Cost-Effective Multimedia in On-line Teaching

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Abstract

The AudioGraph is a mature tool that has been developed and used at Massey University. It brings the power of on-line multimedia directly to educators. In the past, multimedia has been used in on-line education by employing multi-media experts, who are quite removed from the pedagogical issues, resulting in material (CDs or web sites) that quite frequently favour gloss over educational content. This practice can also be prohibitively expensive. AudioGraph is an easy to use tool that non-experts may use to bring their teaching to the web by developing multimedia incorporating images, vector graphics, handwriting and voice. It should be noted that this media is exactly what is used in face-to-face education. Indeed it provides an on-line analogue with a teaching methodology that most practicing teachers or lecturers are familiar with. It also provides the advantage of using animation, with only a little more effort. The media produced by AudioGraph is small in size and requires little bandwidth for students to download; thus it can stream over low-speed modems. Being so easy to use, AudioGraph encourages the educators to adopt new technology and to explore new approaches to education.

The AudioGraph Toolset - an Introduction

The goal of this paper is twofold. Firstly it introduces the AudioGraph tools and secondly it describes an example of their use, namely in on-line teaching at in a conventional university environment. A three year experiment was undertaken, in which the AudioGraph has been used to present a full-time, internal honours course for the last two of those three years, the first being used as a control. The AudioGraph software is the result of some 4 years of research in both developing and using these tools, see: Jesshope and Shafarenko (1997), Jesshope Shafarenko and Slusanschi (1998), Jesshope and Slusanschi (1998), Pearson and Jesshope (1988), Jesshope (1999) and Jesshope (2000). The methodology of teaching that we have used in applying these tools is very similar to what has been named Just in Time Teaching (JITT), Novak and Patterson (1998). AudioGraph can be downloaded from the NZEdSoft web site (http://www.nzesoft.com/) and the tools are available free of charge to anybody wishing to use them.

The tool-set that can be obtained from this site comprises two tools, an authoring tool and a player, which is a plug-in that enhances most web browser functionality, enabling them to play the AudioGraph presentations. The AudioGraph plug-in is known to work with Internet Explorer, Netscape, iCab, Opera and may work with other browsers. The authoring tool, the AudioGraph Recorder, is used for generating web-ready, on-line presentations of teaching sessions. Unlike some other tools, such as Tegrity (2001), AudioGraph records the presentations in the teacher s own time and not by capturing a live class. The results are very similar but usually more polished. The AudioGraph Recorder has only been available for the Macintosh computer platform until recently but as of writing this paper, we are about to make available a Windows PC version of the authoring tool. The AudioGraph plug-in has always been available for both platforms. The plug-in is a small program that gets used by a web browser to extend the media that it can display. In our case the AudioGraph plug-in allows the browser to playback the presentations produced by the AudioGraph Recorder. The student must have this installed to be able to view the presentations.

The key feature of the tools is their ease of use. They have been designed from the outset to be simple, with a clear and intuitive interface. This has meant reducing the number of concepts that the user is confronted with and of course this limits the capabilities of the tool when compared to tool that are used by professionals, such as multimedia experts. Thus AudioGraph, unlike other tools, can be learnt in an afternoon and requires little time to produce professional looking multimedia web sites. The tool makes use of a range of media elements, images, direct voice recording, vector graphics and pen annotation. All of these are techniques used in face-to-face education and hence the teacher immediately feels at home. The images replace the slides that would be used in class. The vector graphics the various drawing devices, such as whiteboard, blackboard, flipchart etc. and of course spoken voice is the essence of a face-to-face presentation. Note that we use no video or

talking heads. We believe these to be poor pedagogical value for the bandwidth required. Still or quasi-moving images can be used at the author s discretion but increase storage and download requirements.

In the past, multimedia has been the province of the multimedia expert. We know this because in 1995 we wanted to generate a large volume (30+ hours) of multi-media material for on-line teaching. Our research at that time led us to the following conclusions:

- the available tools all had a very steep learning curve;
- none of the tools was targeted to the web;
- an expert would require approximate 200 hours of preparation time for each hour of on-line material we required.

