The use of an Electronic Voting System to enhance student feedback

James H. Davenport[1], Alan Hayes[1], and Nitin R. Parmar[2]

[1] Department of Computer Science
University of Bath, Bath BA2 7AY
United Kingdom
{J.H.Davenport,A.Hayes}@bath.ac.uk
[2] e-Learning Team, Learning & Teaching Enhancement Office
University of Bath, Bath BA2 7AY
United Kingdom
N.R.Parmar@bath.ac.uk | http://go.bath.ac.uk/nitin

Abstract. In this paper we present how we have adopted e-Learning technologies in order to enhance our existing practice of both responding to feedback from students and also providing them with meaningful, formative feedback. Our method involves the integration of an Electronic Voting System (EVS) into our learning and teaching approach. The integration reflects our emphasis on the higher order learning skills required by our students. We present how we have applied this approach, in a collaborative learning context, to the tutorial components of a large final year unit on our B.Sc.(hons) Computer Science programme. The use of an EVS is normally thought of as a 'multiple-choice' system, which we feel is superficially inappropriate for the deep learning intended for a final year unit. We have found that, in a formative feedback setting, it is possible to set questions for which there is not necessarily a 'right' answer, and which can therefore provoke greater reflection and debate. We describe how we have adopted the EVS to facilitate such feedback. We present a qualitative reflection and perspective from the teaching team on how the adoption of blending this technique with our traditional approach has modified the preparation, delivery and experience of our tutorial sessions. Additionally, we present the results of surveying our students and present their reflections upon experiencing the adoption of this technology within the tutorial context. We highlight the peer and collaborative engagement experienced by the student cohort. Finally, we present our conclusions and our plans for how we intend to conduct further work in this area with a view to enhancing the feedback process further.

1 Introduction

Wishing to enhance student engagement with the material being taught is nothing new, but pressures on staff–student ratios on the one hand, and the National Student Survey (at least in the U.K.) on the other hand, have brought this issue into greater prominence.

Hence the authors tried an experiment with an Electronic Voting System (EVS: referred to as an Audience Response System, in the local context). Their respective rôles were as follows.

JHD The lecturer for the course chosen for the experiment. An experienced lecturer, who frequently presents off his laptop. Has used PowerPoint before, even though it's *not* his tool of choice.

AH The Director of Studies for the course. He persuaded JHD to make the experiment, and attended all the classes at which it was done, not least in order to hand out and collect the EVS equipment.

NRP The Learning Technologist who, as part of the e-Learning team, is leading the institutional pilot of the EVS.

In the rest of this paper, we discuss the pedagogic context of our use of EVS, the way we tried to engender deep learning, the costs of the system, and the student attitude to the experiment. It is worth noting that the students did not see this as an experiment, merely as a new way of teaching. We finish with some conclusions and open questions. Details of the local context, which may help the reader decide if these findings are relevant to their context, are in the appendices.

2 Pedagogic Context

Details of the pedagogic and technological infrastructure are given in the appendices: here we focus on the context.

The module in question is "Advanced Networking", taught to final year undergraduates[3] in the first semester, being worth 20% of that semester, and 7% of the overall degree. The course is 100% assessed by examination, and has to compete with the first tranche of the final-year project (worth 21% of the overall degree), and with other modules, most of which have coursework, ranging up to 75% of the module assessment. Hence students find it difficult to focus on the networking module. The course is *taught* in October–December, but the examination is in January, which also leads to an "I'll catch up with it over Christmas" effect.

The course is heavily based on [10], which, while an excellent text[4], is heavily factual. It is very easy for students to get into the habit of coming to lectures, listening to the lecturer, whose slides are all from the book or on the web[5], and not engaging with the deeper side of the material.

Much of the relevant pedagogic literature (e.g. [1, 6]) focuses on the use of EVS in large introductory courses. While this is important, the aims of a first-cycle qualification include

> can apply their knowledge and understanding in a manner that indicates
> a professional approach to their work or vocation, and have competences

[3] In terms of the Bologna process [3], "First Cycle" students.

