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Using technology to direct learning in higher education

The way forward?

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ABSTRACT Improvements in technology appear to provide an unprecedented opportunity to improve learning and teaching within the higher education system. At present, however, opinions are divided over the efficacy of such an approach and the extent to which technology should be embraced in teaching. Over a period of two years, we have developed a new 'blended' module where all learning resources are provided online and formal teaching sessions are used to provide the directed learning needed by students. This article explores the effectiveness of using technology to direct learning and identifies generic problems. Using measures of student performance, we demonstrate that technology in higher education can significantly improve student learning when fully aligned to the teaching aims and fully embedded within a module. The ability of students to use technology to repeatedly return to resources was a clear benefit, allowing students to take responsibility for their own study at a pace appropriate for the learner.

KEYWORDS: *directed learning, e-learning, instant feedback, online resources, strategic learning, teaching sessions, virtual fieldtrips*

Introduction

Technology is increasingly being exploited for learning and teaching in universities around the world (Jones and O'Shea, 2004; Laurillard, 2002; Sharpe et al., 2006), largely because it is considered to offer greater flexibility in relation to time, place, pace, entry and exit (Inglis et al., 2002). Its effectiveness within higher education to improve learning and teaching (including reflective practice), however, is difficult to quantify

(Ferdig, 2006; Jones and Paolucci, 1998). While the use of technology can enhance access and learning opportunities for students on and off campus (Biggs, 2003; Stainfield et al., 2000), measuring student-learning gains is considerably more problematic. As a result, a range of views has developed as to its use. From one end of the spectrum, some researchers have argued that the current application of technology in higher education, while providing more time for reflective teaching, does little to improve learning on the part of the student (Kvavik et al., 2004) or can lead to a strategic learning approach to meet specific course objectives (Saunders and Klemming, 2003). In contrast, others have suggested that embedding the appropriate technology into modules can greatly improve the engagement of students during learning (Maier and Warren, 2000; Sanders, 2006).

Part of the uncertainty regarding the efficacy of technology in higher education teaching and learning is almost certainly due to the different forms it can take (Biggs, 2003). In some instances, technology has simply been used to provide online access to basic module information (for instance course objectives, suggested reading and timetables) and lecture content. Alternatively, at the other extreme end of its application, technology has been embraced to develop a fully integrated teaching and learning system where virtually no formal contact exists between the lecturer and students (though this is more typical of distance learning).

For the effective use of technology, it is necessary to focus on the pedagogy and ensure the instruction is tied to the appropriate media (Conole and Oliver, 1998; Ferdig, 2006). Balanced against this, recent work demonstrates that student experience of online learning and communicating can be poor if there is little direct contact between learners and their teachers (McLoughlin and Luca, 2006); in extreme cases, attendance can drop off (Saunders and Klemming, 2003). A compromise is to take a 'blended' approach that combines technology and direct contact (Sharpe et al., 2006), thereby allowing the learners to return to resources repeatedly (if necessary) but with the teachers providing support and guidance. Critically, quantifying the impact of technology on learning has proved problematic (Sharpe et al., 2006); commonly evaluations are based on student reactions and satisfaction to modules (Alexander, 1999). It is important that more data on student performance is generated to test the efficacy of technology in helping learning and whether it provides adequate support to those learners at risk. Foundation-level students are a particularly vulnerable group of learners at risk of failing to make the transition into higher education.

We wished to see whether a blended approach significantly helps foundation-level students with their learning. With the above considerations, we developed a module over a two-year period where all learning

resources were provided online but formal teaching sessions were used to provide the directed learning needed by students. The technology was delivered using resources on the world wide web (Shroder et al., 2002) and within the university's Virtual Learning Environment (called *Queens-Online*). During the two years of the module's development, we undertook a study to explore the effectiveness of using technology for teaching and learning. Here we describe the integration of technology into the developed module, the methods used, and address whether technology can indeed improve student learning. Although the module was on a science-based topic, we believe the lessons learnt here have wider implications to the teaching community.

