An Analysis of the Use of Virtual Delivery of Undergraduate Lectures

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ABSTRACT

Educators and technologists have been wrestling with the most appropriate way in which to use information technology in teaching and in learning, for some years. We have seen online course notes, both linear, hypertext and hypermedia format, lecturer/student communication via electronic bulletin boards or via email, multimedia courseware with student-directed learning and many others. All of these approaches have had limited impact on mainstream teaching in our Universities and colleges and we believe one of the reasons for this is that these attempts all represent a significant shift in the normal student-lecturer relationship and an enormous amount of effort on the part of the lecturer. In our work we have addressed this by using technology to replicate the traditional mode of delivery of lectures to a class. The presentation of lecture material was digitally recorded, both audio and synchronised visuals, and made available for students to take in their own time. In addition we provided 3 orthogonal means to access this material. The present paper describes our analysis of the use of these "virtual lectures" by a class of over 100 students. Our analysis includes log files of all accesses to the online material, pre-course and post-course questionnaires and anonymous questionnaire feedback, some of this is compared to exam performance. Results indicate that mode of delivery, student usage and a student's technical bias have no impact on overall exam performance.

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1 Introduction

As modern computing environments and networking infrastructure arrives on the doorsteps of more and more of us we find increasing pressure to make effective use of this technology. Educators, in particular University educators, appear to feel this pressure most because the students we deal with are the most mature, and the technology in our workplaces tends to be of the most advanced type and thus the opportunity and the benefits are greatest [1]. Despite having motive and opportunity, the uptake on using information technology as an integral part of University education is sporadic, with some experiment and innovation, but little universal impact [2].

Information technology, and in particular multimedia computing, has been used in a variety of ways in University education. This includes the use of computers in class for demonstrations by lecturers, the creation of electronic classrooms with synchronous student and lecturer access, the creation of online course notes in linear [3] or in hypertext/hypermedia formats [4]. We have also seen the creation of off-line multimedia courseware, often distributed on CD-ROM, and the creation of such CBT material has turned into a huge industry. All of these have their roles in our educational system yet none of these are being universally embraced. Various reasons for this can be hypothesised such as costs, the huge investment in lecturer time demanded and the perceived lack of reward for those making such innovations.

In our work we have developed an application for multimedia computing in our teaching which involves replacing the traditional delivery of lecture material to a class of students, with the electronic capture of this delivery and making this delivery available to students whenever they want to take it. By cancelling traditional lectures as we have done and making the material available online we are supporting the ideals of having student-directed and student-controlled learning. The material, which we refer to as *virtual lectures,* is available and it is up to the students to take this material at a time of their choosing and as many times as they want to. Placing this control in the hands of the students provides clear benefits.

In this paper we present an analysis of the use of one course delivered via virtual lectures. The analysis on student usage was performed using the system log files, which record all accesses, timestamped and traced to the individual and the location of the access, the results of pre-course and post-course questionnaires which students completed, and performance in an end-of-course examination.

The course we used was a third year undergraduate course in database, primarily because the subject matter is relatively static compared to other courses in computing. The syllabus includes database design and ER data modelling, the relational model, SQL, the system catalogue, query optimisation, distributed databases, normalisation and database security [5]. Databases are evolving slowly rather than going through more frequent change as with other courses in multimedia systems or networking, for example. Also, the students attending this course are in their third year of a four year degree program and so are more mature, while at the same time exam performance in this course does not count towards the final classification of degree awarded and so it is not absolutely critical. Finally, the subject is a core subject and is taken by all students, thus giving us a maximum number of subjects for analysis.

In the next section of the paper we describe the ways in which we created the virtual lectures for the course and how we made it available. We also describe the various ways in which students could access material and we introduce the students who took the course. In section 3 we describe the types of analysis which we undertook. Specifically we compared the examination results of the group using the multimedia presentation of the material with the corresponding results from a group who had received traditional lectures in an earlier year. We also give details on the usage analysis and the user questionnaires referred to above. In section 4 we present the results of these analyses. A final section brings together our overall conclusions and discusses the impact our results will have on our future teaching of this subject.