Although some of these issues have now changed, at that time, we wanted to produce a complete course on-line, replacing face-to-face lectures with web-based presentations. This large volume of material and the poor ratio of preparation to presentation time above meant that the cost of generating multimedia for our asynchronous teaching needs by this route was prohibitively expensive and so we developed our own tools instead.

Another factor in this route to on-line teaching is that the multimedia experts produce the media and they are often too far removed from the technical area as well as good teaching practice. This results in CDs or web sites that favour gloss, such as animation for its own sake, rather than sound educational content and the use good pedagogical techniques. If the teacher and media expert work closely together they can ameliorate this problem but this only increases the cost of the educational outputs, as there are now two people working on the production, an educator and a multimedia specialist. Again the cost of the multimedia becomes prohibitively expensive for all but the largest of audiences.

The AudioGraph tools were developed because of these factors and they given us a solution to the problems we encountered some five years ago. The tools started life as a simple, Visual-Basic prototype, which was used to develop the course we required. The cost of developing this prototype and using it to produce the on-line course was significantly less that that quoted by the media experts and it was undertaken by a single academic (Professor Shafarenko) in his research time. The prototype was not stable and did not use compression but it did demonstrate the principle. We have now developed the tools to commercial software standards. Although we originally developed the tools for our own use, the project has grown significantly and the tools are now in serious use by over 700 educators worldwide. Absolutely no knowledge of web page design is required to use these tools and very little knowledge of multimedia is required in order to be able to produce very professional web-based presentations.

A requirement of this project was that the media should occupy only a small space on the web server and, more importantly, be accessible to the students by modem. This is an important requirement, especially considering the growing digital divide and hence the tools truly make education accessible to all. We therefore had to use aggressive and state-of-the-art sound and image compression technology to achieve this requirement, see Jesshope Shafarenko and Slusanschi (1998) for details. Being so easy to use, AudioGraph also encourages educators to adopt new technology and to explore new approaches to education. AudioGraph has been used in a variety of ways and some examples of its use are illustrated below:

- the presentation of on-line material to both internal and extramural university students;
- the facilitation of on-line training of equipment and software;
- the replacement of video instructional courses;
- as a means of asynchronous technical communication in virtual organisations;
- as a means by which school children can present their study to their peers and to their teachers.
- as a means of teacher evaluation; and
- as a means of sending electronic greetings;

The best way to introduce these tools to the reader is to give a brief walk through the concepts of the tools and to give examples of their use. This is presented in the next two sections. It must be emphasised that a static paper can not really convey the content of these presentations. Another factor is that there are probably as many styles of presentation as there are users of our tools. Each new user seems to bring his or her own approach to on-line education using AudioGraph. To view some demonstrations, the interested reader is directed to our web site, NZEdSoft (1999).

The AudioGraph Principle and Realisation

The tools are based on what was defined by us as the *AudioGraph principle*, which states that the multimedia elements be arranged as an ordered collection that are played in strict sequence. This is a simplifying principle that effects both authoring and playback. In authoring, there is no concept of time and synchronisation to worry about and in playback the presentation quality is independent download speed and speed of the playback computer. No loss of synchronisation is ever seen, even in the presence of a slow internet connection or very old computers. The media components that the AudioGraph supports are:

- *images*, such as screenshots, outputs from other programs (e.g. PowerPoint), scans, digital photographs, downloaded images, etc. Indeed, all standard image formats are supported.
- *user-drawn graphics*, such as diagrams drawn by the user in the AudioGraph tool, handwriting using a pen-input device, etc.
- *recorded sound clips*, the sound is directly recorded by the author, or by a professional voice, just as in a tape recorder.
- *pauses*, for timing the presentation playback.

