A STUDY INTO THE USE OF COMPUTER AIDED ASSESSMENT TO ENHANCE FORMATIVE ASSESSMENT DURING THE EARLY STAGES OF UNDERGRADUATE CHEMISTRY COURSES

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A Study into the Use of Computer Aided Assessment to Enhance Formative Assessment during the Early Stages of Undergraduate Chemistry Courses

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Abstract

A Virtual Learning Environment (WebCT and latter Moodle) was used to provide students with instant, meaningful feedback on their study of chemistry units during their first semester at University. Short multiple choice questions (MCQ's) were written covering each segment of material delivered in lectures and made available to students over the University computer intranet to allow "24/7" access. The most important aspect of the work was the feedback offered to students within the questions, which was written by undergraduate students to ensure its usefulness. The vast majority of the cohort used the MCQ's, most to gain formative feedback and some as a revision aid prior to summative examinations. During the evaluation, students reported that they found the ready access useful and helpful in learning the material. Some students used the MCQ's in preference to visiting tutors face to face (f2f) but most expressed a preference for the usual tutorial programme over such CAL methods. Most of the cohort used the feedback from the MCQ's to guide their revision, but again were not prepared to use CAL to replace f2f contact with tutors. Our work meets a number of the published conditions for effective feedback to occur. For example, it is immediate, timely and allows students to receive frequent feedback at a level which means that it can be used to inform further study. In the first year of using the MCQ's, there was a significant increase in the average marks in the end of unit examinations and a decrease in the drop-out rate during Semester 1. Although firm conclusions cannot be drawn from one year's data, these results together with the very positive reaction from the students encourage us to further develop the approach into the open source VLE Moodle, which allowed us to address some of the issues.

Introduction and Rationale

A number of staff in the department were concerned that UG students were not fully engaging with the programme of workshops and tutorials and so were not receiving useful formative feedback until end-of-semester examinations.

By this time it was often too late to fill gaps in knowledge or to correct misunderstandings since the teaching programme (which builds on this work) moves on at an increased pace. We were anxious to overcome this while not "spoon-feeding" students; we needed a method that would enhance and encourage them to take responsibility for their own learning and adopt a student centred approach. Although we are new to CAA in general, a small number of colleagues were keen to get involved. We had some experience in using a computer based question program (Question Mark Perception) but, for other purposes, were trialling a VLE and so were keen to investigate whether this could help us. All first year students live in University accommodation that is networked so allowing ready access to CAL materials. The University has a Learning Centre with > 450 networked PC's which is open 24 hr per day. It therefore seemed to us that CAA would potentially allow ready access to feedback.

In terms of the conditions for successful feedback, those most directly relevant to this project were:

1. Sufficient feedback is provided, often enough and in the appropriate detail
2. The feedback is provided rapidly to be useful to the learner
3. Feedback focuses on learning rather than on 'marks'.
4. Feedback is understandable to students, given their sophistication
5. Students should act upon the feedback in order to improve their learning.

The vast majority of students in this study were school leavers with A-level grades in the range BCC – AAA. Around half-a-dozen held International Baccalaureate qualifications, two progressed from university Foundation courses designed for broad entry to HE and one from a GNVQ route. In this cohort, there were no students older than 25. Approx. 40% of the cohort was female. Chemistry teaching at Bath is based around a traditional lecture format (ca. 6 per week, 50minutes duration) supplemented by problem classes (2 per week, 50minutes duration) and small-group tutorials (1 per week, 50minutes duration) with 5 – 6 students in each. Most formative feedback was obtained by students during tutorial and workshop sessions.

Methods

The project background was largely developed through informal discussions with students during tutorials and with colleagues. More in depth discussions were held with a small number of students who had recently completed their first year to further refine our ideas. However, at this stage "data" were largely anecdotal. For each small section (2 – 5 hrs) of lecture material, a short series of multiple choice questions were written to allow students to test their basic understanding of the fundamentals of the material as well as to give some questions to determine whether they could apply this knowledge. This was mounted on the University computer network and students encouraged to use

