bioscience education

Descriptive account

Enhancing the student experience of laboratory practicals through digital video guides

Karen Croker[1], Holger Andersson[2], David Lush[3], Rob Prince[3] and Stephen Gomez[4]

[1]Dept of Biology and Biochemistry, Building 4S, University of Bath, BA2 7AY; [2]CEPPL CETL, University of Plymouth; [3]Faculty of Health and Life Sciences, UWE, Bristol; [4]Teaching and Learning Directorate, University of Plymouth.

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Abstract

Laboratory-based learning allows students to experience bioscience principles first hand. In our experience, practical content and equipment may have changed over time, but teaching methods largely remain the same, typically involving; whole class introduction with a demonstration, students emulating the demonstration in small groups, gathering and analysing data, and concluding with a plenary discussion. We wished to move away from whole class demonstrations and instead encourage a more student-focused learning of procedures to enhance autonomous learning. Using previously developed expertise in videos to support lectures we adapted this approach to laboratory-based learning by producing digital videos as self-directed guides. Videos were produced using domestic-quality equipment and without any professional audio-visual training, resulting in seemingly low production quality. However, students followed the video guides systematically and completed the practicals more efficiently and effectively. Benefits included: development of more autonomous learners; more time to pool and analyse class data; demonstrators' time being used for higher-level interaction with students; and production of reusable learning objects forming the basis of more enquiry-based laboratory learning.

Keywords: Practical demonstrating; laboratory teaching and learning; video instruction; digital video

Introduction

As Hofstein and Mamlok-Naaman (2007) state laboratory experiences have been given a central role in science education. Many benefits are said to come from engaging students in laboratory activities (for examples see Tobin, 1990; Lazarowitz and Tamir, 1994; and Lunetta *et al*., 2007). However over the years some educators have questioned the effectiveness and role of laboratory activities, back in 1982 Hofstein and Lunetta, in response to such concerns, reviewed the history and research findings of laboratory work as a teaching tool. More recently studies of first-year undergraduate bioscience practicals at UK universities have advocated a re-think of traditional approaches (Collis *et al*., 2007, 2008) to make them more engaging, challenging and active (Adams, 2009). It is, therefore, important to explore alternative approaches to maximise the learning potential of practical work.

Laboratory-learning forms the middle of a three-part process, the others being preparation and report-writing/reflection. In our experience, students often arrive at practicals with no clear idea of the techniques employed, the skills required to conduct the experiment, or understanding of the underlying scientific principles. This perception is shared with colleagues within the university and further afield, for example see ChemLabS; (www.chemlabs.bris.ac.uk/DLM.html). Preparation is key as it affects confidence, attitude and success.

IT approaches to support lecture-based learning include multimedia (Rodrigues *et al*., 2001) and podcasting (Salmon and Edirisingha, 2008). In a separate study (Gomez *et al*., 2008) investigating multimedia support for lectures, we found that podcasting audio and video files had limited success, a view shared by Cann (2007). The podcasting paradigm is centred on file-downloading, which can encourage archiving (e.g. for subsequent revision) rather than for immediate engagement and (deep) learning. In contrast, we developed a video delivery system that encouraged immediate engagement as students were not permitted to download audio and video media files but were required to view and listen to them online through a bespoke, password controlled, video player that logged student interaction. As this approach successfully engaged students, we sought to extend it to instructional videos to help develop students into more autonomous learners in the laboratory.

The 3-hour human physiology laboratory sessions in University of the West of England, Bristol, alternate weekly with lectures and involve approximately 80 students taught in two groups on separate occasions during the same week; each session involves two demonstrators, one of whom is an academic. Students generally enjoy laboratory-based work, finding it more engaging than formal lectures. However, laboratory classes are costly in staff time, equipment and consumables so we continually seek to achieve the same or enhanced learning outcomes via more efficient and cost-effective approaches, including the improvement of student guidance.

Previous sessions began with a tutor-led introduction and practical demonstration. Students then move in small groups to workstations to conduct the experiment, guided by practical workbooks. Ideally, a demonstrator's subsequent support would be light-touch, but in reality students rarely took notes, appeared disengaged from the demonstration and struggled with the procedure even when given the instructions in their workbooks. Consequently, demonstrators mainly answered basic questions about equipment set-up and procedure, especially from late-arriving students.