Normally complex programming over time is required when using a multimedia-authoring tool. There are some exceptions but these can not considered multimedia tools. For example PowerPoint allows different media elements to be placed on slides and these may be output to make web presentations. However, PowerPoint provides no functions or display for the sequencing of these media components. In the AudioGraph this is not the case, we provide a window, which controls the sequence of components. Each media component is presented as an icon and the sequence icons is displayed in a window called the Edit Console, a part of which is shown in figure 1. This figure shows image icons, pauses, sounds and user drawn rectangles. Each icon corresponds to something heard of seen in the presentation.

Figure 1. AudioGraph Recorder's Edit Console showing the media components.

Each icon in figure 1 represents an image, a sound, a pause or a drawn graphic component. The window as a whole represents the sequence in time, from left to right. You can see the tape-recorder-style controls in the bottom left corner of this window for previewing the presentation. The second main window shows exactly what the learner will see in the presentation when viewed in the web browser and this is shown in figure 2. Moreover, the two windows are closely linked, such that whenever a component is selected in the edit console, the entire sequence, up to and including the selected icon, is displayed in the slide window. The slide window thus presents a view of the presentation at any point in the sequence's pseudo-time and presents it for editing.

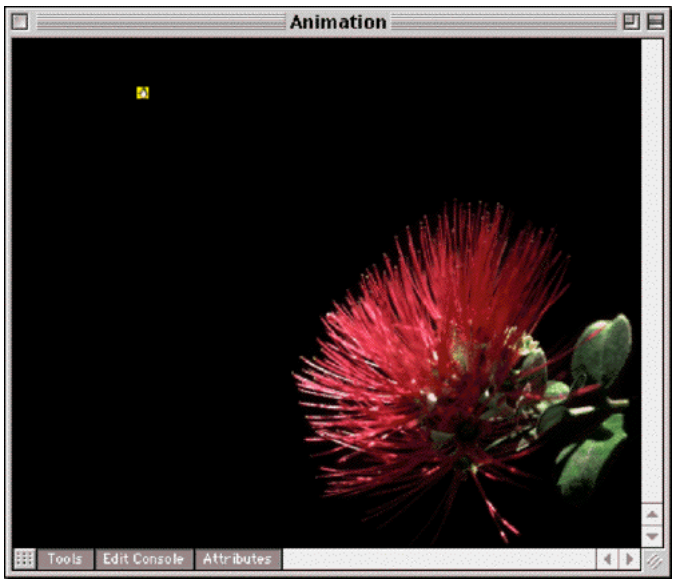

Figure 2. AudioGraph Recorder's Slide window showing a frozen presentation.

To summarise the authoring then, figure 1, the edit console, gives an iconic representation of the temporal aspects of the presentation, whereas figure 2, the slide window, gives the full spatial view of the presentation, but as captured at one given moment in time. That moment in time is determined by exactly what is selected in the edit console. At the start of the presentation, the slide window shows nothing (actually just its background colour) and at the end of the presentation it shows everything. To make a comparison with PowerPoint, the latter view is the only view available when trying to edit presentations that evolve in time and editing involves awkwardly moving elements up and down the display order. Thus the unique difference provided by the AudioGraph recorder is the ability to see and edit the presentation at any point in the presentation between its start and end.

Examples of the Use of AudioGraph

One of the simplest ways of using the AudioGraph is to start with an existing presentation, one that has been produced in PowerPoint for example. This gives a set of images or slides that can then be animated, either as single units or as groups of slides. Transitions can be built, selected areas can be highlighted and a voice-over can be recorded and edited easily, interleaving parts of the spoken transcript with the other annotations, such as highlighting, pen strokes and transitions. Figure 3 shows a snapshot in time of such a presentation, while being played back in a web-browser window by the AudioGraph plug-in. The plug-in adds the main window to the web page, in which the presentation recorded is displayed. The embedding page is also generated from the AudioGraph Recorder, along with an index page. The buttons at the bottom of the window sequence through all of the talking slides in the index or take the learner back to the index. The complete site was generated from a PowerPoint presentation, exported as a Scrapbook file. All pages are generated automatically when the presentation is published.