[4] JHD has reviewed many alternative texts over the years, but has stuck with Stevens.

[5] They are on the web in response to previous student demand!

> typically demonstrated through devising and sustaining arguments and solving problems within their field of study [3]

and JHD was initially worried that a 'fact-based' technology such as EVS might divert students further from the underlying principles in favour of 'easy-to-learn' facts, and figure 1 was an initial attempt to counteract this.

The course is taught as three hours/week, two of which are formal lectures and the third is designated as a "problem class", in which the students are supposed to ask questions. Over the years, as the course has grown from 20 students to 70, these problem classes have become more and more intimidating for the students, and the common question is "can we do past examination questions", which tends to deteriorate into another lecture-style explanation by the lecturer, and does little to enhance student engagement.

One possible solution is an Electronic Voting System (EVS).

2.1 Electronic Voting System Technology

At the beginning of the 2008/2009 academic year, the e-Learning team at the University of Bath chose to embark on a pilot of a TurningPoint-based EVS. This intention was to work with a range of stakeholders to identify and evaluate if use of an EVS could be used as one mechanism to give students greater feedback on their learning. The TurningPoint software, which is a Microsoft PowerPoint plugin, can give normal lecture slides greater impact. In fact, the TurningPoint EVS is a more than just a simple voting system, as it allows for the collection of student feedback and the immediate sharing of the results. Further analysis of the data generated can be completed using the accompanying reporting software.

Following initial use of the EVS at the University of Bath, NRP identified five areas in which the system could be used to support learning and teaching in a face-to-face context.

- For diagnostic testing at the beginning of a lecture
- For monitoring understanding of the content by students
- For enabling the provision of immediate feedback within the context
- For keeping students actively engaged in their learning
- For promoting peer interaction and support

It should be noted that, in *this* experiment, the students were told at the start of the first class that the EVS was being used in anonymous mode, and purely as formative feedback for the students. This contrasts strongly with [5], who stated (after the first year)

> In particular, we announced at the beginning of the semester that the keypads would count as some substantial part (15-25%) of the final grade.

2.2 Our Use of Electronic Voting System

[9] gives various uses of electronic voting systems, but, while we used (in their terminology)

– student feedback on lecturer/lecture

as a side-effect of having the system available[6], our main goal was one they do not give directly:

– assisting students to engage with the material.

Table 1. Number of questions per session

		Question Count			
Session	Week	Warm-up	Content	Course	Total
1	5	1	7	5	13
2	8	1	12	4	17
3	11	1	22	2	25

The Electronic Voting System was used as the primary means of learning in three "problem class" sessions, in weeks 5, 8 and 11 of the class. Table 1 gives a breakdown of the number of questions asked per session. The growth in number of content questions is noteworthy, and can be attributed to two factors.

1. Greater facility on the part of the students. Session 1 ran out of time, and some questions were deferred to session 2 — in the table they are counted as session 2. This effect would probably occur every year.
2. Greater facility on the part of the lecturer, in question setting and "answer slide" writing.

An alternative method would have been to use the EVS intermittently in all, or most, of the sessions, as described in [6].

> Modes of implementation are as varied as the instructors who use them, but typically between two and five questions are given per 50 minutes of class instruction

We chose not to do this for a variety of reasons, which seemed good at the time, even though many of them are transient.

1. The course was already under way, and it seemed to us to be too disruptive to change the formal lecturing style, whereas the problem classes had yet to get under way.
2. The lectures were barely sufficient to get through the allocated material, and JHD was reluctant to lose any time from the formal lectures.
3. Technology failures[7] are much more readily brushed off in a problems class than in a formal lecture, at least for JHD's style of lecturing.

[6] See the last few slides of each session.
[7] Which in fact did not happen, but this was far from guaranteed.