We felt that video technologies could provide a more efficient, flexible and effective way to guide students through a practical and consequently may both improve student learning and the staff experience by allowing more time for higher level interaction. We report on one approach which has widespread implications for practical laboratory work.

Methods

The practicals

Four methodologically complex human physiology practicals from a large, second year undergraduate human physiology module were selected: measurement of blood pressure (BP), measurement of lung function (spirometry), ECG recording and measurement of the associated cardiac vector.

Video Production

A limited budget meant we produced the videos ourselves even though we had no professional AV training, and we used an Archos 504 Camcorder — a low-cost, domestic video camera.

Each practical was filmed outside of timetabled classes with SG as camera operator and the other authors as demonstrators and experimental subjects. There was no rehearsal and the practicals were filmed in a single take, with the camera hand-held and moving around the performers and equipment as necessary (with preparation/discussion taking around five times as long as filming). Videotape was digitised and edited using Camtasia (TechSmith, www.techsmith.com). The camcorder's built-in microphone was of low-quality and picked up noise from the tape mechanism. We attempted to filter the background noise post-production, but found it easier and faster to overlay a new soundtrack using Audacity (http://audacity.sourceforge.net/) (though recent developments mean this can now be carried out within Camtasia.

For each practical, the video recording was split into shorter video clips of 2–4min duration which we termed 'videopods'; each covered one aspect of the practical. On each videopod, following addition of the audio soundtrack, on-screen labels identifying equipment and connections were added, and subtitles layered. Although none of the authors were trained in video post-production we found basic editing in Camtasia relatively intuitive.

Delivery of videos pre- and post-practical

A group of videopods relating to a particular practical was organised as a playlist accessed through a webpage (Figs 1 & 2 overleaf); this allowed users to either follow the instruction in a serial, bite-size fashion or view specific parts non-sequentially. The playlist for a particular practical was called a 'video guide'. The video webpage was available for viewing one week before the practical to encourage familiarisation as well as permanently after the practical as a refresher or for revision purposes. Video delivery was through a Flash media player built into the web-page rather than via direct download for off-line viewing.

Video delivery during the practical

Video usage changed the laboratory practical format. Instead of an initial, large group discussion, students divided into twos or threes around their workstations. In addition to the required equipment for the practical, each workstation had a computer with a bench-top monitor to view the appropriate videos. No printed workbooks were used; instead, students controlled playback using the video guides to suit their own pace. As each student was expected to be a subject, the video guides permitted the relevant part to be accessed without, for example, viewing the set-up instructions each time. Students found time to take notes from the video pre- and post- practical. All the physiology background, health and safety information and instructions were provided in the videos. Students were assured that demonstrators would be present to answer questions. They were also informed how class data were to be pooled and analysed during the plenary session.

Questionnaire

A questionnaire, approved via the Faculty Research Governance system, sampled student and staff opinions. Participants gave their full informed consent and could withdraw at any time: none did so.

Figure 1 *Example screenshot demonstrating equipment set-up*

A screenshot taken from an example video practical guide. The media player window is on the left above the controls to play, pause, advance and replay the video; this permitted students to control the play and pace of the videos. On the right is the videopod playlist, with each explaining a particular part of the practical or physiological principle. The videopods can be played as one continuous video-guide or students can select the appropriate video for the task they are performing. Each video-guide contained a narration and text captions.