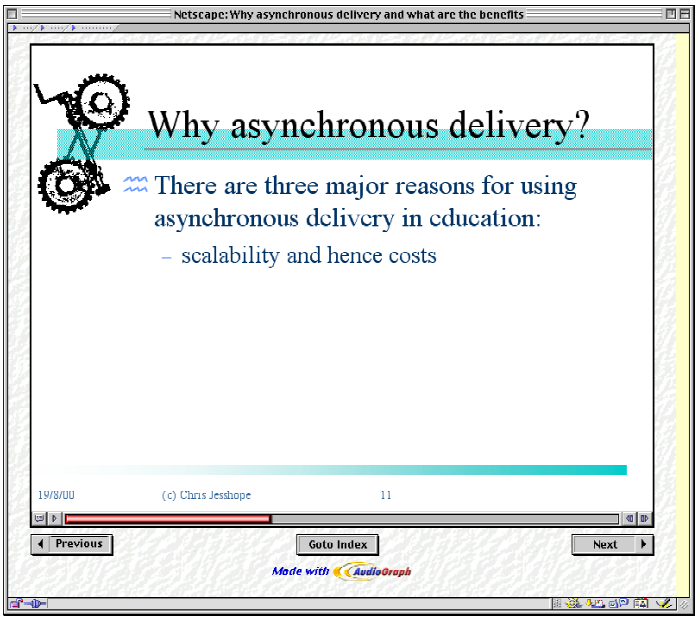

Figure 3. An AudioGraph presentation based on PowerPoint slides.

Figure 4 shows a snapshot of another presentation being played by the AudioGraph plug-in, which uses a completely different authoring technique. This presentation is built entirely from a sequence of user-drawn graphics and voice clips, recorded directly in the AudioGraph tool. It is the equivalent of an on-line, chalk-and-talk presentation. Its pedagogical value however, is very much enhanced over what might be achieved in a classroom. This is due to the fact that the student has complete control of the speed of delivery. If the teacher is going too fast, then the student simply clicks on the screen to stop the presentation. If something has been missed or if the progress is too slow, the student uses the progress bar at the bottom of the presentation window to rewind or fast forward the presentation. In other words the student is in control and dictates the pace of learning.

The other pedagogical feature that is not possible to achieve in a classroom environment is that the diagrams can be animated, which is something that is difficult, if not impossible to achieve using pen and board. In this case the presenter is dynamically highlighting a diagram while at the same time developing some mathematics corresponding to the highlighted portion of the diagram. The past steps are also washed-out to emphasise the current step, which is presented in full colour.

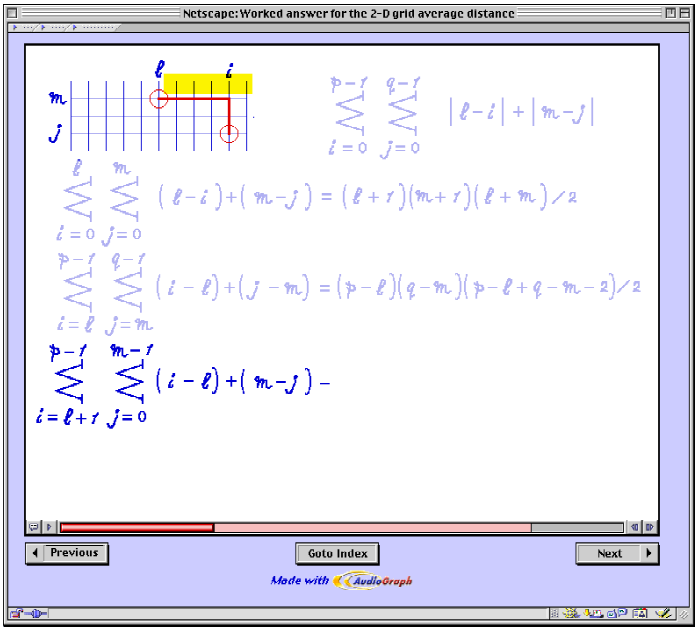

Figure 4. An AudioGraph presentation based on an asynchronous chalk and talk technique.