4. The deployment of the EVS was logistically complicated — see section 4.2.

The full sessions can be found at the course URL: `http://staff.bath.ac.uk/masjhd/CM30078.html`. We reproduce some of the slides here, in the format that the students would see it *after* they have attempted to answer the questions[8]. It is worth noting that they get real-time feedback, not only as to what the right answer is, but also as to how they compare with their peers. It is one thing to be wrong with several others, another thing to be distinguished (albeit in your own mind only) by your ignorance.

3 The Questions used

Following the usual "warm-up" questions[9], the first "real" slide and the corresponding answer slide are shown in figure 1. The main aim of this was to emphasise the points in the answer slide — the surface content of the question was largely irrelevant from this point of view. Equally, the fact that a majority of the students got it "right" was largely irrelevant to JHD.

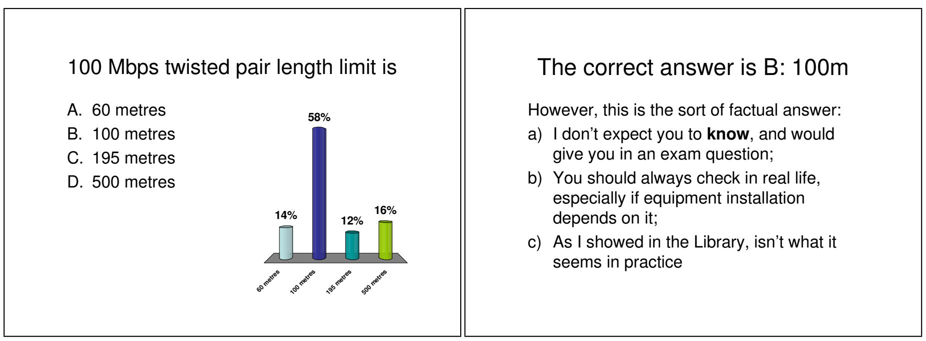

Fig. 1. Simple question, but pedagogic points (Session 1, slides 7–8)

Bloom's taxonomy [4] classifies learning into six cognitive levels (knowledge, comprehension, application, analysis, synthesis and evaluation). The taxonomy represents an increasing level of learning abstraction and difficulty ranging from memory recall (knowledge) through to making critically informed judgements (evaluation). The qualifications framework of [8] contains descriptors that describe the learning outcome expectations for both undergraduate and postgraduate provision in the Higher Education sector. The final year of an undergraduate programme is labelled as level 6 within this framework. The learning outcomes expressed at this level make reference to outcomes that are described as "critical evaluation" and "an appreciation of the uncertainty, ambiguity and limits

[8] However, in practice many of the slides, particularly answer slides, were phased.
[9] One totally generic and one (figure 7) on the material.

of knowledge". It is the enabling of the student engagement with these higher-order skills that was the focus of our experiment. Our goal was to utilise an EVS system to promote this deep learning within the student.

Figure 2 is an example of how we used the EVS system to engage the students at this level. The question has been designed in a manner such that there is not one correct answer. The students need to utilise their analysis and evaluation skills in order to address the question. In observing the class when this was presented two things were immediately notable. The first was the initial silence within the class as the students began to engage with what was being asked. The second was the readiness with which the students engaged with their peers in order to discuss the issues that were pertinent to the question. In surveying students who had been grouped together to formulate a collective, group response from students to questions posed within an EVS context [1] reports that almost 80% of student cohort felt that such discussion led to a better understanding of the subject matter. Our expectation, from our initial analysis, is that we would anticipate a similar enhancement in understanding within this deep learning context.