it during their studies in order to monitor their progress. It was in no way compulsory for students. However, part of the summative assessment for the units is a 2 hr MCQ unseen examination and students were told that most of the "past paper questions" were included in the MCQ's. Individual MCQ's were 'released' as the material was covered in lectures during Semester 1. A range of different question types was employed to test knowledge, ability to interpret simple observations as well as background mathematical skills and quantitative abilities. One advantage of using a computer over a paper based system is that some questions were designed around animations to enhance students understanding of e.g. reaction mechanisms. (Examples of the questions and the approaches are available on request). Simply telling students whether they had answered questions correctly or not would be of limited value. Into each question was therefore built some constructive feedback. Even if the question was right, feedback was given to enhance the learning (e.g. "Well done – you obviously remembered the correct units for the gas constant, R") and reinforce good habits. Wrong answers were met with an attempt to indicate where students had made errors.(e.g. "Have you considered the units of the gas constant ?", "Think about how many joules are in a kilojoule" or "What does the '1' in 'SN_1' mean?". In this way, students were not simply fed the answer but forced to think about why they were not correct in the first attempt. In the event that they were completely unable to answer a question, students were encouraged to use the question as a basis for discussions during tutorials and workshop sessions. The ready access to the computer network facilitated several conditions. No marks were recorded by staff (although they are available within the VLE) so that students were aware that doing the MCQ was solely to check their current state of knowledge and ability and for them to gauge areas of weakness on which further work was needed. In order to meet Condition 4, a student was employed who had just completed the year of study. They wrote or edited much of the feedback to ensure that it was at the correct level.

Resources

We used a VLE – WebCT, and later on integrated it into Moodle to make use of resources such as wiki's and synchronous discussion forums. In principle any CAA system (e.g. Question Mark Perception, etc.) could be used but we were evaluating a VLE for other uses and it was convenient for students to only use one system. Students need to be able to use a PC in order to access the VLE. A crude evaluation of the effectiveness of our approach can be gained from a comparison of the 2004/05 unit results and the umber of students who dropped out during Semester 1 compared with previous years. However, this of course is open to very considerable uncertainty given the number of factors that influence these criteria. The primary evaluation has therefore been by asking students to fill in a questionnaire (see appendix for paper based version). In addition, our project was aimed at students right at the start of their university careers so that they would not have had time to develop study strategies sufficiently early to make a later comparison meaningful. Also, we wanted only to use one questionnaire so as to avoid "questionnaire fatigue". A feedback questionnaire was therefore designed to incorporate the relevant questions directly relating to our project and more

generic ones about the VLE. These were produced in both paper and e-reports media. Students were asked to complete the questionnaire in early April, allowing time after the examinations and receipt of results (mid February) for students to reflect on their use of our MCQ's. The results of the questionnaire are shown in Appendix 2. Out of a total cohort of 115, 98 students returned questionnaires, a response rate of 85%.

Results and Discussion

In terms of the summative assessment of the unit, there was a distinct improvement in performance for this session. The assessment comprises a piece of coursework done mid-way through the semester together with a MCQ examination and a problems based examination held at the end of the semester. This year's cohort showed a significant improvement over the previous year with the average mark moving from 56.7 (s.d. = 13.4 to 65.2 (s.d.=10.6) this year. For each individual component, an improvement was shown with the most pronounced (perhaps not unexpectedly) in the MCQ examination where the average moved from 53.1 to 60.1. In the current academic year, only 1 student withdrew from the course before the Easter vacation compared with 6 in the previous session. Of course this is at best a crude evaluation of the effectiveness of our approach. Many other factors affect performance and withdrawal rates. The average A-level entry grades were somewhat higher for the later cohort (BBB versus BBC) and this may account for some of the improvement. However, we can at least conclude that the introduction of enhanced feedback has not had a negative effect on performance

Analysis of evaluation questionnaires

Of the cohort who answered the questionnaires, we were pleased to see that over 80% had used to the system to at least some extent. Given the well known cynicism of some students (the "it doesn't count so I won't bother" syndrome) this was satisfying. Of the students who did not use the packages, (18% of the respondents), their quoted reasons can be grouped into three main categories:

1. Motivation and student effort, typified by responses such as:

- "Didn't have the time, kept forgetting."
- "Didn't think it would be worthwhile".
- "General laziness. I also found them a little tricky to find. Lots of good intentions but never got around to it!"
- "Never had time during the exam period, spent most time on past papers etc. Should have planned to use them earlier in the term."

We have to accept that some students will never take advantage of the learning opportunities offered no matter what the mode of delivery.

2. Technical factors, including:

- "tried it a couple of times didn't work, so couldn't actually use it. Kept freezing. If it had worked would have used it."
- "Couldn't find them on the net. More links from the Chemistry pages would be helpful."
- "also would have had to have gone to the library in order to use a computer."
- "I did not have computer access in my room and it can be difficult to get a computer in the library."
- "Attempted to use them but became frustrated with systems' inability to handle 99% correct answers. e.g. 99kJmol^{-1} was right but 99(space)kJmol^{-1} was wrong."