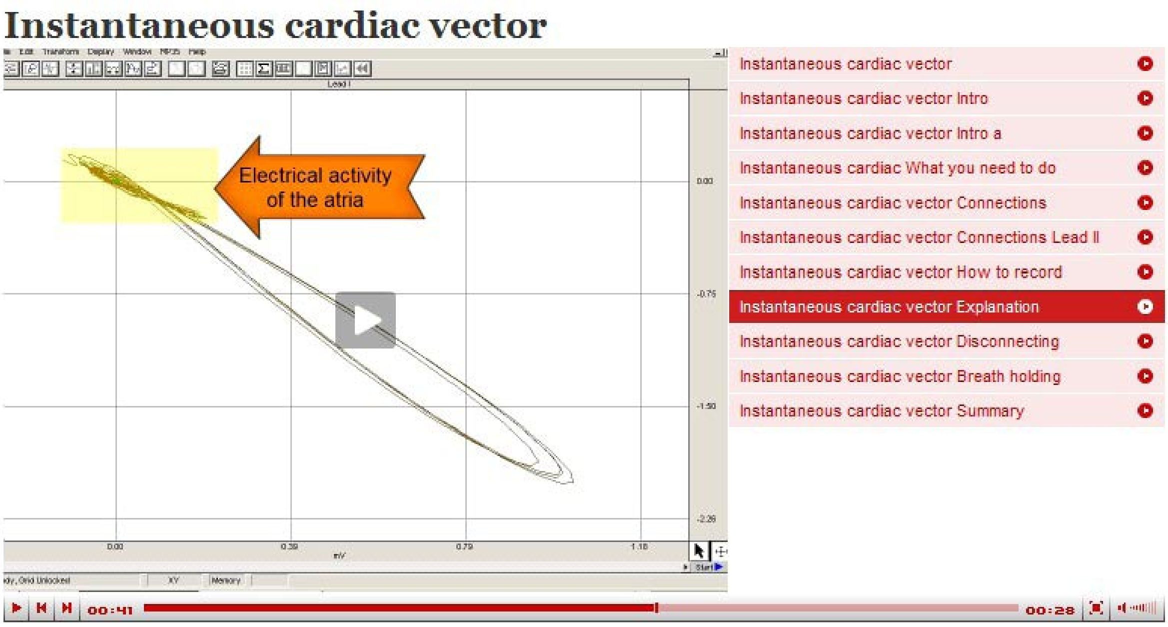

Figure 2 *Example screenshot demonstrating explanation of recordings*

A screenshot of one of the video-guides, 'instantaneous cardiac vector' showing an example result and explaining the various parts of the recording to enhance students' understanding of their results. This allowed students to self-assess the success of their methods and make adjustments on their own thereby encouraging greater autonomy in their learning. In this way, the students did not need to wait for a demonstrator to be available to check their results or wait for the group discussion at the end to validate their data.

Results

Sample population

The 74 students were enrolled on a second year undergraduate module in human physiology. Their age distribution was (n in brackets): 19y (26); 20y (22); 21y (10); 22–23y (6); 24–26y (7); 29–32y (3). There were 35 males and 39 females. When asked to assess their IT skills level on an arbitrary scale, 22 selected ‘Excellent’, 36 ‘Good’, 14 ‘Average’ and 1 selected ‘Poor’.

Student compliance

For all participants, video-guidance was a step-change in the delivery of laboratory practicals. Students appeared to adapt rapidly, however, by quickly splitting into groups, viewing the videos and setting up the equipment to take their physiological measurements. As a result, demonstrators’ input shifted drastically to higher-level student engagement concerning physiological principles, calculations and experimental design rather than troubleshooting equipment. Qualitatively, students seemed more able to work independently and tended to ask questions more for confirmation than instruction. All three demonstrators, who were not connected with instigating this study, informally expressed high levels of satisfaction, noting that students took ownership of their laboratory work, and worked through the instructions and analysed data with less demonstrator assistance.

Recording Quality

The anticipated negative comments concerning the low quality of the video recordings and their relatively amateur production standards were not forthcoming; when asked, most students did not notice or care about those aspects.

The soundtrack

All videos contained subtitles as well as an audio soundtrack, but all groups elected not to mute the soundtrack. Although the near-simultaneous playback of many soundtracks was somewhat disconcerting to the demonstrators, this was not mentioned by the students. When told they could turn off the audio and follow the text captions, students said they preferred the spoken instructions.

Increased efficiency

In practice, students navigated through the video guides systematically and engaged with the practicals diligently. The level of help required was reduced, suggesting a sense of empowerment and self-confidence as they were in control of the speed of instruction. The completion and success rates also appeared to increase, allowing more time to be spent on pooling class data and analysing results. Initially, videos contained only instructions for performing the experiments, with calculations left for the concluding group discussion. Following requests by students, videos were introduced that incorporated how to calculate and analyse the data. The time-saving meant that, by the end of the session, pooled data could be discussed by the demonstrator, along with physiological and statistical principles. Such whole group analysis was difficult to undertake with the former approach. Students would be able to see how their data compared with others.