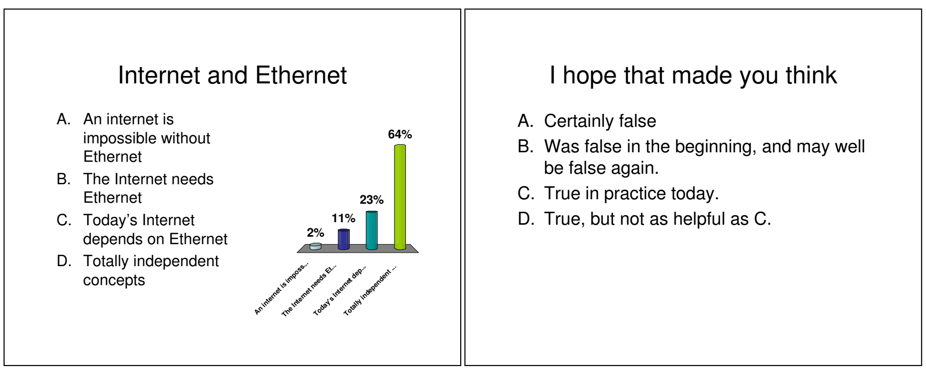

Fig. 2. "Deep thought" question (Session 1, slides 9–10)

It is also possible to ask questions which probe around the area ostensibly being asked for. Routing (i.e. how packets traverse the Internet) is a complex question, and the standard terminology distinguishes between

Routing Mechanisms
Routing Policies
Routing Protocols
Routing Programs (generally called daemons).

Bearing in mind that this course is assessed 100% by examination, the only way to reinforce this point in the students' minds in the past was to set examination questions of the form "*Explain the differences between routing mechanisms, policies, protocols and program*".

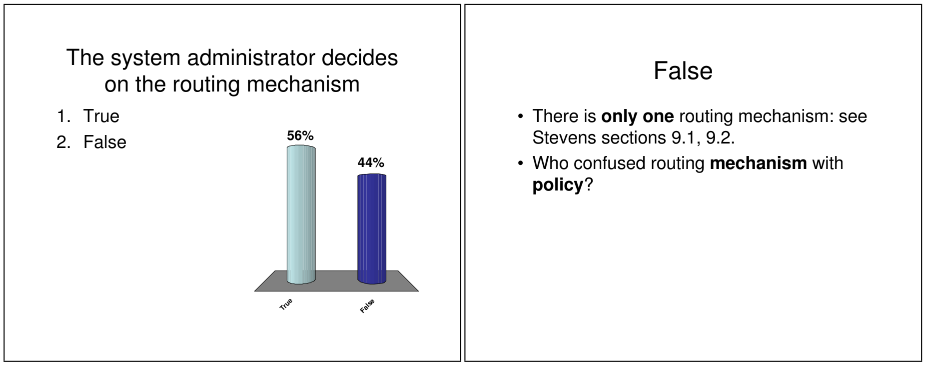

Fig. 3. A question with a deeper point (Session 1, slides 15–16)

In the EVS context, we can proceed slightly differently, as illustrated in figure 3. It is, from the data presented, impossible to know *why* a (small) majority of students got the wrong answer, but, judging from the sheepish looks when the last bullet point of the answer slide was revealed, many did indeed have that confusion.

It is perfectly possible to ask questions in this context which have *no* right answer: figure 4 is one such example from the first session, and 5 from the second. This idea is not new to us: [5] write

> In more recent applications, we have experimented with partially correct answers and with even more than one correct answer.

Here we discovered that it is important for the lecturer not to amplify the question, but rather say "ask your neighbour — what do *you* think".

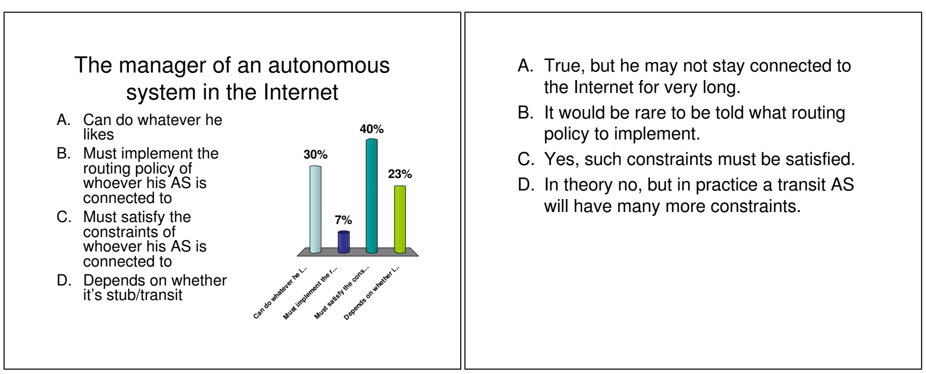

Fig. 4. A question with no right answer (Session 1, slides 17–18)