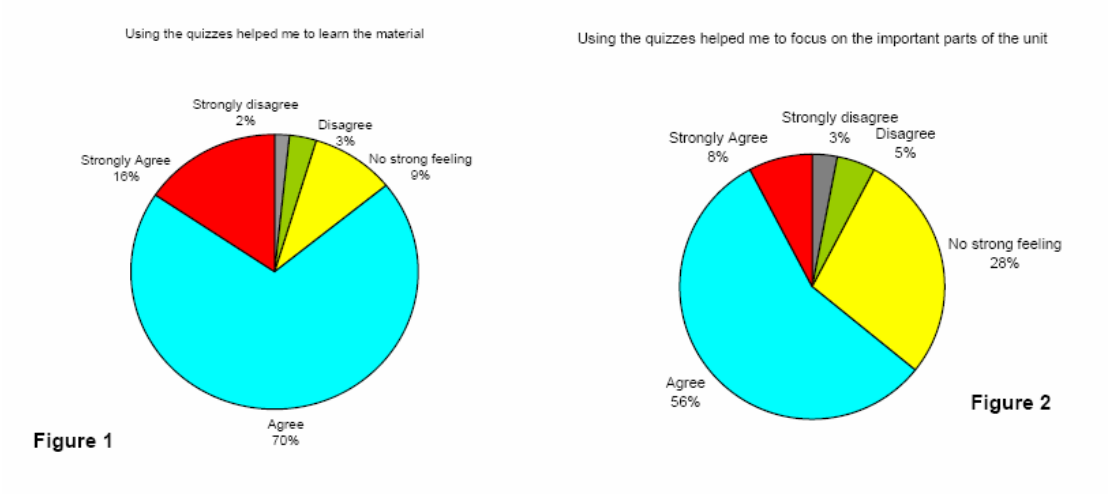
This was a relatively small number of reported problems considering it was our first experience of using the VLE system. The access problems are something that we will take seriously, and were generally down to linking our VLE with our student records system (SAMIS). The final comment is interesting but development of CAA systems has now rectified this. However, it seems that this student was focussing more on 'getting the mark' than acknowledging that they had obtained the right answer as an aid to learning.

3. Pedagogic factors and preferred learning and revision styles:

- "I don't find computer learning particularly useful. I tend to remember things by rote if I use MCQ's, instead of learning and understanding. Part of this was due to lack of time – I prioritised that my normal revision method was more effective."
- "Preferred to revise using books and notes with past papers, rather than using the computer, I don't really feel that MCQ's are my favourite way to learn, I often feel extremely unmotivated to do them."
- "I did not feel that the MCQ's would help me, as they are not the style of revision that I know helps me the most."
- "I would rather learn using a pen and paper! "
- "I find past exam papers more useful because in the past, MCQ's have not been as hard etc. as past papers."
- "I used past exam questions, as well as tutorials and workshops to assess how well I revised.
- Also, I didn't judge quite how much revision was needed in order to do well, and was fairly lazy!"

Given the strong steer from many sources that current students are computer literate and regard traditional teaching such as "chalk and talk" as old-fashioned, we were surprised at these comments, albeit that they are a small number. The responses were initially anonymous so that it is not possible to correlate use of the system with individual comments to see if students'

performance might have been hampered by not using the MCQ's. Although the evidence from the latest study using Moodle seems to show a strong link. Of the 80 students who did use the system, 65% used them for formative feedback during the semester, the other 35% using them as a revision tool in the run up to the end of semester examinations. Of the former group, about half used all the MCQ's and of the rest, the preference was to use the MCQ's for units that were found difficult rather than those in which students were most interested (questions 2 and 3). Few students used them only to prepare for coursework. A gratifying feature was that the majority of students felt that using the MCQ's had helped them to learn the material covered in the units (see Figures 1 and 2). While anecdotal in nature this, along with the improvement in examination performance, suggests that we met condition 5.



Significantly though, students were neutral on whether the feedback had helped them plan their study (question 13). Only 7 students either strongly agreed or strongly disagreed that this was the case and equal numbers either agreed or disagreed (Figure 3). Similar responses were received concerning the effectiveness of the approach in bridging the school-university transition (question 14). There was a slight preference for the suggestion that using the packages helped to develop independent learning although few students seemed to have used the feedback as a basis for seeking further help during tutorials. Only 10 students felt that the CAA approach was better than the traditional tutorials, even though it is more readily available (Figure 4).