2 Creation of Virtual Lectures

In preparing the virtual lectures course our starting point was the traditional lecture delivery given in previous years. Instead of delivering the course to a class of perhaps 130 students in forty 1-hour lectures, the material was divided up into 119 "chunks" or standalone elements.[1] These topics are each individual elements of the course and several of them would normally be woven together to make up a 1-hour lecture. Each of the topics was turned into a "presentation" consisting of an audio track and a set of associated visuals, which should be presented at various synchronisation points throughout the "presentation". While each presentation is independent there is an overall linear ordering to the presentations, which is the same as the ordering of material when presented via traditional lectures.

The audio was recorded using CoolEdit96 [6], a shareware audio recording tool, by sampling 16-bit samples at 22KHz and the recording was post-processed to normalise and reduce noise. The audio was then converted into RealAudio format [7] and placed on our RealAudio server. Prior to the recording of each presentation, the visuals to be presented were created. These visuals were created as an equivalent of OHP "slides", a screen of text and image information which was used as a prop to the audio stream. During the recording, the timepoints at which the set of visuals for a presentation should naturally appear would be noted. After the recording, each page or OHP "slide" used during the presentation was turned into an HTML page using FrontPage [8], and placed on our WWW server. Most of these 300+ HTML pages contained text and image, while some contained simple animations in the form of GIF89a graphics. We chose to use GIF89a animations rather than Java because it made the synchronisation easier. For each of the 119 presentations we then created a synchronisation file, detailing the synchronisation points at which the various HTML pages should be presented to the user.

To play a presentation a user uses a RealAudio player, free for personal use, which has start/stop/pause/rewind/FF controls, and the RealAudio player launches the audio for the presentation. The technology we used, however, has two important features. Firstly, as an audio presentation is played, the HTML pages given in the synchronisation file for that audio

[1] These varied from 1 or 2 minutes up to 71 minutes, with the average being about 10 minutes long. In retrospect we now realise that the 71 minute presentation (on SQL syntax) was too long

track, appear in the users favoured WWW browser, either Netscape or Internet Explorer. As the user rewinds, fast forwards or jumps to a location within the presentation, the RealAudio server instructs the WWW browser on which HTML page to load, so the audio and visuals are always in synch. The second important feature of RealAudio from our perspective was that the delivery could be streamed. That means that as a user requests an audio track to be played, the data is downloaded and plays as soon as enough has been buffered. The downloading continues at a rate fast enough to keep the buffers full, which in turn means that the bandwidth requirements for RealAudio are relatively low and a connection via a 28.8kbps modem is adequate.

In delivering this course using traditional one-to-many lectures, a total of 40 hours of lecturing was needed. This distilled naturally into about 18 hours of virtual lectures, for exactly the same content. This can be put down to the concentrated nature of the virtual lectures presentation, a point we return to later.

To facilitate users in navigating the material we replicated the traditional table-of-contents we have used in the traditional delivery. In this case we have 14 chapters, each divided into sections and subsections and each of these points to an audio presentation. The entire audio was then hand-transcribed into ASCII and using tools developed by our *Multimedia Information Retrieval* research group we developed a search mechanism whereby a user's typed-in search request would retrieved a ranked list of starting points throughout the course, in mid-presentation, where the topic of the user's query was discussed. Clicking on one of these would launch the presentation at that point in the course. Finally, we manually created a back-of-the-book index of topics and sub-topics with each of these pointing to the place in the course, again possibly in mid-presentation, where that topic was discussed [9].

Each student on the course was given a unique ID and password to access the materials in their own time. The PCs in several laboratories on campus were configured with the RealAudio player installed and pointers were created to where the player could be downloaded. Paper copies of the visuals were copied and distributed to students and a once-fortnightly meeting/tutorial between the lecturer and students was held to go over difficult material answering any clarifications students required, and working through example material. Traditional lectures for this course were cancelled and students were given pointers to the online material instead. All communications with students in terms of continuous assessment schedules, availability of new material, past exam papers, etc., was via the WWW.

3 Types of Analysis

In the context of our virtual lectures project there are many aspects which we would like to measure such as development costs, transferability to other subjects, effort required to maintain the course, student reaction, ease of learning and the amount of material actually learned by students. Some of these are documented elsewhere while in this paper we are primarily interested in whether the virtual lectures worked as a vehicle for teaching. While end-of-year exams are a crude measure of the amount of material learned, and we know that, they are the only measure we have available to us, and so we use them.