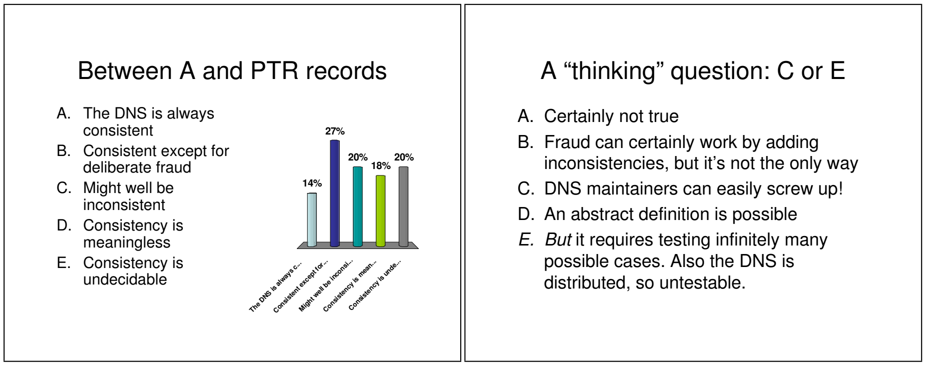

Fig. 5. Another question with no right answer (Session 2, slides 15–16)

The examples above serve to illustrate our approach to facilitate deep learning within the students. We have essentially adopted two distinct mechanisms. The first is to present the student with a question for which there is not a single correct answer. In this context the deep engagement is through the students deliberating upon several distinct, possible and correct responses to the question being asked. The second is to present the students a question for which there is only one correct solution. However, the question is posed in such broad terms that in order to determine the correct answer the students need to employ the higher order skills of analysis, evaluation and ambiguity resolution in order to contextualise, choose and apply the technological principles that are pertinent to addressing the question being addressed. In adopting a blended approach which encompassed both types of mechanism we have observed the students engage in deep learning and peer supported discussion. We believe that this has led to an enhanced learning experience for our students.

4 Costs of the EVS

4.1 Central Costs

The startup cost for such an initiative is not insubstantial. A single USB RF receiver was costed at an average of £220, with the clickers costed at £35 per unit[10]. The total capital expenditure was therefore £8100.

On average, NRP works as a 0.3 Full-Time Equivalent (FTE) on the EVS project, and has spent substantial time in creating a structure of the implementation of the project. Whilst much of the support and training material for the TurningPoint hardware is available to lecturers through the project website,

[10] This contrasts with the $CAN30≈£17 at Waterloo. There *may* be a psychological break point here in terms of student purchase of clickers, since in the UK context it is no longer obviously "cheaper than a book" [2].

some face-to-face sessions have also been arranged. Hence, even in one year, the staff cost here exceeds the capital cost.

The e-Learning team use the EVS (for diagnostic testing and evaluation) in all of their staff development workshops, for highlighting one of contexts in which the EVS can be used. Individual training sessions with staff typically last between 30-60 minutes, where in addition to some basic instruction of the component parts of the EVS and the software, some pedagogical issues of using the technology are also addressed.

4.2 Costs to the Lecturer

The initial learning curve was not too bad: 4 hours was spent in installing the PowerPoint add-on on JHD's laptop, his writing a few test questions and then running through them with NRP and the equipment to check that they worked, and to correct a few misconceptions.

Each 50-minute session (which was already timetabled, and would have been spent on something else if it were not for the use of EVS) required about five hours of preparation in terms of writing the questions. One question to which we do not know the answer yet is how re-usable these are. Some probably are, but in view of the fact that the material has to be topical, the re-use will be significantly less than total, say 50%.