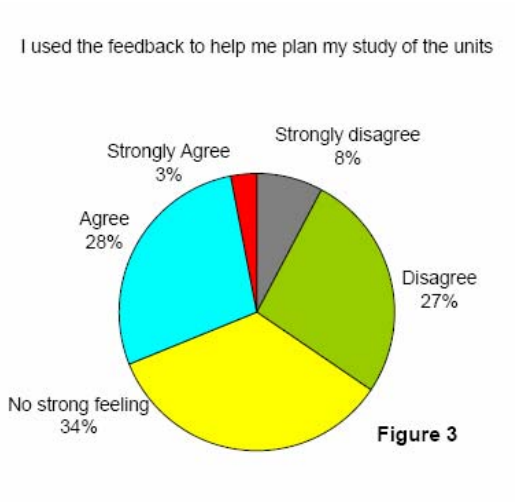


Figure 3

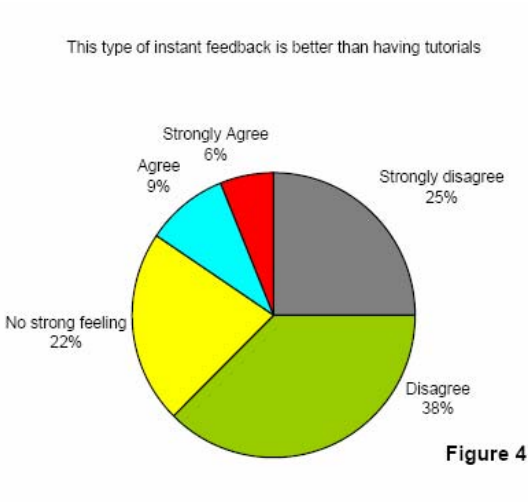


Figure 4

Only 5 students felt that the questions were too hard and 11 did not understand the feedback given. While the latter figure is higher than we would like, the results indicate that we largely met our target of the MCQ's and feedback being at the correct level for the particular cohort of students, meeting condition for effective feedback.

A larger proportion of the class used the feedback MCQ's as an aid to revision for the final assessments. Of these 80 students, all but 9 used the MCQ's to gauge how their revision was proceeding and the majority used them as a diagnostic tool to focus their revision (Figure 5) and the majority (73%) agreed that the feedback was helpful in learning the material. 85% of students liked the ability to get answers at any time, of relevance to Condition 2. Again not surprisingly, students expressed strong preference for visiting Tutors to get problems answered rather than simply using electronic means (Figure 6).

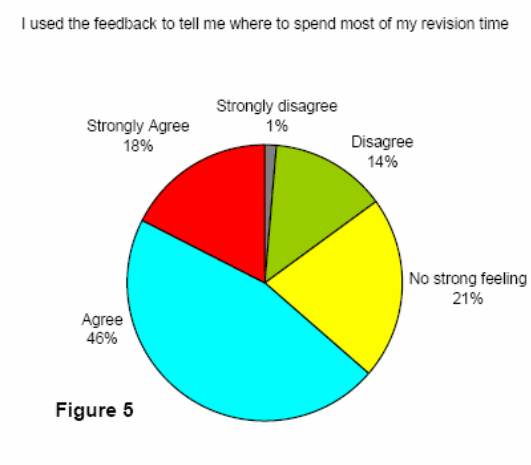


Figure 5

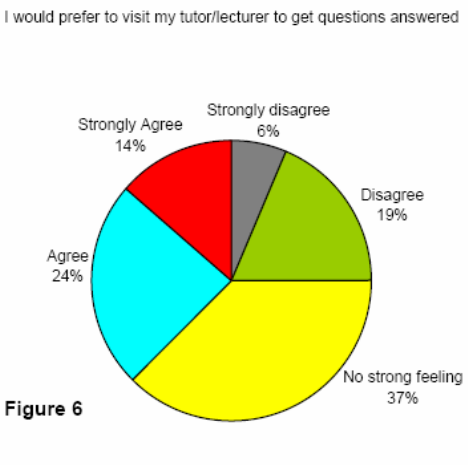


Figure 6

Analysis of overall aims and objectives of the project

When we designed the system, our hope was that the system would lead to:

- All students using it after each lecture “section” was completed
- Better focus of tutorials and workshops
- Prevention of some visits to staff with trivial problems
- More effective use of staff time in dealing with problems
- Less questions to staff during the revision period
- More effective revision
- Better performance in assessments

So, what was the result? A good proportion (82% of a 85% response rate) of the cohort did use it for formative feedback during the semester while a second group used it as a revision aid. Although few students said that they used the MCQ’s to focus tutorials, comments from staff suggested that there were less visits with trivial problems this year although there is no firm evidence. Most students felt that using the MCQ’s had improved their overall assessment performance and this is supported by the change in average marks, albeit for a single cohort.