At the end of the course, students take a written examination of 3 hours duration in which they answer questions about the course content. These questions are a blend of recall (turn some English queries into SQL), and understanding (comparing aspects of databases related to different parts of the course). The overall exam mark is a combination of the written exam and a mark given for a series of continuous assessment exercises but for the purposes of these analyses we use only the mark from the written exam.

There are several types of analysis one can perform to measure many kinds of variables in a project such as this. In our case we were interested in three particular aspects. The first was the impact of multimedia delivery on exam performance compared to traditional delivery methods. The second was the patterns of usage of the system. As each user has their own ID, it is possible to analyse, from the http log files, the date, time, location and identification of every audio presentation played by every student during the course. This is invaluable material and can be compared with exam performance to see how various usage patterns affect overall exam performance. From the beginning of the course through to the date of the written exam, the course lasted approximately 150 days, including the Christmas vacation and pre-exam study periods. Related to this we chose 5 different variables to measure study behaviour, which can be extracted automatically from log files and these are:

- AHIT: the first date that a student logged into the system and played an audio presentation
- ZHIT: the last date that a student logged into the system and played an audio presentation
- HIT50: the number of audio presentations taken by a student up to and including day 50 of the course (the one third point)

- HIT100: the number of audio presentations taken by a student up to and including day 100 of the course (the two thirds point)
- TOTHIT: the total number of audio presentations taken by a student

In the next section we shall see how these correlated with exam performance.

The third issue of interest was the extent to which prior experience of multimedia conferred advantage on such students. In addition to hard usage figures for the course, we carried out a pre-course questionnaire, in class, which measured each student's technical adeptness. This questionnaire asked things like whether the students had a PC or a modem at home, how often they browsed the web and for what reasons, whether they had created their own home page, how much HTML they knew, whether they had heard of or used RealAudio, and so on. The pre-course questionnaire was designed to measure the technical nature of each student albeit not as a single figure but as a set of answers to the above questions. Because these questionnaires were named, these answers could also be correlated with performance in the final exam. Students completed these questionnaires at the start of the course and the questions asked are shown in Appendix A. Some of these require answers on a linear scale of 1 to 9 and some are dummy (binary) variables, i.e. yes/no question. As with usage of the virtual lectures, the answers to these questions were correlated with exam marks and the results of this are presented in the next section.

4 Results of Analysis

There were a total of 115 students who registered for the course, attended interviews, completed the questionnaires, used the system and completed the written examination. These students form the basis for our analysis. While others are registered for the course (about 15 students) they are excluded because they are repeat students, they withdrew from the written examination, withdrew from the course, or did not complete survey forms.

4.1 Comparison of delivery types

Our first analysis was to determine if the overall level of examination performance was affected in any way by choosing to deliver the course in multimedia form as opposed to traditional lectures. We compared the distribution of examination marks for the years 1995 (traditional delivery) with those for 1997 (multimedia delivery), the former effectively acting

as a control group. Note that in the 1995/96 academic year the course had been taught and the examinations graded by a different individual, so that if those figures been used the effects of delivery method and course co-ordinator would have been confounded. Table 1. gives the means and standard deviations of the marks from the 1995 and 1997 database examinations.

Table 1. Means and standard deviations of examination marks for years in which both traditional and multimedia modes of course delivery were employed.

	1995 (Traditional)	1997 (Multimedia)
Mean	49.4	51.1
Standard deviation	13.5	13.6
Students	132	111

As can be seen from this table there is only a slight difference in the mean marks between the two years and a standard z- test for the differences of two means indicates that it is not statistical significant. We conclude that levels of attainment have not been compromised by the introduction of an alternative method of course delivery.

4.2 Analysis of Usage

The figures for AHIT, HIT50, HIT100, ZHIT and TOTHIT were chosen to collectively indicate study patterns. A low (early in the course) AHIT, high HIT50, HIT100 and TOTHIT figures and high (late in course) ZHIT figures would indicate a student who started the course early, covered the material throughout the duration of the course and took a good deal of the overall course and was taking lectures right up to exam time, presumably for revision. The reader is reminded that the whole course is made up of 119 individual audio presentations and that there are a total of 12,960 logged “plays” of audio presentations by the 115 students.