Developing the module

Within Northern Ireland, there is currently a Foundation Level 0 entrance (to be phased out in due course) for students who have insufficient or inappropriate qualifications (or grades) for immediate entry into the conventional three-year degree pathway. In view of the expansion in student numbers, a new Level 0 module has been developed at Queen's University Belfast entitled 'Volcanoes, Humans and Environmental Catastrophes' (hereafter referred to as the 'Volcanoes' module). The module has six sections and aims to explore the dynamic relationship between volcanoes, humans and the environment. Students are introduced to the basic principles of volcanology, followed by exploring the effects of eruptions on human evolution, ecology, climate and civilization. The Volcanoes module finishes by investigating how the effects of volcanic eruptions can be mitigated. The module is one of six that are necessary to pass Level 0 and is taught by one lecturer. In the two-year period of development, the class size was identical in size, with 75 students of mixed gender and a typical age of 18–19 years.

Volcanoes began in 2002/2003. During this first year, the technology was not fully integrated into the module. This was largely for two reasons: (1) to identify whether foundation-level students were comfortable with the use of technology for independent learning; and (2) if successful, to provide a statistical comparison with a more integrated approach during the following year. The 2002/2003 module consisted of twelve lectures on volcanoes; lectures were given in a conversational style to engage with the students and allow for spontaneous questioning. The technology was used to support teaching and learning in all other spheres. For instance, the lectures were supported by web-based resources available through *Queens-Online* that were accessible off-campus, allowing learning to continue 'any-time, anyplace'. Email was also used for two-way communication with

students. Embedded within the lecture programme was one 'hands-on' practical followed by five integrated 'virtual' fieldtrips of different volcanic regions. The fieldtrips were accessed through Queens-Online and assessed online. Assessment of the module in this year comprised completion of all practicals and fieldtrips (worth 30%), a mid-semester test (20%) and a final examination (50%). The mid-semester test was taken through Queens-Online but the final exam was completed under traditional formal examination conditions.

During the first year of teaching, it was found that students were not completing the reading prior to lectures; they in fact came to rely on the sessions to give them the necessary background, and students were often becoming acquainted with the material only for the first time during the lecture. It was also clear that the students were comfortable with the use of technology. As a result, during the next teaching year, the module was modified to incorporate more technology into the teaching and learning. Following the pioneering work by Mazur (1998), it was decided to replace lectures with less formal teaching sessions, focusing the latter on underlying concepts. In 2003/2004, the 'hands-on' practical was replaced with an additional virtual fieldtrip, and an online discussion page was also utilized. Assessment of the module was the same as the first year of the module.

In the new learning environment of the second teaching year, students were heavily guided in their reading and web resources prior to the teaching session. Ten non-assessed questions were provided in advance of the teaching session to help direct reading. Students attended the one-hour teaching sessions in a computer laboratory and were presented with the same ten non-assessed questions to reinforce learning. Each question was answered independently in the first 15 minutes using a multiple-choice scoring system available through Queens-Online; the results were automatically collated and fed into a pre-prepared PowerPoint™ presentation. Each question was discussed in the class, and students were invited to explain their answer to a neighbour and convince them why they had answered differently. The questions were designed to encourage students to think through the arguments being developed and provide them with a way to self-assess their understanding of the concept. After a brief discussion of each question between pairs (typically 2–3 minutes), the class results were presented and the correct answer explained.

To further reinforce their learning, the virtual fieldtrips were developed to allow the students to explore the environment of six different volcanic regions around the world using streamlined film footage, high-quality images and text: The Giant's Causeway, Northern Ireland; the AD 79

eruption of Vesuvius, Italy; the eruption of Santorini and the collapse of the Minoan civilization on Crete; volcanoes of New Zealand; volcanoes of Australia; and a modern evacuation of Naples, Italy (Figure 1). Students accessed the fieldtrip via the relevant fieldtrip link provided in Queens-Online. Such an approach, however, did not preclude developing group working skills by the use of online discussion pages that were available to encourage in-depth discussions between students, allowing greater consultation between class members during (and after) the fieldtrip when face-to-face meeting in a relatively restricted space was impractical.

By using technology it was possible to utilize Computer Assisted Assessment (CAA), aligned to the aims and objectives of the module (Maier et al., 1998). CAA not only provided immediate, timely and effective feedback but helped guide student reading and 'feed forward' to subsequent work (Higher Education Academy, 2005; Juwah et al., 2004). Furthermore, by providing a virtually instantaneous marking of fieldtrip submissions and other elements of assessment (e.g. a mid-semester test), time was 'created' for the lecturer to reflect on which components of the module had been little understood and which students were at risk from poor attendance and/or poor grades which could be addressed in subsequent sessions. Once the fieldtrip was completed, students accessed the relevant 'Assessment' option for the fieldtrip through Queens-Online. The questions were given as multiple-choice options and the selection made online. The above was complemented by the mid-semester test of 50 multiple-choice questions that was undertaken under examination conditions using the same assessment format as the fieldtrip

Results and discussion

The two cohorts of students allowed us to assess the efficacy of technology in helping learning within the module. The results from the different components of the module are discussed below.