In addition, AH handed out and collected the EVS equipment. JHD was already timetabled for a different class preceding this one, and it would have been physically impossible for him to do both classes and collect and issue the equipment. Similarly, it would have been very difficult for him to collect up all the equipment and return it, as well as give a subsequent lecture. Hence, at least in the University of Bath context, it seems that use of this equipment either requires an assistant (AH in this case) or blocking out the lecturer for the hours[11] either side of the class.

5 Student Opinion

The last few slides of each EVS-enabled class were used to gain student opinion (as has been remarked elsewhere [6], EVS are a simple way of doing so, especially if, as in our case, the devices are anonymous). Opinion at the end of the first slide was clearly positive, see figure 6.

Following the first session of EVS use, a short online survey was conducted by JHD in conjunction with the e-Learning team, in an attempt to gauge student reaction following the first use of the EVS. Reaction was generally positive with one student commenting that: *"...it gives a good view on how the rest of the class is doing in comparison and lets you know how much harder you should be working"*. Another student added: *"It was useful to be able to see my answer*

[11] Of course, *most* of each hour would be available for other work, since the AVS would consume only 10 minutes or so either side of the class, but the point is that another timetabled teaching hour would not be possible.

in comparison to other peoples. This gave me an easy way to benchmark my learning against others to see how I was doing on the course."

Further comments were noted in the end of unit evalution, which students was once again asked to complete online. Several commented on the fact that the EVS had been used to support problems' classes and would support further embedding of the technology within their learning.

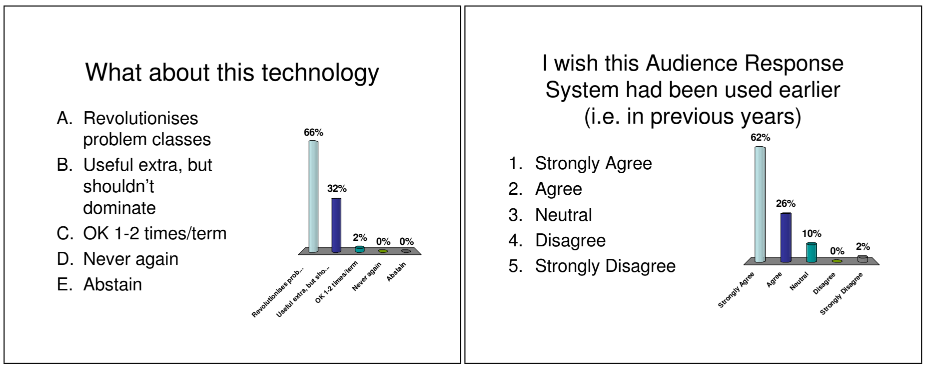

Fig. 6. Student Opinion: (a) Session 1, slide 25; (b) Sesssion 2, slide 33

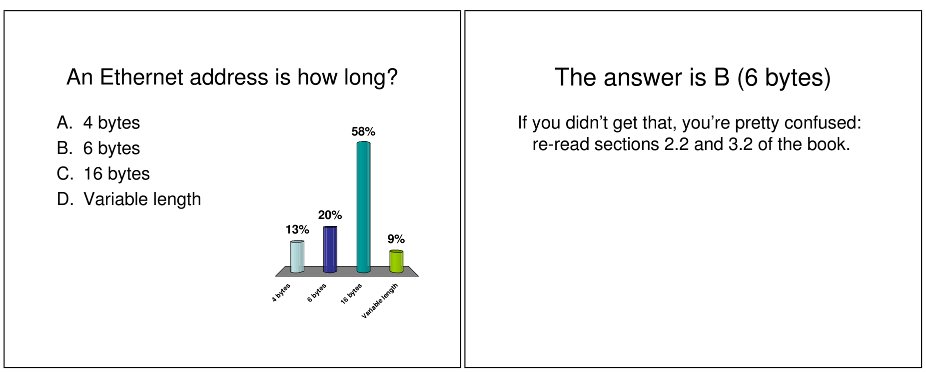

Fig. 7. A factual question displaying lack of comprehension (session 1, slides 5–6)

6 Conclusion and Further Questions

We can see the following conclusions from this usage of EVS.