Increased effectiveness

Increased efficiency may be related to task completion time, but it is more difficult to assess increased effectiveness. One possible measure would be the quality of student output, and on this basis the video guides achieved the same quality, as assessed by the demonstrators, but achieved in less time and with less intervention by the demonstrator.

A questionnaire survey was conducted of students' preferences and experiences, and the results are summarised in Table 1.

***Table 1** Summary table of results of the student questionnaire relating to use of digital video guides*

Questions (Number of respondents given in brackets)	Yes %	No %	No pref %
Do you prefer practical work to lectures? (70)	**59**	41	0
Do you prefer the video-guides to printed instructions for guiding you through the practical? (77)	**90**	9	1
Do you prefer the video-guides to a demonstrator showing how to carry out the practical? (78)	**70**	29	1
Do you feel you learn more from the video-guides to printed instructions? (78)	**70**	29	1
Do you prefer to learn on a one-to-one basis? (76)	43	**55**	2
Do you prefer to learn as part of a group? (75)	**71**	27	2
Did the video pod files allow you to work at your own pace? (78)	**100**	0	0
Was the material appropriate? (77)	**100**	0	0
Did you preview the video-guides before the laboratory session? (78)	49	**51**	0
Did you revisit the video pod files after the laboratory session? (75)	44	**56**	0
Did the video-guides affect your attendance at practicals positively? (73)	**92**	8	0
Did you feel the subject material was appropriate to use video-guides? (77)	**100**	0	0
Where did you view the video-guides? At home (H) | At university (U) | Other (O) (70)	(H) **60**	(U) 20	(O) 20

Preference for practicals

Of the students who responded 59% preferred practical work to lectures. Though we expected practicals to be more popular than lectures, many students did not like being experimental subjects and were concerned about being the focus of laboratory scrutiny.

Preference for video guides

Given the novel nature (to these students) of this form of learning support, it was gratifying that 90% said they preferred video-guidance to printed workbooks; a preference supported by comments such as '*can all our practicals have these videos?'* . In addition, 70% also indicated they preferred video-guidance to a demonstrator and 30% wanted the practical to start with a demonstration before using the video-guides. All students liked video-guidance though there was variation in preference over how they were deployed.

Preferred learning approaches

When asked if they preferred to learn on on a one-to-one basis, student opinion was split 43% 'Yes' and 55% 'No' (2% had 'no preference'). This could reflect a preference for interaction with tutors or engagement with video-guides on an individual basis. However, when asked 'Do you prefer to learn as part of a group?' 71% responded 'Yes' (27% 'No' and 2% had 'no preference'). When asked, 'Did the videopod files allow you to work at your own pace?' all students answered 'Yes'. The same outcome was elicited by 'Did you feel the subject material was appropriate for video-guides?' Overall, therefore, the students approved of the application of video support to their learning.

Pre- and post-viewing of the videos

The videos viewed in the practical were also made freely available to students via the web. There was an equal split between those who did (49%) and did not (51%) preview the videos beforehand. Generally, those that did not, indicated they intended to but had either forgotten to watch them or could not remember where to access them. When asked if they revisited the videos after the practical, 44% replied 'Yes'. Of those viewing the videos outside the practical session, 60% did so on their home computers, 20% from university computers and 20% from other locations (e.g. at the homes of friends or family).

Attendance at practicals

A common concern when increasing prior access to learning materials is decreased student attendance. This is particularly important for practicals where participation is central to the learning experience. When asked, 'Did the video-guides affect your attendance at practicals positively?' 92% said Yes and 8% No, indicating that contrary to popular belief, access to learning materials beforehand provided additional encouragement for students to attend. Even though only 51% viewed the videos beforehand, the high positive response rate obtained here (92%) may be related to the fact that students knew that videos would be used in the next practical and because they found this approach to be useful, it encouraged them to attend subsequent practicals.