The graphs shown in Figure 1 show the values exam mark platted against AHIT, ZHIT, HIT50, HIT100 and TOTHIT, for each of the 115 students.

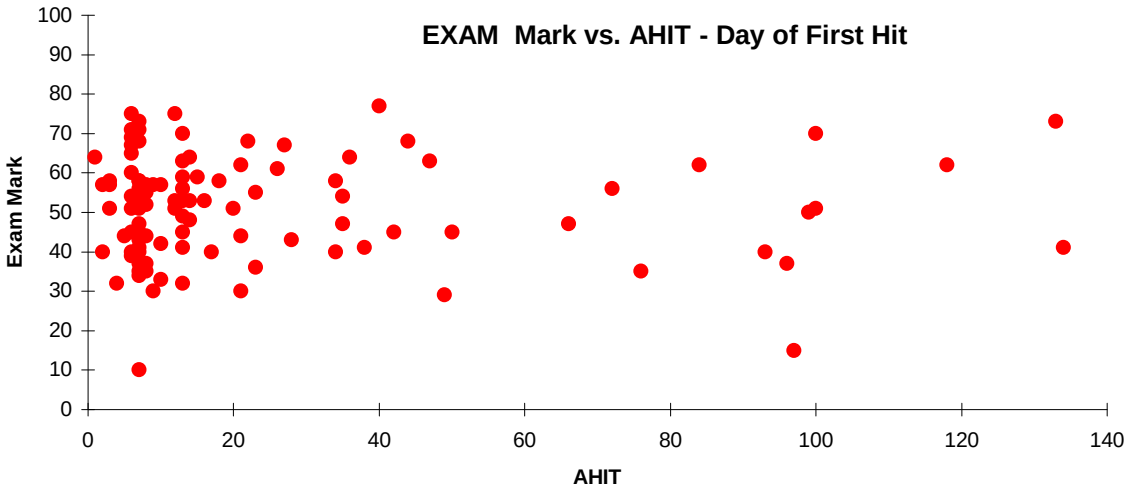

Figure 1(a): Exam Mark vs. AHIT

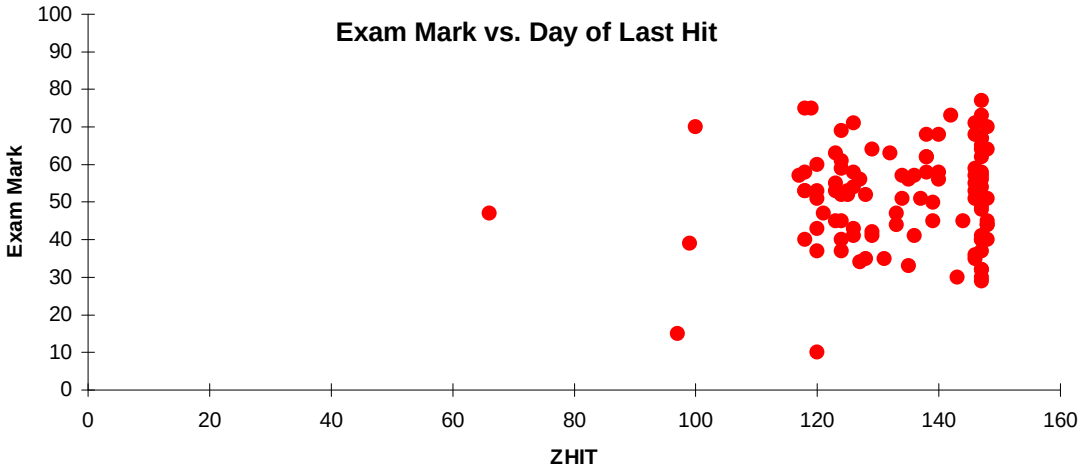

Figure 1(b): Exam Mark vs. ZHIT

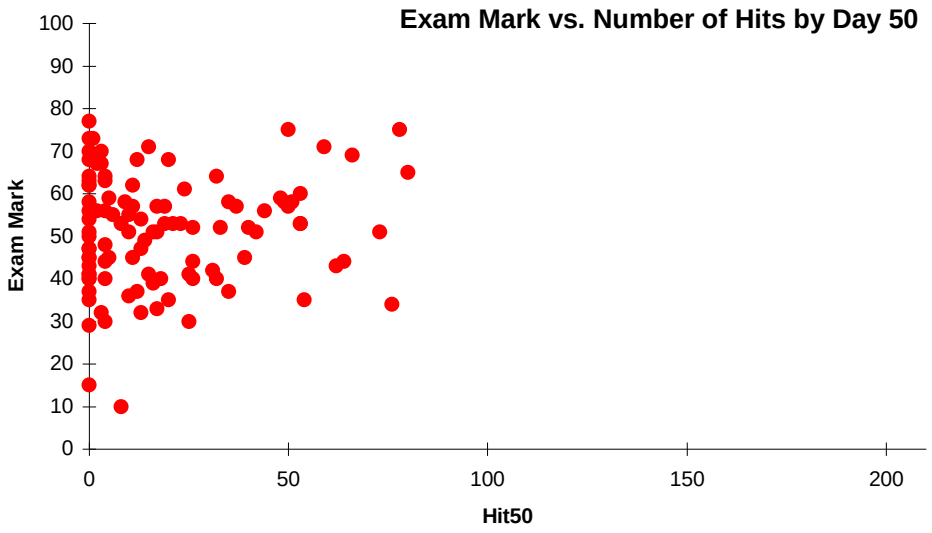

Figure 1(c): Exam Mark vs. HIT50

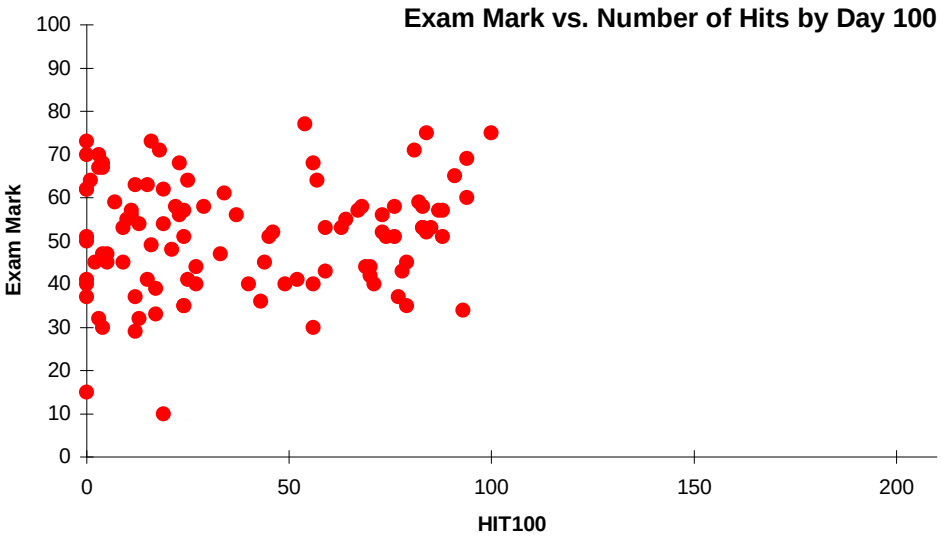

Figure 1(d): Exam Mark vs. HIT100

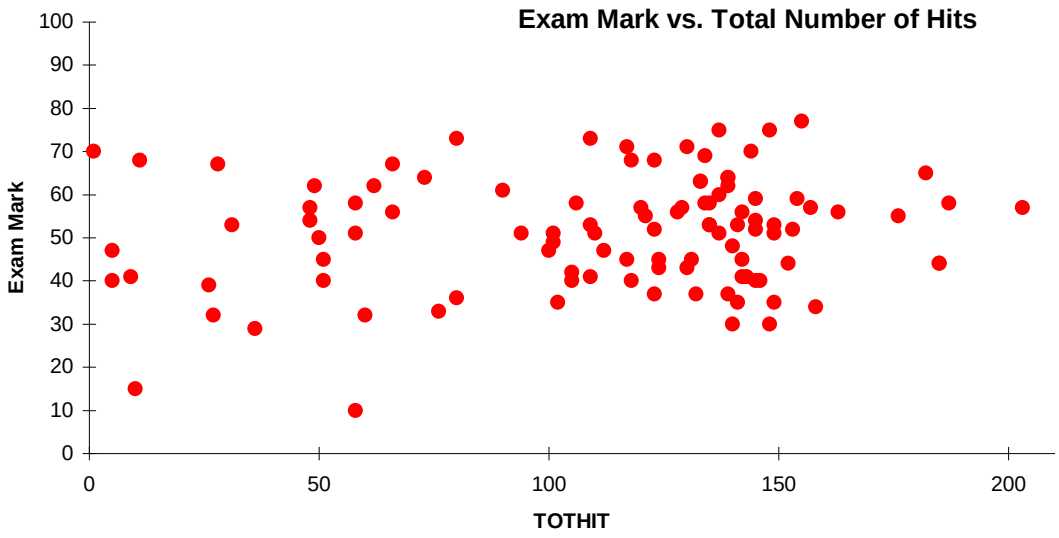

Figure 1(e): Exam Mark vs. TOTHIT

Figure 1(a) shows that while many students started the course, i.e. took their first virtual lecture within the first week, there were many who left their first encounter with the virtual lectures until quite late. Figure 1(b) shows that many of the students took their final lectures, probably revision, in the few days before the exam, and all but a small few used the system within 1 month of the exam. The HIT50 and HIT100 figures in Figures 1(c) and 1(d) show many students who did not taken even one virtual lecture at those stages of the course and the TOTHIT Figure in 1(e) shows a great spread of usage with some taking only a small portion of the course and others taking up to 200 plays.