- It is possible to convert a relatively sceptical lecturer (JHD) into a strong user of this system *in the appropriate context*.

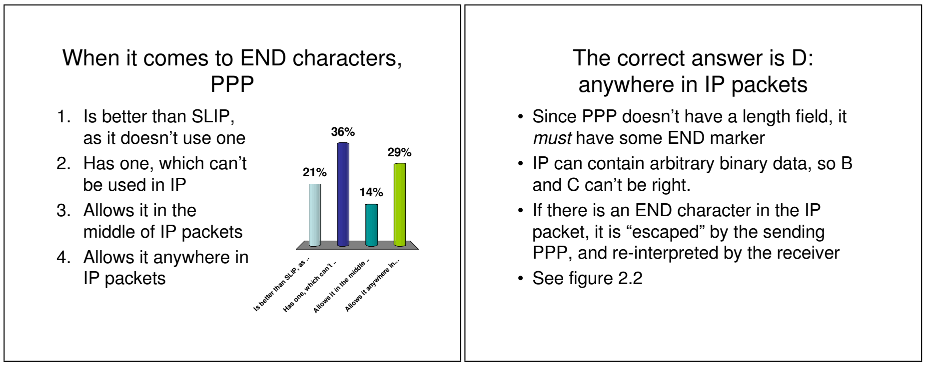

Fig. 8. Another question displaying lack of comprehension (session 1, slides 11-12)

– This technology does enable the lecturer to gauge levels of misapprehension, as seen from figures 7 and 8, in a way that would be hard otherwise in an examination-only course of this size.
– It is possible to use EVS to help students with deeper points than mere factual knowledge.
– When used at this level, the lecturer has to be prepared to improvise. Figure 8 led to a five-minute explanation of the points in the answer slide.
– The students like it (this is certainly not a new point, but it is an important one).

There are various further questions that have arisen.

1. Our usage of the EVS was based firmly around "one student: one handset". Although we observed student discussion (see the discussion above of figure 2), our usage was not set up for this. [7] report strong benefits from more formal peer discussion, and we should investogate this.
2. Although popular with the students who attended (about 42 in each session, and apparently a strong commonality), there were 71 students on the course, and therefore 29 who did not take up these problem classes (but who were largely at the formal lectures). The total anonymity did not permit any correlation of examination results with attendance at the EVS sessions, and this was a distinct experimental drawback.

There is one point of relevance to institutional policy that the first two authors would like to make. The logistic difficulties of issuing and collecting the EVS (section 4.2 — we are referring to the student handsets) did constrain the use of the EVS to intensive use in a small number of sessions, rather than being integrated. Though it is not totally clear, it seems very likely that the facility of [7] was fitted with the relevant equipment. The University of Waterloo (Ontario) gets[12] students to *buy* such handsets: they can be sold on to the next generation

[12] The motivation we know about [2] is that EVS work *is* assessed, at 1 point for answering at all, and 1 point for the correct answer.

in the same way that textbooks are, and through the campus bookshop. The handsets are about $CAN30 each [2], and less than 5% of students cite 'cost' as a reason for not continuing with this technology. If there is to be an institutional commitment to serious use of this technology, then one or the other route probably has to be followed to reduce the logistic difficulties.