Our aim was to use CAA to enhance our traditional teaching methods, not to replace them. In this we seem to have been successful, at least in terms of student acceptability. One telling comment which applies to CAL methods in general rather than specifically to this project was:

“I came to Bath because of the friendliness and approachability of staff – and then you send me away to work with a computer on my own”.

Clearly, we need to manage the introduction of CAL carefully if detrimental changes to our departmental ethos are not to occur.

Analysis of the conditions for effective feedback

The conditions of major interest to this project are shown in **bold**.

	Condition	Project response
1	Assessed tasks capture sufficient student time and effort	The MCQ’s were well used and so captured time and effort. The results suggest that this was, in the main, sufficient.
2	These tasks distribute student effort evenly across topics & weeks	This applies to those students who used the feedback through the semester, less so for those using it as a revision aid.
3	These tasks engage students in productive learning activity	The results suggest that activity to have been productive!
4	Assessment communicates clear and high expectations to students	Not applicable here.
5	**Sufficient feedback is provided, often enough & in enough detail**	**Feedback is available whenever students want it; it is up to them to use the MCQ’s. Most students found the level of detail in the feedback appropriate.**

6	**The feedback is provided quickly enough to be useful to students**	**It is instant and so can be acted upon rapidly.**
7	**Feedback focuses on learning rather than on marks or students**	**The feedback focuses on getting students to think about the material and to re-study in the case of incorrect answers. There are no links to assessment grades.**
8	Feedback is linked to the purpose of the assignment and to criteria	Not applicable here.
9	**Feedback is understandable to students, given their sophistication**	**The feedback was designed by students and the survey results suggest that it was at the right level.**
10	Feedback is received by students and attended to	Feedback is certainly received by students and their comments suggest that most acted on it.
11	Feedback is acted upon by students to improve their work or their learning	This is difficult to quantify but seems to have been a satisfactory result of our work.

Conclusions

Overall, the project was successful. We underestimated the time commitment required to set up such a system of MCQ's, even when using a commercial software product such as WebCT or open source Moodle and importing questions into it from WebCT. We were pleased at the comparative lack of technical problems faced by students – albeit that this was offset by the staff set-up time spent ensuring that things were robust. The main unforeseen circumstance that we encountered was the comparative overloading of students in the first few weeks of their university careers. Although we hoped that our feedback system would help in the school-university transition, it was hardly used in the first few weeks. Enquiries to students showed that many were overwhelmed by the number of new procedures, tasks, skills and general activities that take place in the first couple of weeks, both academically and socially. A second introductory session was held after 4-5 weeks of the semester and usage increased afterward. The initial set-up time and technical support necessary for such a system should not be underestimated. Sourcing, devising and inputting the questions was time consuming (ca. 13 weeks for an undergraduate student). Even though a commercial VLE was used initially, there were technical issues in its use in terms of student access, passwords etc. and in working out how to include some question types (e.g. those with video clips or the interface with PowerPoint). Individual students also needed help with accessing and navigating the system, although this improved when Moodle was adopted with its user friendly interface.

References

Conditions Under Which Assessment Supports Students' Learning Graham Gibbs and Claire Simpson Learning and Teaching in Higher Education 1, 3-31.

Appendix 1: Student evaluation questionnaire

FAST Project Feedback Questionnaire

The feedback packages were developed using funding from a UK wide initiative entitled *Formative Assessment in Science and Engineering*. Your feedback will be important in refining the quizzes for future students and will feed into the national evaluation of the project.

Section 1: Your use of the quizzes

Did you use the WebCT revision/feedback quizzes?