It is interesting to note the progress bar at the bottom of the plug-in window in figure 4 (above the previous/index/next hyperlink buttons). It shows two actions, the download progress (the flat bar) and the playback progress (the darker pseudo-3D shaded bar). This diagram was captured during playback and indicates that the media is playing at the same time as it is being downloaded, which is called streaming by media professionals. This presentation is a good example of streaming, it is nearly 500Kbytes in length and would take several minutes to download at normal modem speeds but the presentation is over 5 minutes in length. Because of the streaming capability, the student does not have to wait for the download before viewing the presentation, the down-load and playback occur simultaneously, with little or no perceived delay by the student before the presentation commences, even when using a slow modem connection.

It should also be noted that as the presentation is less than 500Kbytes in length and lasts for more than 5 minutes, this represents an average download bandwidth of less than100 KBytes per minute. In other words just 1.7Kbytes per second or 14 Kbits per second, the speed of a relatively slow modem.

We might also like to analyse the disc space required for AudioGraph media files. As an extreme case let us consider a complete on-line degree in a given subject. At Massey University for example, this would be the equivalent of 8 courses per year for three years, where each course was equivalent to about 36 lectures of 50 minutes each. Our experience shows that the on-line equivalent of a lecture, due to its asynchronous nature, is approximately one half of its live presentation length. Thus we can calculate a figure for the sum of the length of all presentations required for a complete Massey degree as being:

Presentation time = 8x3x36x25 = 21,600 minutes.

Given that each minute of presentation is equivalent to approximately 100Kbytes of data, then our complete 3-year degree course requires only 2.16 GBytes of data. To put that in perspective, this is the same a 3 CDs worth of data or about 3 hours of high fidelity music. 1 CD per year is a rather modest requirement then, once the presentations have been recorded.

Using AudioGraph in on-line Teaching

This section gives some qualitative and quantitative results from an experiment using AudioGraph as a means of delivering learning material to students instead of using face-to-face lectures. AudioGraph was used to teach a class of post-graduate students in a paper on advanced computer architecture. This was an internal group of between 20-40 students honours students each year. The experiment was undertaken over a 3 years period and was an attempt to:

- learn how the AudioGraph could be used to update conventional teaching methods; and
- evaluate both qualitatively and quantitatively the benefits of this approach.

1998 was the control year and during this year, the paper was offered conventionally using mostly face-to-face lectures, based on PowerPoint presentations. Additionally prerecorded video lectures of external lecturers were used to supplement this material. During this year, the author of this paper, as well as presenting the lectures to class, used the same material and recorded the lectures using the AudioGraph tools. The same course was then given in 1999 and again in 2000, using the AudioGraph, web-based multimedia material as the primary means of teaching the course. The material was updated in each subsequent year but only about 10% of the material was changed in total.

The PowerPoint material used in the face-to-face lectures required approximately 36 lectures to present, with each lecture requiring approximately 50 minutes of face-to-face contact. This material was compressed into approximately 20 hours of on-line material after being recorded as AudioGraph presentations. This recording was done largely in the authors research time and required approximately 100 hours of preparation time. In addition to this, approximately another 100 hours was required to digitise and select from the videos used in class and to design a web site to contain the AudioGraph material, the digitised video and also links to other sites on the web. This web site can be seen at (Jesshope 1998-2000).

One of the lessons we had learnt from our early use of the AudioGraph was that unless the students had a clear schedule of study they tended to flounder. Thus one of the most important pages on the web site was a schedule of exactly what material was to be studied during each week of the course. It should be emphasised that this was an internal course and the course was scheduled over one semester of 15 weeks of which 3 were used for revision and examination. This particular paper had always been assessed entirely coursework, with a mixture of single and group assignments.