References

1. M. Bade, D. Drane, Y.B.-D. Kolikant, and M. Schuller. A Clicker Approach to Calculus. *Notices A.M.S.*, 56:253–265, 2009.
2. B.W. Becker. Private Communication. 20 February 2009.
3. Bergen Conference of European Ministers Responsible for Higher Education. The framework of qualifications for the European Higher Education Area. `http://www.bologna-bergen2005.no/EN/BASIC/050520_Framework_qualifications.pdf`, May 19–20, 2005.
4. B. Bloom. *Taxonomy of Educational Objectives: the Classification of Educational Goals* Longman, London, 1956.
5. R.A. Burnstein and L.M. Lederman. Using wireless keypads in lecture classes. *Phys. Teach.*, 39:8–11, 2001.
6. J.E. Caldwell. Clickers in the Large Classroom: Current Research and Best-Practice Tips. *Life Sciences Education*, 6:9–20, 2007.
7. D. Nicol and J. Boyle. Peer Instruction versus Class-wide Discussion in Large Classes: a comparison of two interaction classes in the wired classroom. *Studies in Higher Education* 28:457–473, 2003. `http://dx.doi.org/10.1080/0307507032000122297`.
8. The Quality Assurance Agency. *The Framework for Higher Education Qualifications in England, Wales and Northern Ireland*. `http://www.qaa.ac.uk/academicinfrastructure/FHEQ/EWNI08/FHEQ08.pdf`.
9. V. Simpson and M. Oliver. Using Electronic Voting Systems in Lectures. `http://www.ucl.ac.uk/learningtechnology/assessment/ElectronicVotingSystems.pdf`, 2002.
10. W.R. Stevens. TCP/IP Illustrated Volume 1: The Protocols. *Addison-Wesley*, 1994.

A Pedagogic Infrastructure at Bath

The University of Bath is physically a compact[13] 1960s campus, with some later additions. "General Teaching Area" (GTA) is a scarce resource[14] centrally controlled and timetabled, and it is not unusual for a course with three timetabled hours to have them in three different rooms in three different buildings. The lecture theatres are very traditional, and we do not have the benefits of the adaptation described in [7, p. 460] to facilitate group disucssion. Audio Visual (AV) support is provided by an organisationally central team, physically centrally located, which maintains and issues the EVS hardware. Technical and

[13] All but one of the teaching spaces are within an easy five-minute walk of each other.
[14] The University is 12th highest out of 132 to report teaching area allocation, with an occupancy rate of 74%, as against a U.K. median of 53%.

pedagogical support is provided by members of the e-Learning team, led by NRP.

Timetabling is in hour-long units, and a "one hour lecture" is actually 50 minutes long, with ten minutes allocated for the change-over, which in practice tends to be relatively tight.

B Technical Infrastructure at Bath

The e-Learning team opted to purchase the TurningPoint ResponseCard RF EVS[15]. This radio-based option is perfect for small and large groups alike. With an operating range of 60 metres, it is ideal for a variety of rooms around the university campus. Unlike the IR (Infra Red) model, the RF model does not require a 'line of sight' between the clicker and the USB receiver, which makes it particularly useful in larger rooms.

At the beginning of the 2008/2009 academic year, e-Learning team purchased 5 bags of 40 *clickers*, with each bag containing a USB Radio Frequency (RF) receiver. A single RF receiver can support up to 1000 *clickers* meaning that several bags can be used together without any problems. The hardware is shown in figure 9. The USB RF receiver is usually plugged into a PC at the front of the teaching room, which in turn is connected to a projector.

The EVS comes with a suite of software, which has two distinct purposes. On the one hand, it can be used when *writing* the questions, as part of a normal PowerPoint presentation. On the other hand, when run on a computer *with* the USB receiver, it can be used to set the questions and collect the answers. There is no logical need for the writing and setting computers to be the same, though in fact JHD used his laptop for both.

Following liaison with colleagues in BUCS (Bath University Computing Services), the software to support the EVS was installed on every Public Access Computer (PAC), such as those in the Library and Learning Centre (over 400), and on the PCs on the rostra of General Teaching Area rooms. The intention of installing the software on PACs was to enable students to create their own interactive slides if and when required. JHD in fact installed the software on his own laptop.

For staff using centrally managed PCs on their desktops, the EVS software could be installed on their PC through contacting with their departmental IT supporters. In addition, the software, both PC and Mac versions, could be downloaded from the EVS project website at `http://go.bath.ac.uk/evs` for installation on personal devices.

[15] Further information about this hardware can be found on the Turning Technologies website: http://www.turningtechnologies.com/

Fig. 9. The hardware: USB receiver (lecturer's use) and clicker