Biology students' perceptions of learning from video exemplars of practical techniques: some lessons for teaching strategies

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Abstract

Video demonstrations are considered a useful way of preparing students for laboratory practicals or fieldwork, but the benefits may be dependent on the type of task and the level of prior understanding. In this study we initially replicate the findings of others in that 62% of student questionnaire respondents found video exemplars of technically complex laboratory practical tasks helpful. This, however, contrasts with the views from student focus groups undertaking ecological sampling techniques utilising relatively simple equipment. In the focus groups it seemed that prior practical experience had a greater impact on learning than the video exemplars. Furthermore, students' practical concerns were overshadowed by worries of experimental design and data analysis. Our findings suggest video exemplars to be a more effective teaching tool for technically complex procedures. Students' concerns regarding data handling merit further investigation as they may lead them to choose less challenging third year projects.

Keywords: video; laboratory; fieldwork; practical work; exemplars

Introduction

Undergraduate practical sessions have a central role in science education (Hofstein and Mamlok-Naaman, 2007) and within the biological sciences organisations concerned with academic standards see practical work as a vital component of degree courses (e.g. Great Britain, Quality Assurance Agency for Higher Education, 2007; Great Britain, Society of Biology, 2013). Yet, despite the emphasis attributed to science practice, universities seem not to be effective at producing graduates with the skills required by employers (Association of the British Pharmaceutical Industry, 2008; Great Britain, House of Lords Select Committee on Science and Technology, 2012).

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Considering university practical sessions from the students' perspective may be helpful in unravelling possible reasons for the mismatch between university aspirations and employers' experiences. For students, investigative practical work does promote a greater sense of professional scientific identity (MacKenzie and Ruxton, 2007) and Collis et al. (2008) found that first year students perceived laboratory practical sessions to serve a variety of functions such as learning new skills, illustrating lecture material and facilitating social interaction. Hence students value practical work for worthy reasons, but it may be that students perceive practical attributes in subtly different ways to their tutors. Firstly, while students relish learning the skills to use more complex equipment, it is noticeable that their emphasis seems to be on equipment use *per se* rather than on understanding the purpose for using such equipment (Collis et al., 2008). Here, the observation of Kirschner and Huisman (1998) that undergraduate students often think of practical exercises as isolated from other course components may be pertinent; a view that seems at odds with their previously stated illustrative role for practical work. Finally, first year biological sciences undergraduates perceive their university practical sessions as less personal than their prior college experiences (Collis et al., 2008). Perhaps the social function of university practical sessions is reduced by factors such as larger class sizes and multiple staff members; factors that are often outside the control of individual lecturers and which may contribute to students considering them as separate, isolated activities.

The availability of video exemplars of practical techniques may serve to enhance students' practical experience since they may provide additional exposure to procedures outside the laboratory session when the environment is less pressurised by the immediate need to undertake practical procedures. Such videos have been previously used in physiology practical sessions (Croker et al., 2010) where they were made available both prior to the session and within the session at small group workstations designed to facilitate student interaction. They were shown to lead to increased student engagement in their scientific practice as illustrated by the quotation below.

> "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." (Croker et al., 2010, p.10)

Furthermore, demonstrators in these practical sessions reported that they spent a greater proportion of their time answering higher level student queries rather than simply trouble-shooting technical equipment issues (Croker et al., 2010). More time was also available at the end of the sessions for whole class discussions of pooled class data.

Video exemplars of practical techniques therefore seem to contribute to learning and the relevance of specific aspects of visualisations of practice to this process has been the subject of previous empirical investigations based typically on standardised tasks which were unfamiliar to the participants. An early study by Ferguson and Hegarty (1995)

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considered learning the mechanics of pulley systems. Line diagrams were compared with hands-on dynamic interaction with real machines. The media did not affect students' ability to choose efficient pulley systems, but the dynamic interaction with real machines did enhance their ability to apply their knowledge to real world situations presented in a post-instruction test. In this study, and also in the study of Croker et al. (2010), in addition to seeing movement students had the opportunity to repeat particular components at their own volition. Hence (i) the impact of movement (ii) the ability to control that movement and (iii) the degree of realism may have all contributed to the observed differences. Subsequent studies have endeavoured to separate these three aspects of visualisations.