What is interesting about these graphs is how there seems to be no correlation between exam mark and any of the usage figures. The results in Figure 1(e) are worth further comment. If the total number of audio plays needed to complete the entire course is 119, this graph shows that about half of the students took less than the full course, some of them barely any part at all, while the other half took more than the full course by re-taking parts. The graph clearly shows that the amount of the course taken does not correlate at all with exam performance. The results of regressing exam mark on all of the usage measures are given in Table 2.

Table 2: Regression of exam mark against usage

Variable	Coefficient	T
ZHIT	0.633	0.62
HIT50	0.062	0.56
HIT100	0.005	0.06
TOTHIT	0.050	1.35
AHIT	0.051	0.98

R-SQR = 0.045 F = 0.983

As can be seen from the t-statistics [10], none of the usage variables had a co-efficient significantly different from zero.

Clearly Table 1 confirms that no significant relationships were found between usage and exam performance which is initially a somewhat surprising result given that one's intuition would suggest that good study habits (starting early, keeping up with the course at a steady pace etc..) should be repaid by higher exam marks. Notwithstanding the fact that the above measures of usage are relatively crude, it is probably fair to say that if any substantive relationship were to exist between exam performance and usage, at least some would emerge from the above analysis and this has clearly not happened.

4.3 Analysis of Prior Experience

The third hypothesis that we explored in analysing our virtual lectures was that prior experience of the WWW and RealAudio and the technical nature of a student had an effect on his/her result and this could be tested by regressing the exam mark variable against the pre-course questionnaire variables. This questionnaire is shown in an Appendix and the results of the regression are tabulated below. The correlation measures used are the same as with the earlier analysis.

Table 3. Results of regressing Exam Mark on variables associated with prior experience of WWW

Variable	Question	Measure	Coefficient	T	VIF
Q1	How often browsing	1 .. 9	-0.512	-0.51	2.88
Q2	Heard of RealAudio ?	Y/N	1.390	0.39	2.13
Q3	Seen RealAudio in action ?	Y/N	8.734	1.22	6.27
Q4	Downloaded RealAudio player ?	Y/N	-7.497	-1.03	5.76
Q5	Prepared own home page ?	Y/N	1.240	0.29	3.13
Q6	Know how much HTML	1 .. 9	-0.571	-0.49	5.03
Q7	Grasp of WWW	1 .. 9	0.220	0.23	3.22
Q8	Own a PC ?	Y/N	-1.482	-0.32	3.31
Q9	Own a modem ?	Y/N	9.309	2.68	1.55
Q10	Use for University work ?	Y/N	2.759	0.62	2.94
Q11	How many sessions ?	0 .. ?	0.247	0.80	2.98
Q12	How many chapters ?	0 .. 13	1.003	1.70	3.49
Q13	How much repeating ?	1 .. ?	-6.352	-1.01	2.85
	Sex	M / F	1.922	0.56	1.31