The mode of delivery for the AudioGraph enabled course was as follows. The students were given a CD of the web site prepared in 1998 and the same site was made available to them on-line. In this way they had access to the material at home and in laboratories without needing the hang on-line for a significant length of time while at home. The schedule provided a week by week picture of the material they were to learn. In addition to the AudioGraph presentations, the students were each scheduled for a one-hour tutorial session. These groups comprised about 12 students and the time-slots previously used for lectures were recycled for these tutorials. The author therefore provided the same overall contact time with the students but in smaller groups. The individual student's contact time was reduced from three hours per week to one but they were also expected to spend the time required each week to "attend" the on-line lectures. During the tutorials, the group discussed problems they had had in understanding the on-line material and the author frequently gave small additional presentations on difficult issues. This time was also used for setting and discussing assignments, going through worked examples and for group presentations. For example in 2000, a group assignment was set was to research and present a related topic. The presentations were made and assessed during one week of the tutorial sessions, the only week when all students attended together. All other assignments were assessed from individually written papers or reports. In 2000 there was an option of a practical assignment that required a significant amount of programming, producing a simulation of one of the architectures studied. This was originally designed to stretch the top 10% of the class but in the event was taken up and completed successfully completed by over one third of the class.

The results from these three cohorts of students (1998,1999 and 2000) are summarised in Figure 1, according to the percentage of the class receiving a certain grade. While these results are certainly not conclusive, due to the relatively small samples (31, 33 and 23 respectively), they do give an indication of a certain improvement in learning. There is a substantial improvement of the average mark from year to year for the class from a GPA of 4.0/8 in 1998 to 4.7/8 in 1999 and to 5.5/8 in 2000. Moreover, the most surprising result was that in both 1999 and 2000, with the exception of one student who did not complete the course for personal reasons in 1999, all students received a C+ grade or better, whereas in 1998 the failure rate was about 12%.

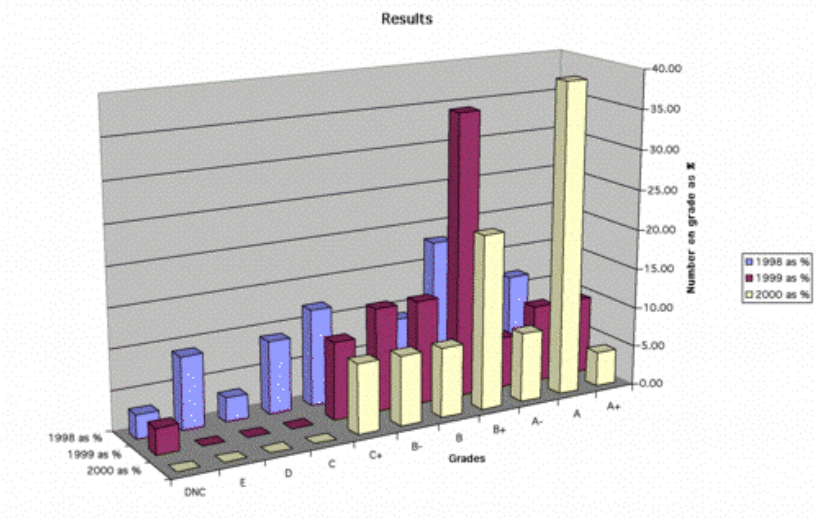

Figure 1. Showing the marks distribution for the control group (of 33) in 1998 and the experimental group (of 31) in 1999

Another difference in the results is seen as a modification of the distribution from a bimodal one (1998) to a more normal one (1999 and 2000), which seems to be characteristic of a shift from face-to-face to self-paced learning, when the input ability to a course is mixed. The mode that was removed was exactly the one that corresponded to the struggling students, e.g. DNC through C in 1988. See table 1 for the exact distributions as a percentage of the class in each equivalence group. Exactly the same shift in the distribution of the results was seen in trials based on the prototype AudioGraph (Jesshope and Shafarenko 1997), which was evaluated by Segal in (1997), although the distribution of students' results for that experiment were never published.