Teaching sessions

In the first year of teaching, no register was taken for the number of students attending the lecture sessions; overall numbers remained relatively high (>60 students) for each lecture. In the second year, however, because of the establishment of the teaching sessions all the questions were completed online using Queens-Online, and it was therefore possible to monitor the number of students attending the formal periods. It was observed that the number of students dropped off considerably after the first two weeks of teaching (where full classes were recorded) (Figure 2).

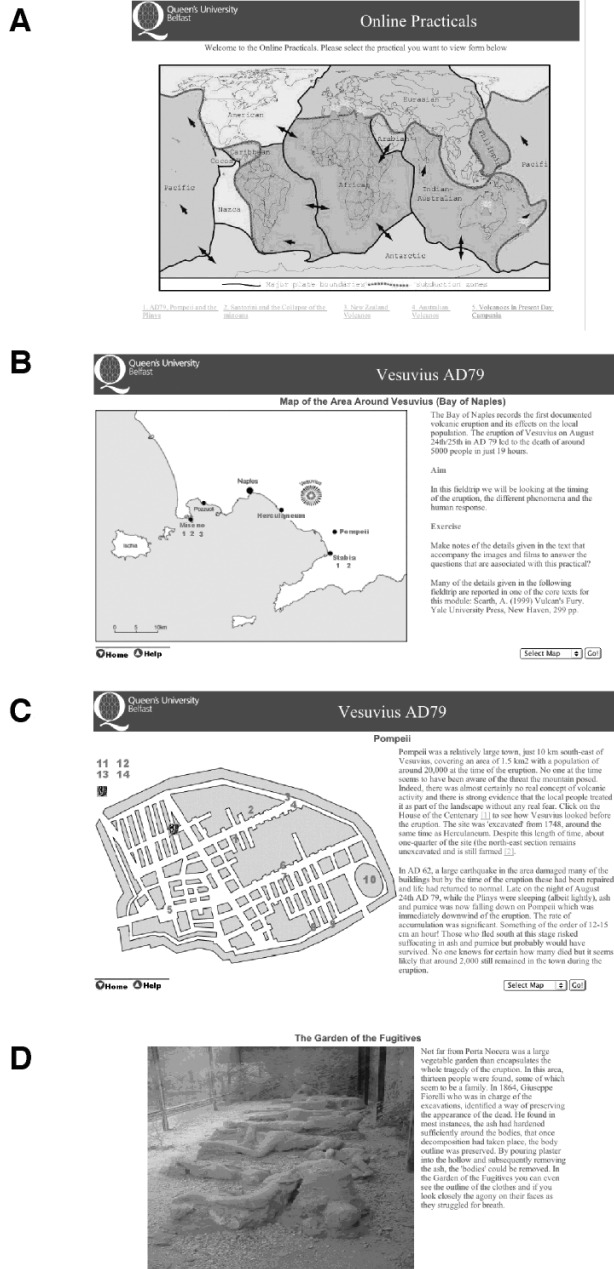


Figure 1 Example virtual fieldtrip, illustrating the structure and options for the AD79 eruption of Vesuvius, including (A) world map of tectonic plates, (B) the Bay of Naples, (C) Pompeii, and (D) the human consequences.

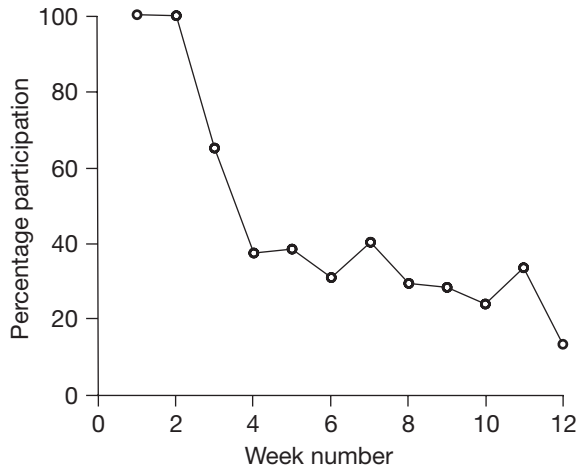


Figure 2 Attendance of teaching sessions in 2003/2004

Following virtually full attendance in the first two weeks, the proportion of students taking part in the teaching sessions was routinely around 25% in the final few weeks, reaching as low as 13% in the final session.