Using computer visualisations of a pulley system, Boucheix and Schneider (2009) studied effects on learning of, firstly, movement by comparing an animation to static diagrams and, secondly, user control by comparing non-controllable and controllable animations. They found that animation did result in learners developing a better functional mental model of the pulley system whereas user control of that animation had little effect. The effect of user control may, however, be related to the nature of the task being learned. In the case of more procedural learning, in this case the tying of nautical knots, Schwan and Riempp (2004) found control to have a strong effect.

Finally, the effect of realism was investigated by Scheiter et al. (2009) who compared learning from realistic animations in the form of video microphotography of a form of cell division, mitosis, with schematic animations of the same process. By comparing pre-viewing and post-viewing tests they found that, while all students learned to some extent, viewing the schematic animations led to better conceptual understanding. Pragmatically, however, while schematic animations may lower the cognitive load on the learner by removing irrelevancies, current technology enables realistic videos to be produced more easily so they remain an attractive option for use in teaching.

In practice students rarely learn from a single type of visualisation. For example, they may have access to both a video and an illustrated account of the process written in a textbook. Consequently, the effectiveness of visualisations as learning aids is dependent not only on understanding the meaning of individual visualisations, but also on appreciating the relationship between the different visualisations (Ainsworth, 2006) and, subsequently, the relationship between visualisations and the real world. Students' prior knowledge and the ease of understanding of the procedures may be a crucial factor enabling this appreciation to occur.

> "It should be noted that the functions that representations serve often depend on learners' knowledge and goals not system designer's intent" (Ainsworth, 2006, p.189)

In this paper we report the findings of a study comparing the use of realistic videos as teaching aids for practical techniques involving different types of equipment. The study has two research questions:

- What benefits do second year undergraduate biological science students perceive from video demonstrations of a) fieldwork and b) laboratory techniques?
- To what extent do such videos influence the development of students' scientific thinking?

Methodology

Setting: The research was carried out in a post-1992 university in the UK within the field of biological sciences. The study involved two second year undergraduate modules. The first was a module entitled Biomedical Analysis in which groups of 8-9 students undertook a series of biochemical and physiological practical investigations designed to develop their understanding of clinical disease states. This module has been previously described since it formed the basis of a prior study (Merry et al., 2010). Five short videos (approximately 5 minutes each) of tutors demonstrating specialist biomedical equipment such as analysers of biological fluids that students would be required to utilise in the module's practical sessions were uploaded onto the module website. These were made available to students before the sessions and also after the sessions for revisiting with no restrictions on the number of times that students viewed them.

The second module was entitled Marine Zoology and here a similar number of videos demonstrating species identification and ecological sampling techniques using simple equipment such as quadrats were shown in class to cohort groups of students before they undertook a coastal practical field trip involving the use of these techniques.

Participants: Pragmatic considerations including student availability, cohort sizes and compliance with the wishes of module tutors necessitated different approaches for each of the two modules. The whole of a single cohort of 43 Biomedical Analysis students were invited to complete questionnaires and 29 (67%) did so. For Marine Zoology focus groups of 4-6 students were derived from each of four different cohorts of students by opportunistic sampling. The cohorts were from four different academic years and were designated A-D. Each focus group represented approximately 30% of the students in the cohort and in accordance with institutional ethical procedures all focus group participants gave informed consent before taking part in the study. To endeavour to assess the impact of the videos each focus group was interviewed on up to three occasions as described in *Procedures.*

Instruments: The Biomedical Analysis student module feedback form contained three open ended prompts which provided data for this study:

1. 'Please add your comments on those aspects of the module that you enjoyed/found most interesting.'

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2. 'Please add your comments on those aspects of the module that you found most difficult.'
3. 'How did you use the video demonstrations in Blackboard? We would like to know what you thought of them, and what you think we should add.'

Prompts 1 and 2 facilitated student responses concerning equipment usage and data analysis. Prompt 3 was to directly collect perceptions and usage of the provided videos.

Marine Zoology focus groups were carried out in order to investigate students' perceptions of ecological sampling and survey techniques including what factors are influential in the development of those perceptions and how the perceptions contribute to their overall view of themselves as professional biologists. The focus groups were semi-structured and the schedule primarily concerned:

- understanding of ecological sampling and survey techniques
- perceptions of independent project work
- understanding of ecological habitats and how this affects their overall conceptions of biological processes

Focus group discussions concerning prompts 1 and 2 collected student perceptions of equipment usage and data analysis. Within discussions concerning prompt 3 student perceptions of the provided videos were explored.