R-SQR = 0.188 F = 1.621

As can be seen from this table only Q9 (Has a student a modem/internet connection ?) has a significant associated t statistic, which is just significant at the 1% level. However, because of the fact that some 14 variables were entered into the regression, it would be inappropriate to read too much into this single t statistic, indeed the F statistic is not even significant at the 5% significance level. Variable Inflation Factors (VIF's) are also reported, since, by virtue of the way that the questionnaire was designed, a certain level of multi-collinearity was to be expected. These statistics, although detecting the previously suspected multi-collinearity, are redundant in view of the acceptance of the null hypothesis of prior experience having no influence on performance.

5 Conclusions

The results in this paper have shown that when virtual lectures are used in place of traditional delivery methods there is no significant difference in attainment levels as measured by end of year examination marks. Furthermore, neither prior experience nor study/usage patterns have any impact on performance in end of year examinations when using virtual lectures for course delivery as we have described here. Initially this may seem a surprising result but on reflection it should be no surprise at all. What we have done in this work is to provide an electronic version of a course delivery paradigm with which all of the parties (students and faculty) are all familiar, albeit with some additional benefits to the student of availability,

repetition and facilitating student-directed learning. In our traditional mode of course presentation we can also have a sporadic attendance rate at lectures by students; in practice, the larger the class the easier it is for a student not to attend, perhaps because of the increased likelihood of anonymity when missing a class, or perhaps because a student gets less value from a larger gathering of fellow students. It is probably true to say that good attendance at our traditional lectures does not imply good performance in exams and vice-versa and this is exactly the result we have found with our virtual lectures.

The costs of developing virtual lectures can be broken into a number of categories. The first measure is in terms of equipment and infrastructure which is not a great cost because personal computing and networking is in place in most Universities anyway. The computing requirements for the server are not great. In terms of technical support to create and maintain the virtual lectures, this required a full-time assistant for a period of about 10 months but much of this effort was directed towards the creation of the search facility and in the development of layout and ironing out initial difficulties such as choosing the best audio sampling rate and locating the best tools to use. In retrospect we believe that the table of contents for navigation is essential, the index is a nice idea, but the search is a luxury because of the amount of time needed to create it and the few occasions in which it was actually used. Even during times of revision, students preferred to use other navigation mechanisms to find material.

The greatest cost of the development of our form of virtual lectures is the lecturer time and this is not insignificant. However, when compared to other paradigms for making material available electronically, virtual lectures require less pre-processing and preparation of material than, say, the development of concept maps or hypermedia courseware. This is an important point. There is a reluctance on the part of many faculty members to use information technology to create and maintain online information because of the accurate perception that it takes a huge amount of time. Virtual lectures involves course preparation in a paradigm which is familiar to lecturers and thus the costs of virtual lectures in terms of preparation of course content, is not significant. We believe this is very encouraging for the potential application to other courses.

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Appendix A: Survey Questions

Q1: How often do you use the web ? [Never … Addict]

Q2: Have you heard of RealAudio ?

Q3: Have you seen RealAudio in action ?

Q4: Have you downloaded the RealAudio player ?

Q5: Have you prepared your own WWW home page ?

Q6: How much HTML do you know in order to make your home page look good ? [None … Guru]

Q7: How would you regard your grasp of WWW in terms of knowing what is there and how to find things ? [Novice .. Shark]

Q8: Do you have a PC/MAC at home or at work ?

Q9: Does it have a modem & internet connection ?

Q10: Do you use it for University projects/Study ?

Q11: How many sessions did the student have with the virtual lectures throughout the year (from log analysis)

Q12: How many chapters (from 13) of the course did the student take throughout the year (from log analysis

Q13: How much of a repeat factor was present in the student taking the course, i.e. how much online revision was used ?