From the additional comments made, students said that previously they were concerned about being experimental subjects and not understanding what to do in the practicals. Seeing the practical enacted beforehand allayed their fears as they had a better understanding of what was required of them. This sentiment was summed up by, *'It made me want to come more, as I already knew beforehand what I would be doing'*, *'[the videos] increased my attendance'* and *'[I was] more motivated'* and *'[the videos] made me want to go as they are more enjoyable and easier to follow'*. One person said, *'[I] Missed a session but was able to not miss any info due to pod files'*.

Videos guides as learning tools

We wondered if the videos did more than just systematically guide students through the practical. We asked, 'Do you think the video-guide approach prepares you better for the practical?' to which 96% answered 'Yes' and 4% 'No'. A number of students wrote supplementary comments which helped define this aspect further: some representative quotes in favour included…

> *'Definitely you have advance knowledge so less time is wasted getting set up for the practical and appropriate clothing can be worn',*
>
> *'If you already understand what you are going to do it allows you to apply the background information your lecturer provides',*
>
> *'It gives you the overview of it before you come. Then once you do it, you understand more',*
>
> *'It's very, very good way to prepare for the lectures and practicals',*
>
> *'Yes – have an idea of what to do before hand so need less explanation when you arrive - more time for practical'*
>
> *'Yes it allows us to gain an understanding of the practical before attending so more time during the practical can be spent doing the experiment than reading about it',*
>
> *'Yes it does, obviously if it is viewed in advance. However, viewing them in retrospect is also rewarding + informative'.*

Some less positive responses were:

'No, I prefer a demonstrator/lecturer to talk through the practical and to be able to ask/answer questions',

'Not really, but it is very effective during the practical work because the instructions are understood better & more accurate results can be gotten at the end'

Other applications of video guides

We asked students 'What further sort of material would you like to see as video pod-guides?'; some ideas included:

'Everything on my course',

'Working through practise exam papers',

'All lectures',

'More instruction on calculations',

'Interpreting the results',

'Reading lists, suggestions for preparation, suitable clothing etc'

'Practicals for other modules'.

Application of video-guides to other modules

Students studying the Human Physiology module also took modules from various other bioscience disciplines (such as immunology, molecular biology, microbiology, pathology and genetics) and statistics and research methods. There was unanimous agreement among the 74 respondents that video-guides should also be used for other modules with comments such as:

'Yes definitely in [module X]; as the work is very complex.',

'Yes, this would be an approach every subject could use to allow students to research/ learn more about what they are doing & more importantly why',

'Yes, easy to go over material again and again if I didn't understand it',

'Yes, especially [module Y] as there are many calculations involved and its better if we could go over it at home too (step by step guide)'.

Only one student admitted a preference for printed text saying,

'I enjoy time to read around by using text books'.

Discussion

Instructional videos

The use of video in education is not new (eg JOVE, www.jove.com) but is often introduced to replace hands-on experience with a simulation (Tan *et al.*, 1989). Our study uses video for self-guidance of students performing laboratory experiments in biosciences, and a similar approach in the Bristol ChemLabS project uses interactive assessments and video to prepare and guide students in chemistry practicals. Indeed, Adams (2009) calls for a BioLabS version of ChemLabS. However, ChemLabS was a £4.5m Centre of Excellence in Teaching and Learning project, whereas our approach achieved a positive step-change, as evidence by student and staff feedback, in conducting bioscience laboratory practicals but at a negligible cost. Although there is merit to producing a national bioscience laboratory video resource, departments have different equipment, teaching emphasis and staff expertise, and our approach permits the rapid, low-cost development of bespoke videos featuring the actual equipment available to the students and operated and narrated by staff familiar to the students.

Filmed simulations can be seen as poor replacements for hands-on work, which could be a barrier to their wider adoption. Attitudes to film and video in education was explored in a paper by Hobbs (2006), who traced usage back to schoolteachers trying to reduce the demands of their job or entertain and motivate their students. The lack of widespread usage (with notable exceptions such as the Open University) suggests that video has never been regarded as a serious, intellectual educational medium compared with text — though this attitude is likely to change with the increasing global appetite for educational video material on websites such as iTunesU and You Tube Edu.