The schedule was developed as described by Fielding (1993). Briefly, this involved (i) identifying topics surrounding the research questions (ii) clustering and sequencing of relevant topics and (iii) designing informal interview probes. The same schedule was used for repeat focus groups.

Procedures: Hard copy questionnaires were distributed to Biomedical Analysis students at the start the final taught laboratory session of the module. They were anonymous and students were invited to complete them during the session. At the stage of submitting questionnaire responses, students had completed the taught component of the module, but had not yet undertaken their final module assessment.

Table 1 provides details of the timing of the focus groups in relation to the progression of the student cohorts through the Marine Zoology module. Focus groups were conducted at particular time points such that a sense of the relative impact of the videos and the coastal field course practical work could be developed. All participants had prior experience of viewing laboratory specimens of marine organisms and of practical field work in non-coastal settings.

All focus groups were confidential and the data generated was anonymous. They were conducted by two of the authors of this paper who had no input into the teaching of the module. Focus groups were audio recorded and the researchers also made contemporaneous notes. Transcriptions were made from the audio recordings.

Table 1: Student Focus Groups

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Student Cohort	Group No.	Videos viewed	Field Course undertaken
A	A1	No	Yes
B	B1	Yes	No
C	C1	No	No
C	C2	No	Yes
D	D1	No	No
D	D2	Yes	No
D	D3	Yes	Yes

Analysis: A semi-quantitative analysis of the Biomedical Analysis questionnaire responses was undertaken. All questionnaire responses were read by a single researcher who derived a coding framework to classify comments into themes (Creswell, 2008). The frequency of each theme was then determined.

Qualitative analysis of student interview data involved clustering of units of relevant meaning (Cohen, Manion and Morrison, 2007). Two authors independently read the transcripts and agreed themes and representative quotes in subsequent discussions.

Results

Questionnaire data were collected from Biomedical Analysis students at a single time point at the end of the taught component of the module. In the case of Marine Zoology students repeat focus groups were conducted to identify progressive changes in thinking following exposure to the video exemplars and subsequent fieldwork. However such changes were not apparent on initial reading of the transcripts and so the data from all the focus group sessions was combined and four overall themes were identified. These were perceptions of the video exemplars, motivation for practical work, contribution of prior practical experiences to learning, and perceptions of data analysis as problematic. Three of these themes also emerged in the Biomedical Analysis questionnaire data enabling comparisons between the two student types to be made. Possible reasons for the limited impact of the Marine Zoology video exemplars are explored in the Discussion section.

Students' perceptions of the video exemplars: Eighteen Biomedical Analysis students (62% of respondents) reported that they found the videos useful, although why this was so and how they actually used them was not recorded. Contrastingly, 7 students stated that they did not use them. Reasons for non-engagement were long download times (2 students) and the fact that the videos were located separately from the practical schedules (1 student).

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Marine Zoology students showed less enthusiasm for the videos. They generally regarded them as not being authentic investigative science as the following two quotations from focus group D2 illustrate:

> “Well no, this person what was on the video was obviously doin’ it for educational purposes.” (Student 2)
>
> “It’s not like they were researchin’!” (Student 3)

Student motivation for practical work: Biomedical Analysis students reported the following aspects of the module as being enjoyable or interesting: a) the diversity of practical work (13 students), b) using different equipment (9 students) and c) undertaking practicals based on humans (8 students).

Marine Zoology students also demonstrated motivation for practical work as illustrated by the following exchange from focus group D1:

> “It’s all well and good talkin’ about somethin’ that you can only see under a microscope…” (Student 4)
> “…Or on a video!” (Student 3)
> “Ermm …yeah or from a distance, but when you’ve got it…almost in your hands at the time, I erm, I think it gives yer a different response to it, and when you can, when you can link somethin’ in with somethin’ you know already, you – know you come on in leaps and bounds” (Student 4)

Contribution of practical experiences to student learning: While it was not directly sought in either the Biomedical Analysis or Marine Zoology prompts, the influence of practical experiences in general did emerge as a strong theme within the Marine Zoology student focus groups as the following three quotes illustrate:

> “Oh, for me personally it’s volunteering...like woodland management and grassland management, I’ve picked up a lot of ahhh, helpful techniques...from that.” (Group A1, Student 4)
>
> “I actually remember it better if I can see somebody…actually performin’ it an’ doin’ it, because you produce a picture in your mind don’t yer!” (Group D1, Student 3)
>
> “Er, um - well [name of tutor]…mentioned about it he said, that you – know ecologists tend to be, er quite a practical bunch, an’ if…an’ if a stick…will do the same job…you’ll use a stick…” (Group D1, Student 5)

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Importantly, Marine Zoology students used their practical experience to interpret their existing knowledge so placing it into context. This is illustrated by the following exchange from focus group A1:

> "…ahumm.. well learning the literature before I went up there [to the field course] and looking at the dead examples that we'd got and you suddenly find yourself going 'Oh yeah-hh, that's why it's there…" (Student 4)
> "And they're more colourful live than dead." (Student 2)

They also developed their scientific thinking through practical experiences as illustrated by the following two quotes:

> "…an' during, during the practical [field course] I – I really sensed…no, you're not right about this an' I'll show you why you're not right, an' I really didn't expect myself to say that." (Group D3, Student 5)

> "…you've got less control over things like what you're measuring then it's difficult to erm, say how much er-of-er, how much of a scientific judgement you can make…' (Group B1, Student 6)

Data analysis was seen as problematic: While 4 Biomedical Analysis students reported that they enjoyed/found interesting working with data, 14 students stated that they found it one of the most difficult aspects of the module. One student, as a free text comment, stated 'Data analysis should be a module on its own'.

Marine Zoology students also perceived data analysis as problematic as illustrated by the following quote from focus group C2 and exchange from focus group C1:

> "…we could almost do with a statistics module or a…not a marked one! Just like a…like a tutor course or something like a crash-course" (Student 2)

> "…its useful to have someone to say …or help you with your weak points which maybe probably be my statistics …I could do the research by myself but I'm going to need help at the end, to make it make any sense..." (Student 4)
> 'Yeah like [name of student] said I'll probably need help with, statistics so, I'll have to ask someone or research…probably go to project tutor." (Student 3)

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Discussion

Our data suggests that video exemplars of practical techniques were more favourably received by students undertaking a biomedical module (Biomedical Analysis) rather than an environmental module (Marine Zoology). Secondly, both Biomedical Analysis and Marine Zoology students seemed highly motivated to undertake practical work so observed differences between the two types of students could not be attributed to different levels of enthusiasm. Our findings are consistent with McLean and Denning (2000) who have previously argued that 'self-regulation and the ability to monitor one's own learning is motivating' (p.475). Self-regulation in terms of the need to make judgements as to how best to proceed would seem to be an intrinsic characteristic of the practical work undertaken by both types of students and hence a potential cause of students' enthusiasm. Thirdly, the repeat sessions conducted with individual focus groups of Marine Zoology students failed to identify progressive changes in their scientific thinking following their exposure to the video exemplars. For these students practical experience itself seemed to be a dominant factor steering their thinking. Finally, while high motivation for practical work was evident, both types of students expressed concerns regarding data analysis. It is interesting that students themselves identify a deficiency that has been highlighted by the UK Government (Great Britain, House of Lords Select Committee on Science and Technology, 2012) in relation to the provision of graduates with appropriate skills for employers. This is a matter of concern both in the longer term suggesting changes to teaching curricula, but also more immediately in that it may lead to students selecting less challenging 'safe' project work which may not fully develop their overall skill set.

One factor that may have been influential in creating the different responses to video exemplars between Biomedical Analysis and Marine Zoology students was the complexity of the equipment being demonstrated. For Biomedical Analysis students the videos concerned specialist partially automated equipment for the measurement of human body fluid and physiological parameters. The equipment was unfamiliar to students and it required a defined sequence of activities, often a sequence of keys on a keypad, in order for the equipment to generate the data outputs required, which were typically precise numbers on a visual display. As such the videos were procedural in nature and students were subsequently required to replicate the sequence of actions in the following practical session. Marine Zoology students, however, were presented with videos involving relatively straightforward equipment with principles of use that could be easily understood. Nevertheless, while the equipment was straightforward, the findings were not always obvious. For example, to generate data from a placed quadrat may require the user to apply prior knowledge and observational skills to make judgements concerning species identification and number of organisms present. The learning that the Marine Zoology videos were endeavouring to facilitate therefore had an abstract and conceptual component that was less evident in the Biomedical Analysis videos. Students

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were not required to learn a prescribed sequence of actions, rather to use the videos as illustrative material to learn how identification and judgements might be made. This type of viewing imposes a greater cognitive load on the viewer (Schwan and Riemp, 2004) which was likely to be further increased in the case of Marine Zoology students by the lack of availability of the videos for repeat viewing.