☐ **Yes** (*Please go to Section 2*)

☐ **No** *(Please go Section 4)*

Section 2. Using the quizzes for feedback

(If you used the quizzes only in the run up to the end-of-unit examinations, please go to Section 3 overleaf)

Please rate the extent to which you agree with each of the following statements by ticking the appropriate box

	strongly agree	agree	somewhat/don't know	disagree	strongly disagree
I used all the quizzes that were provided	☐	☐	☐	☐	☐
I used the quizzes only for units that I found difficult	☐	☐	☐	☐	☐
I used the quizzes only for units that interested me most	☐	☐	☐	☐	☐
I took the quizzes several times to see if I improved	☐	☐	☐	☐	☐
I used the quizzes only to help prepare for coursework/tutorials	☐	☐	☐	☐	☐
Using the quizzes helped me to focus on the important parts of the units	☐	☐	☐	☐	☐
Using the quizzes helped me to learn the material	☐	☐	☐	☐	☐
The questions were too hard	☐	☐	☐	☐	☐
I couldn't understand the feedback that was given in the questions	☐	☐	☐	☐	☐
This type of "instant feedback" is better than having tutorials	☐	☐	☐	☐	☐
The feedback was sufficient to help me understand where I went wrong	☐	☐	☐	☐	☐
I used the feedback to help me to plan my study of the units	☐	☐	☐	☐	☐
Using the quizzes helped me to bridge the gap between school/college and university	☐	☐	☐	☐	☐

Using these packages helped me to develop independent learning rather than just relying on tutors	☐	☐	☐	☐	☐
I used the feedback to know what questions to ask during tutorials	☐	☐	☐	☐	☐

Please add any comments that you wish to make on the reverse of the questionnaire.

Section 3. Using the quizzes for exam revision

Please rate the extent to which you agree with each of the following statements by ticking the appropriate box

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I used the quizzes to assess how well my revision was going	☐	☐	☐	☐	☐
I used the feedback to tell me where I needed to spend most of my revision time	☐	☐	☐	☐	☐
The feedback on answers was useful in learning the material	☐	☐	☐	☐	☐
Using the quizzes meant that I didn't have to visit my tutor/lecturer with problems	☐	☐	☐	☐	☐
I liked being able to get answers at any time	☐	☐	☐	☐	☐
I would prefer to visit my tutor /lecturer to get my questions answered.	☐	☐	☐	☐	☐
Having access to the quizzes improved my performance in the examinations.	☐	☐	☐	☐	☐

Please add any comments that you wish to make on the reverse of the questionnaire.

Section 4.

Please explain why you didn't use the quizzes.

(Continue overleaf if necessary)

You have finished the questionnaire. ***Thank you for your help***!

Appendix 2: Evaluation questionnaire responses

Section 1		NO	(%)	YES	(%)		TOTAL	
1	Did you use the quizzes	**18**	18.4	**80**	81.6		98	
Section 2		Strongly disagree	Disagree	No strong feeling	Agree	Strongly Agree		Strongly disagree
2	I used all the quizzes that were provided	12	20	9	13	10	64	19%
3	I used the quizzes only for units that I found difficult	7	17	5	29	6	64	11%
4	I used the quizzes only for units that interested me most	11	30	12	10	1	64	17%
5	I took the quizzes several times to see if I improved	7	21	11	21	4	64	11%
6	I used the quizzes only to help prepare for coursework/tutorials	13	30	14	6	1	64	20%
7	Using the quizzes helped me to focus on the important parts of the unit	2	3	18	36	5	64	3%
8	Using the quizzes helped me to learn the material	1	2	6	45	10	64	2%
9	The questions were too hard	8	28	23	5		64	13%
10	I couldn't understand the feedback that was given in the questions	8	37	8	10	1	64	13%
11	This type of instant feedback is better than having tutorials	16	24	14	6	4	64	25%
12	Feedback was sufficient to help me understand where I went wrong	3	9	17	32	3	64	5%
13	I used the feedback to help me plan my study of the units	5	17	22	18	2	64	8%
14	Using the quizzes helped me to bridge the gap between school/college and university	8	16	23	17		64	13%
15	Using these packages helped me to develop indepdendent learning	3	9	27	22	3	64	5%
16	I used the feedback to know what questions to ask during tutorials	8	19	23	14		64	13%
Section 3								
17	I used the quizzes to assess how well my revision was going		9	10	44	17	80	0%
18	I used the feedback to tell me where to spend most of my revision time	1	11	17	37	14	80	1%
19	The feedback on answers was helpful in learning the material	1	4	17	46	12	80	1%
20	Using quizzes meant I didn't have to visit my tutor/lecturer with problems	12	32	18	17	1	80	15%
21	I liked being able to get answers at any time	1	1	10	39	29	80	1%
22	I would prefer to visit my tutor/lecturer to get questions answered	5	15	30	19	11	80	6%
23	Having access to the quizzes improved my performance in the exams	1	7	33	31	8	80	1%