Given the nature of the students within the Volcanoes module (i.e. insufficient or inappropriate qualifications/grades for immediate entry into the degree pathway), there were concerns about levels of motivation on both attendance and performance. The timing of the major fall in numbers suggests that the online accessibility of all the resources (including the results of the teaching sessions) may indeed have reduced the incentive for active participation by students (Saunders and Klemming, 2003), though individuals may also have been uncomfortable with the discussion format of the sessions. Overall, it appears that fully integrating the module led to a drop in attendance of the formal teaching sessions.

Virtual fieldtrips

In the first year of the Volcanoes module (2002/2003) students were issued with copies of the fieldtrip questions before the beginning of the session; they were required to consider the questions before the fieldtrip. The questioning was designed to enable students to consider concepts and think about the wider issues. Students were often observed to be looking for the answers to the assessment component during fieldtrip sessions, and leaving the fieldtrip when these answers were completed. Most students did not appear to take the full time on offer (a maximum of three hours) to make notes from the various resource elements in the fieldtrips. This is supported by comments made at the end of the module, such as 'Knowing

the questions before the practicals discouraged me to read the whole practical.' In an attempt to address this, the questions were not issued to the students at the beginning of the fieldtrips in 2003/2004. Instead, students were provided with broad themes to explore, with questions only being made 'live' 45 minutes after the start of the fieldtrip. As a result, students could explore their environment without the immediate need of answering questions and took a longer period of time to explore the fieldtrips and reflect on previous teaching sessions. In practice, the online discussion pages were rarely used and, when they were, the use was largely of a social nature rather than directly contributing to any active learning, consistent with findings made in other studies (McLuckie and Topping, 2004).

In an attempt to assess the effectiveness of the fieldtrips for learning, questions were given to the students as a 'pre-test' before the commencement of the fieldtrips. These questions were on a similar theme to that being addressed within the fieldtrip and had been covered to some extent by the background reading for the lectures/teaching sessions. The pre-test questions were non-assessed. In both years the marks gained during the fieldtrips were higher than those achieved in the pre-tests (Table 1), indicating the importance of reinforcement. In virtually all instances, there was marked improvement in 2003/2004 compared with the previous year.

Furthermore, it became clear that a large majority of students returned to the fieldtrips at a later date, indicating that as a resource these were being utilized at a separate time to that formally allocated. In the first year of operation, the fieldtrips were accessed on average nine times per student (including the formal session when the fieldtrip was first made 'live'). By the second year, the accessing of fieldtrips had doubled on the previous year with each student utilizing the total resources on average 18 times. In addition, in the second year of teaching, each student accessed the online resources on average over 100 times, probably because the online resources were more explicitly embedded in the module compared with the first year. Comments from students at the end of the module attested

Table 1 Proportional change in grades (expressed as %) between pre-test and fieldtrip questions for individual practicals in 2002/2003 and 2003/2004. A value of 100% would indicate no improvement in learning following fieldtrip attendance.

	<i>Practical 1</i>	<i>Practical 2</i>	<i>Practical 3</i>	<i>Practical 4</i>	<i>Practical 5</i>	<i>Practical 6</i>	<i>Total</i>
2002/03			160.7	138.6	187.0	124.8	151.4
2003/04	184.5	132.5	126.8	215.5	230.8	139.9	172.8

to the value that students place on practical work. Comments included 'The practicals helped me apply knowledge gained in class, helping me remember topics. Practical stimulated my interest and made me want to learn' and 'I found them [practicals] very useful as it is independent learning you cant just switch off.' There was a virtually unanimous response by students responding at the end of term that the virtual fieldtrips/practical work was the most successful element of the module. It has long been recognized that multimedia elements and interactivity keep interest in online learning (McLester, 2001). The movies provided a powerful tool for enhancing student learning, allowing them to appreciate the scale of their environment and in many instances collect primary data (which was not often possible using still images). Overall, the virtual fieldtrips played an important role in helping student-led learning and reinforcing the lessons from the formal contact hours.