	A+	A	A-	B+	B	B-	C+	C	D	E	DNC
1998	6.1	12.1	18.2	18.2	9.1	0	12.1	9.1	3.0	9.1	3.0
1999	9.7	9.7	6.5	35,5	12.9	12.9	9.7	0	0	0	3.2
2000	4.3	39.1	8.7	21.7	8.7	8.7	8.7	0	0	0	0

Table 1. Distribution of results during the years 1998,1999 and 2000.

At Massey University, we have a formal system for providing feedback from students via questionnaires on courses offered and this course was surveyed in 1999. The detailed results of this process are confidential and it is only possible to summarise the results here. The evaluation for this paper gave an average quantitative response that was above (or in some cases well above) the neutral response in all categories. This shows at the very least an acceptance of, if not a preference for, this mode of delivery compared to the face-to-face delivery of lectures. In the qualitative feedback section, comments were received that showed quite individual learning patterns using this material. Some students thought the extensive use of verbal comment was not so helpful and found the visual aids usually sufficient to understand the material, whereas others found the verbal comment and the ability to replay these, of great help in assimilating the material. It is surmised that these represent the extremes of the class in learning ability and clearly indicates the advantage of self-pacing the delivery.

It is interesting to project these results onto the characteristics of typical lifelong learning situations. The concept of just-in-time teaching is quite appropriate in this situation. Courses are likely to be taken on demand rather than in institution-designed programs and the input ability is likely to have a high standard deviation, exactly as in our experiments above. These are the situations where the use of web-based multimedia material

excels. This is not only due to the self-paced nature of the delivery but also because of the ability to link together a whole corpus of related material to provide background for the lower quartile of input ability and to stretch the upper quartile.

Finally it is appropriate to add the following comment. Not only did the students fare better at this paper; they also appeared to enjoy its delivery and content. This was confirmed by numerous email messages to the author following the completion of the course. Moreover, the author also found that he had also enjoyed the relationship with the students more in this mode of delivery than in the rather detached mode of face-to-face lecturing.

Conclusions

AudioGraph recorded lectures have been used in the delivery of an honours paper over two years at Massey University. In this mode, conventional lectures were replaced by on-line AudioGraph material and the time freed up was used for more interactive tutorials and problem solving sessions with the students. The results of this experiment have shown that the course was more enjoyable to both the students and the lecturer involved and the students' performance was raised and indeed continue to improve as experience was gained in the use of these techniques. The GPA average for the class was raised from 4.0/8 to 5.5/8 over the three years of the experiment and, in the final year of this experiment, groups of students had achieved results in practical work that the author would not have believed possible prior to this experiment.

The AudioGraph tools have also been used in schools and in company training. Indeed, our analysis of the AudioGraph web-site registrations have shown the usage splits roughly 1/3 each to these three areas, namely university, school and industrial training use. In schools the use has been varied. One project has used it for teacher evaluation, by including recorded presentations in a teacher's assessment portfolio. In another school, children are using the tool to produce creative presentations as coursework. This shows that the tools are not difficult to use, if young children can master them in such a short time (the tools have only been available for a year). As yet, there have been no published results from the last two experiments. However, both interested, Pearson and Jesshope (1988), and independent, Segal, J. (1997), evaluations have been made of the use of the AudioGraph in University teaching.

From our experiments, it has been shown that multimedia preparation time is nowhere near as time-consuming as the multimedia professionals would have us believe, at least this is the case when using the AudioGraph tools. Typically the preparation requirement is some 2 to10 times the eventual presentation time. As already indicated, the on-line presentation of a course tends to be typically just one half of the length of the corresponding live presentation. This means that the effort in preparing an AudioGraph course is, in the best case, on a par with giving such a course live just once only and, in the worst case, in giving the course live some five times in total. The AudioGraph tools therefore, seem to offer the prospect of very cheap education for all. However, as found in Massey University, there are many issues that have yet to be resolved. Perhaps the most important is how to reward staff for their participation in the preparation of such material. The author used his own research time to do this preparation but had an ulterior motive, the evaluation of the use of these tools. This can not be expected to be the norm and loading models must be adopted that reward the preparation of these resources.

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