Towards an improved laboratory practical

Collis *et al*. (2007, 2008) proposed an ideal format for laboratory classes involving students observing a phenomenon, asking questions and devising a testable hypothesis through experimental design, and recording and analysing their results to validate their hypothesis. Although our approach did not match this particular ideal, it did help set up a framework within which that could occur. By allowing measurements to be made more efficiently, time was available to explore class data and discuss future directions. We applied our video approach deliberately to practicals where the instructions were systematic. Data collection was not the end-point but rather provided the means by which students could then test their hypotheses, with demonstrator time being used more effectively through higher level engagement which set up the framework for more active learning.

IT infrastructure

Ideally, a laboratory IT infrastructure permitting allocation of a computer to each experimental workstation is required. Increasingly, computers are extensively used in physiology teaching laboratories for data collection and analysis, and in our case this was not an issue. An existing familiarity with laboratory computers may have contributed to their adoption by students for video guidance. Additionally, students are experienced computer users and increasingly use them for educational purposes; in this study, all but one student said their IT skills were excellent to average. It is not surprising, therefore, to find this demographic of students readily accepting the use of video and to view that use as neither a culture shock nor revolutionary.

Application of video approach in laboratories without computers

This web-based approach could also work in laboratories with limited or no computer availability if students utilised their own laptops and wi-fi connections were available. Universities are continually encouraging laptop use and widening the reach of wi-fi connectivity, so although inclusivity could be an issue for some students and special precautions may apply to laboratory settings and, lack of IT equipment need not necessarily limit use of video-guides.

Portable devices

This study also explored using the video guides pre-loaded onto portable digital media players (Archos 504 Camcorder), but this was soon abandoned as the screen and controls were very small and often required both hands to control the device. Nevertheless, we feel that portable players (such as the iPhone or iPad) could play a future role as a popular alternative to desktop computers and will undoubtedly be the subject of a separate study.

Production skills and video quality

Another perceived barrier to adoption of video guides is the technology involved in filming, post-production and delivery. Although we had access to professional cameras and AV technicians, we addressed long-term sustainability in an increasingly low-resource environment by using low-cost alternatives. We mostly used a domestic video camera, though a few recordings used an even lower-specification camera in an Archos portable media player (which could record directly onto a built-in hard drive). The effective use of video technologies within teaching is an emerging area represented by web sites such as DIVERSE (http://tojde.anadolu.edu.tr/tojde16/news/diverse.htm)

Due to eagerness and a desire to minimise production time, we tended not rehearse to find the best camera angles etc.; recordings were also made in one take, so camera movement was not always smooth. Nevertheless, these recordings seemed good enough to achieve our principal aim of guiding students through the practical, a view supported by lack of adverse comment by the students as well as their successful completion of the practicals. This might reflect students' familiarity with low-quality, user-generated video on social network sites and sites such as YouTube.

Although videos were post-produced using commercial software, Camtasia, its basic capability resembled that freely available within some operating systems.

We used a bespoke delivery system to make the videos available to the students; however, they could just as easily be stored on laboratory computers or placed within VLEs.

Concerns of academics

Physiology was not the original target discipline for our video-guide approach, but our proposals were rejected by staff from the other field. Their concerns, which impacted on our questionnaire and may reflect the concerns of others considering this approach, included a counter-productive effect on student practical attendance. Staff felt that making videos available before the practical would encourage students to regard the videos as an alternative to attendance. Staff also thought the videos would diminish the student experience by reducing personal interaction with demonstrators (e.g. mini-tutorials and feedback opportunities). Concerns that senior management would see videos as a cost-effective alternative to laboratory work were also expressed.

In reality, our studies suggest that students are more likely to attend practical sessions after viewing videos, and felt better prepared, more enthused, and knew what to expect.

Concerning loss of dynamic interaction between demonstrator and student, our studies showed a positive change. Previously, interaction focussed on issues with the equipment and the experiment not working; following video guidance, demonstrators were able to engage at a higher intellectual level — so making the role more rewarding.

With regard to replacing hands-on experience, this was never an objective of the video approach. Although students preferred the video approach to demonstrations, they still wanted an initial demonstration and valued the interaction with demonstrators. They regarded the videos as useful guidance for the routine parts of the practical, but valued the human element for the more complex aspects. This blended approach seemed to enhance the students' experience of laboratory work while maximising what can achieved with limited time, staff and equipment resources.