Mid-semester test

A mid-semester test was undertaken online in both years. The mean marks for the first and second years of teaching were 26.6 out of 50 (53%) and 26.1% (52%) respectively, indicating little difference in the performance of the two cohorts between the years. Although few people enjoy taking tests, verbal feedback indicated that students preferred this approach to a paper examination. CAA was also welcomed by the lecturer. Marking time was slashed typically from three hours to virtually nothing, and the time taken to transfer the grades into the module spreadsheet dropped from one hour of individual score entry to around ten minutes copying and pasting the results. This provided further time for reflection on individual questions to identify areas of uncertainty and misunderstanding in the class, which could then be either placed online or addressed at the next teaching session. As a result, students received constant feedback on their progress and were then able (if motivated) to direct their learning accordingly.

Impact on student performance

The class size of the two cohorts of students was identical between the teaching years. Furthermore, because the students had insufficient or inappropriate qualifications/grades for immediate entry into the degree pathway and were taught by the same lecturer, they were considered ideal populations for statistical comparison to explore the effectiveness of technology on learning and teaching. Unfortunately, the different approaches to teaching the module had very little effect on the final grades received by students. The mean marks for students in the first and second years of

Table 2 Average marks and z-test results for students taking the 'Volcanoes' module in 2002/2003 and 2003/2004

	No. of students	No. of students passed (%)	Average final grade		
			Total	Students passed	Students failed
2002/03	75	56 (74.7)	47.3	54.4	26.2
2003/04	75	65 (86.7)	50.5	54.1	27.3
z-test	Sample score 2.29		Critical value at 0.05 significance level: 1.67		

teaching the module were 47% and 51% respectively; those who passed received 54% in both years while those who failed received 26–27% on average.

The significant result from this study, however, was that a greater proportion of students passed the module in the second year. In the first year the number of students who passed the module (achieving greater than 40%) was 56 (75% of all students) (Table 2). In the second year, however, the proportion of students who passed increased to 65 students (87% of all students). A z-test on the number of students passing the module indicates that there was a significant difference in the proportion of students passing the module (the sample score of 2.29 exceeds the critical value of 1.67 at the 0.05 significance level).

Although the overall grades did not change between the cohorts, the increased number of students passing the module supports the view that appropriately aligned technology in higher education does improve learning and teaching; partially integrating technology in the first year of the module was less successful. Increasing the technological content of the module led to increased access of online resources and allowed a more directed teaching approach. This was at the cost of student attendance in classes but appears to have had a significant impact on the overall success rate. The practical upshot, therefore, was that although students did not attend class, they continued to work.

Conclusions

Using measures of student performance, we found that, in contrast to some studies (Kvavik et al., 2004), technology in higher education can significantly improve student learning (Sharpe et al., 2006). The important thing is that technology must be fully aligned to the teaching aims and fully embedded within any module; when fully integrated into a module, technology can significantly improve the student pass rate,

particularly for a foundation group considered to be at risk of failing to make the transition to higher education. A potential problem is that, if incorrectly established, technology can allow students to develop a strategic learning approach. Importantly, in spite of the formal teaching sessions, student attendance at class was found to decrease with an increase in the availability of online resources. We would not recommend the removal of formal contact hours, however. One approach does not suit all learners, and formal contact hours probably play an important role in providing support and guidance for those students who need it.

A limitation of the study was that it focused on students in one module over a two-year period, i.e. different students but effectively with a similar profile. Ideally the study should have been extended over a three-year period to include a non-technological cohort of students. Future work is now required to gather data from other fields and years to test whether the above results are replicated at all levels of higher education. Unfortunately, it was also not possible to carry out in-depth interviews with students because of the low numbers of responses, so we cannot be sure why many did not attend teaching sessions or how they were using the online resources to self-study; this will form a greater focus in future work.

Despite this, the ability of students to use technology to repeatedly return to resources was a clear benefit. The constant availability of resources allowed students to take responsibility for their own study at a pace appropriate for the learner. In combination with constant feedback, this appears to have provided a more directed teaching approach. On the part of the teaching staff, CAA increased marking efficiency, allowing more time for reflection; the lecturer was therefore able to identify and immediately address areas of misunderstanding and uncertainty. The overall time cost of developing the module was more than compensated by the increased marking efficiency. With future developments in technology (e.g. Web 2.0 applications), student networking will probably play a more significant role in cross-institutional and international learning.

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