for this information I have learnt a lot; wish I took it in as well as you have shown it”.

It is clear too that the students appreciate the amount of time involved:

"Just a quick e-mail to let you know that I find the Blackboard system very helpful. Thank you for spending the time in putting all the relevant information there".

"I log on black board everyday to revise my lecture notes. The online notes provide you an opportunity to study anywhere you are irrespective of time. It is a worth effort to put notes on-line. Thank you for the effort"

To date only one critical comment has arisen from a student who would like to see a clearer indication as to which lecture each component of the support material relates to:

"I do feel that the layout of chemistry on blackboard should be improved. When you log on it doesn't remind you what week that lecture was done…".

Account will be taken of this when revising the material for the next academic year.

Conclusions

Students appeared to find the presence of the on-line teaching exercises reassuring, in the sense that they knew there was extra revision material available if they required it. It also became clear, from the statistics available on the Blackboard site, that students were regularly accessing the site on weekends and so working from home.

Part of the argument for undertaking this work was to increase the amount of teaching material outside of class hours – thus benefiting students with non-traditional backgrounds and with family responsibilities that sometimes caused erratic attendance. It became apparent, however, whilst the material was extensively used, it was providing additional support for conscientious students, and it was not being significantly used by the non-attendees.

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