A second possible contributory factor for the differences in student perception of the videos may have been the identity of the individuals demonstrating the techniques in the videos. The Biomedical Analysis videos, like those used by Croker et al. (2010), were produced by a course tutor who presented the technique in the laboratory in which the students worked. This contrasted with Marine Zoology videos which were obtained commercially. They were of higher professional quality, but the presenters and locations were unfamiliar. We have shown previously (Orsmond et al., 2005) that learning from tutor feedback is influenced by students' perception of that tutor. Analogously, the familiarity and students' views of the video presenter are likely to influence how the message is perceived.

Thirdly, the temporal separation of the viewing of the video exemplars and performing the techniques may have influenced students' perceptions of their value. In the case of Biomedical Analysis the videos were available for the students to watch immediately before the practical session and this contrasted with Marine Zoology where videos were viewed in the university typically three weeks before the fieldwork was undertaken.

Taken together, these factors would seem to be important in shaping how video exemplars might be more effectively used to support students' learning in practical situations. Interestingly, the study described by Croker et al. (2010) contained each of these factors in that the learning was procedural, the videos were produced by the course tutors and viewing was not separated from the practical sessions. Croker et al. (2010), however, failed to suggest these factors as a crucial component of the successful teaching intervention that they report and this may have been because their study was descriptive of a single setting rather than comparative of video usage in different contexts. Perhaps a further unidentified factor in the success of the study of Croker at al. (2010) was the peer discussion that they engendered by making the videos available to students at small group workstations. The benefits of peer discussion when utilising written exemplars in a variety of disciplines have been outlined by Hendry (2013) and it is to be expected that peer discussion of video exemplars would be equally beneficial, although this was not a component of our current work.

Finally, our study highlighted students' concerns regarding data analysis. Both Biomedical Analysis and Marine Zoology students found this a more challenging aspect of their learning and both types of students requested further support in this area. This concern is interesting because it contrasts with their general enthusiasm for practical work which generates data, and also reflects concerns expressed by employers as outlined by the Great Britain House of Lords Select Committee on Science and

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Technology (2012). In addition to longer term aspirations of providing appropriate graduates for others to employ, it is suggested that there is a more pressing need to address this situation because of the possibility that it will cause current students to choose more straightforward, less challenging, final year projects in order to generate simpler, more manageable, data sets. Students who take such options are likely to lose opportunities to develop some of the professional skills required by employers.

A particular limitation of the current study was that it included comparisons between modules where data was collected using different methodologies. Hence further studies comparing the use of video exemplars of practical techniques of different complexities, familiarity and ease of data interpretation are required to both corroborate our conclusions and to indentify, more precisely, the factors that most strongly affect effective video use. Student ability is also likely to affect the effectiveness of video exemplars. Orsmond and Merry (2013) showed that high achieving students process the information within tutors' feedback in different ways to non-high achieving students. Analogously, the information within video exemplars may be also processed differently and studies are required to investigate such differences so that tutors do not use video exemplars in ways which cause cognitive overload to some of their cohort. Finally, the perception of students of data analysis as problematic and its potential to affect project choice warrents further investigation to determine of this suggested correlation is genuine.

In conclusion, our data provide some lessons for tutors concerning the use of video exemplars of practical techniques within their teaching. Such videos are likely to be most effective when they involve complex procedural techniques using equipment that is unfamiliar to the students. It is also recommended that students should have free access to the video exemplars for repeat viewing and videos featuring their current tutors as presenters will be preferable to commercial programmes despite the likely lower technical quality. Furthermore, learning will be promoted if peer discussion of the video exemplars is facilitated, possibly by also making them also available during the practical sessions. The implications of students' perceptions of data analysis as probelematic need to be elucidated in future studies.

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