Handouts

The traditional approach to supporting practicals, as for lectures, is to provide students with paper handouts. In our experience, students find difficulty translating written instructions into precise and accurate actions. In studies where the performance of students using text-based instructions was compared with those given more responsibility for conducting the experiment, it was found that the latter group was more engaged and acquired enhanced reasoning skills (Lord and Orkwiszewski, 2006). To encourage active learning, no tutor-prepared handouts were available for students using our video guidance; instead, we recommended that they took notes from the videos.

Playlist approach

One innovation we introduced was the use of the playlist approach to video navigation. Breaking a video into a series of individual 'tracks' simplified navigation. Students are accustomed to music playlists, through which they maintain full control over the arrangement of and access to the music files. Likewise, our students could also create their own video playlists for revision purposes, and could access relevant parts of each video easily.

Other benefits

This study highlighted a number of unanticipated benefits. Students arriving late could use a spare workstation to start the practical without interrupting the demonstrator's ongoing support of the other students. Extending this would permit greater flexibility through phased starts in situations where there is limited equipment or space. We explored the possibility of providing soundtracks in different languages for international students whose first language is not English, especially for covering important areas such as health and safety; in fact, current international students could improve their language skills by helping to translate and record the soundtrack (informal enquiries suggested sufficient potential student volunteers). Extending the idea of flexibility, video guides would allow more complex arrangements of different practicals to run simultaneously, so making better use of limited equipment and/or staffing resources.

Deploying videos on networked computer workstations allows students easy access to other learning materials, including previous work, and puts the practical in context with the rest of the module. By allowing students to cross reference between theory and practice it is hoped that our video guidance approach helps address the observation by Kirschner and Huisman (1998) that undergraduate students think of practical exercises as isolated activities not related to previous work.

Video can support the enquiry-based learning (EBL) approach to laboratory work suggested by Adams (2009) and Chaplin (2003). The present approach could be potentially developed such that students could film and share their work to help avoid repeat mistakes and adopt successful approaches. Wilson *et al.* (2008) recognised the importance of laboratory work for social interaction with peers and tutors. Making videos of student practicals would allow this social interaction to be networked to draw in a wider audience, important given the potential for social networking to contribute to learning for the net-generation. Student-filmed work could also be used for the assessment of skills, competences and understanding, or for validating work performed. Student-led EBL can be complex to manage in terms of availability of equipment, and knowledge of how to perform experiments or intensive supervision. Having videos demonstrating a suite of techniques could support this more flexible approach to practicals.

Chemistry is one area of science for which video support is relatively advanced; McClean and Hagan (2009) used it for students to reflect on their laboratory learning as well as within a social site for students to share experiences. Although students were initially apprehensive about making reflective videos, overall they were satisfied with the approach. Although that project differs from the one presented here, there is scope for students to give tips and advice in video format for other students performing our physiology practicals.

Furthermore Harwood and McMahon (1997) found that high school chemistry students whose laboratory sessions were supplemented with instructional videos had significantly higher achievement scores compared to those without. They also found that educational science video media in general were effective instructional tools as they brought the abstract within each student's personal meaningful realm, thereby positively affecting their attitude.

Summary

Digital video guides enhanced the students' learning experience in numerous ways. They allowed students to preview the practical beforehand and increased attendance. The videos enabled students to become more autonomous and efficient learners in the laboratory and allowed more time during the practical for higher level interaction with demonstrators, including time to pool and analyse group data. Although the production quality of the videos was not of professional standard, students considered them to be 'good enough' for guiding them through procedures, techniques and calculations. The ease and low cost of producing the videos put this technique within the reach of most teaching laboratories. Demonstrating became a more rewarding experience by being less about equipment troubleshooting. Because access to the videos continued long after the practical, students could use them for revision and 're-live' the procedures.

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Communicating Author

Professor Stephen Gomez, Head of Work Based & Placement Learning.
3, Endsleigh Place, University of Plymouth, Drake Circus, Plymouth, PL4 8AA.
E-mail:stephen.gomez@plymouth.ac.uk Phone: 01752 587924

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